

A recent population assessment of the American crocodile (*Crocodylus acutus*) in Turneffe Atoll, Belize

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ABSTRACT— We investigated the status of the American crocodile (*Crocodylus acutus*) in Turneffe Atoll, Belize during 2002 and 2004. A combination of spotlight surveys and counts of recently hatched nests were used to census the crocodile population. A total of 49 crocodiles were observed along 40.1 km of survey route (1.2 crocodiles/km) during spotlight surveys in 2002. This encounter rate was not significantly different from that reported in surveys conducted during the mid-1990's. Eight and 20 recently hatched nests were found in 2002 and 2004, respectively. The number of nests found in 2004 exceeds the previously reported maximum count of 15, suggesting that recruitment of breeding females into the population may be occurring. Crocodile nests were found at four sites in Turneffe Atoll. The most significant nesting beach in Belize is located on Northern Cay and currently threatened by a proposed tourist development. Failure to protect this beach could have potentially devastating consequences for *C. acutus* in Belize.

THE American crocodile (*Crocodylus acutus*) has one of the most extensive distributions of any crocodylian in the New World, occurring along the Atlantic and Pacific Coasts of Mexico, and Central and South America as well as the Caribbean islands of Cuba, Jamaica, Hispaniola, and the southern tip of Florida (Thorbjarnarson, 1989). American crocodile populations throughout this range have declined due to past over-exploitation, continued illegal hunting, and habitat destruction (Thorbjarnarson, 1989). *Crocodylus acutus* is currently recognized as 'vulnerable' by the International Union for the Conservation of Nature and Natural Resources (IUCN), listed on Appendix I of the Convention on International Trade in Endangered Species of Fauna and Flora (Thorbjarnarson, 1992; Ross, 1998), and considered threatened by the Belize Department of Fisheries (McField et al., 1996; Platt & Thorbjarnarson, 2000a).

Owing to the paucity of reliable population estimates, surveys of *C. acutus* in Belize were accorded high priority by the IUCN Crocodile Specialist Group (Thorbjarnarson, 1992; Ross, 1998). Preliminary surveys of offshore cays (islands) were initiated during 1994 and 1995 (Platt & Thorbjarnarson, 1996), and a country-wide survey of offshore and mainland habitats was completed in November 1997 (Platt & Thorbjarnarson, 1997, 2000a; Platt et al., 1999b). Platt & Thorbjarnarson (2000a) estimated that fewer than 1000 non-hatchling *C. acutus* inhabit Belize; the largest populations occurred on offshore cays and the Turneffe Atoll, while only scattered individuals were found in mainland coastal habitats.

Turneffe Atoll harbours the largest *C. acutus* population and highest concentration of nesting activity in Belize (Platt et al., 1999a; Platt & Thorbjarnarson, 2000a). An estimated 200 to 300

non-hatchling crocodiles inhabit the atoll, including 15-25 breeding females. Moreover, Turneffe Atoll is thought to serve as a source population for *C. acutus* elsewhere in the coastal zone, and as such plays a vital role in regional metapopulation dynamics (Platt & Thorbjarnarson, 2000a). Reproduction of *C. acutus* in Turneffe Atoll is highly dependent on elevated beach ridges composed of coarse sand. Suitable nesting beaches are rare in the atoll owing to a combination of natural and anthropogenic factors (Platt & Thorbjarnarson, 2000a). Because nesting beaches are increasingly threatened by development, Platt & Thorbjarnarson (2000a) concluded that the conservation status of *C. acutus* in the Turneffe Atoll should at best be considered tenuous, and recommended a long-term monitoring program based on nest counts and spotlight surveys to determine population trends. We here provide a recent assessment of the American crocodile in Turneffe Atoll using survey data collected in 2002. Significantly, this is the first assessment undertaken since completion of the country-wide survey in 1997 (Platt & Thorbjarnarson, 1977).

Study area

Turneffe Atoll (Figure 1) is the largest of three atolls in Belize, and one of only four atolls in the Western Hemisphere (Stoddart, 1962). It is located approximately 35 km from the mainland, and is 50 km north-south and 16 km east-west with an estimated surface area of 533 km² (Perkins, 1983). The atoll consists of a chain of islands partially enclosing three shallow lagoons: Southern, Central, and Northern (shown as Vincent's Lagoon on some maps). Most of Turneffe Atoll is dominated by mangrove swamps (*Rhizophora*

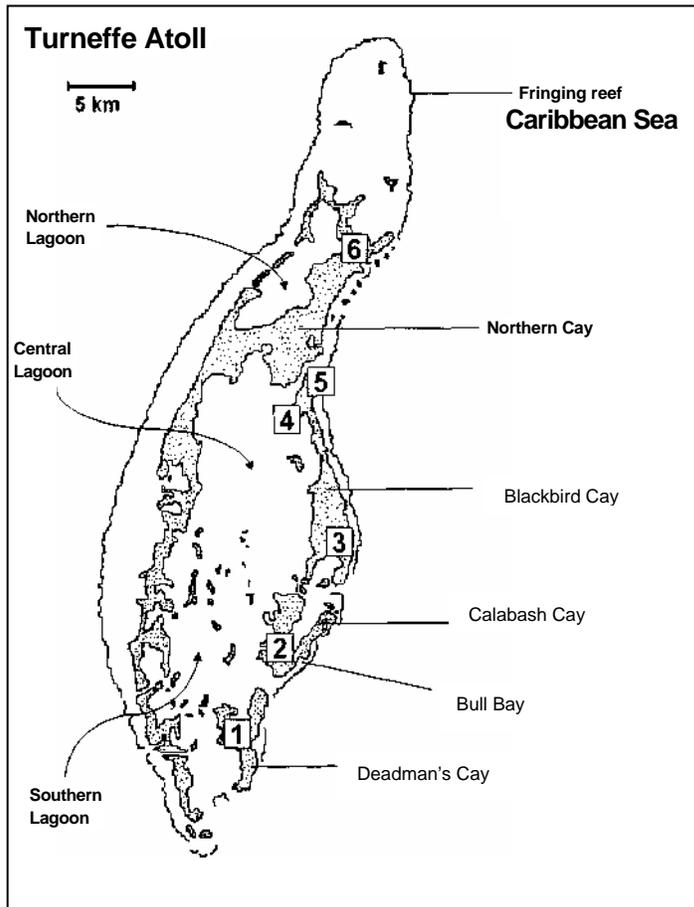


Figure 1. Map of Turneffe Atoll showing localities mentioned in text. Numbers correspond to nesting beaches listed in Table 1. Coordinates of nesting beaches are provided in Platt & Thorbjarnarson (1997, 2000b).

mangle, *Avicennia germinans*, and *Laguncularia racemosa*), while beach ridges are characterized by cay littoral forest (Stoddart, 1962; McField et al., 1996). The topography, climate, vegetation, biodiversity, and history of the atoll are fully described elsewhere (Stoddart, 1962; Stoddart, 1963; Perkins, 1983; McField et al., 1996; Platt et al., 1999a; Platt et al., 2000). Turneffe Atoll remains sparsely populated; four resorts, a research centre, and scattered fishing camps are the only permanent dwellings found in the atoll (Platt et al., 1999a).

Location	1994	1995	1996	1997	2002	2004
1. Deadman's Cay	1	1	0	0	0	0
2. Calabash Cay	0	NA	0	0	1	2
3. Blackbird Cay (south)	0	NA	5	3	1	3
4. Blackbird Cay (west)	2	1	1	2	0	0
5. Blackbird Cay (north)	0	0	0	0	0	4
6. Northern Cay	8	NA	7	10	6	11
Total	11	2	13	15	8	20

METHODS

Fieldwork in the Turneffe Atoll was conducted from 27th June to 15th July 2002, and 20th to 25th July 2004. We censused the crocodile population in 2002 using a combination of spotlight surveys (Bayliss, 1987) and nest counts, but only the latter were conducted during 2004. Spotlight surveys were conducted from a 5 m motorized skiff beginning 15 to 30 minutes after sunset. Crocodile eyeshines were detected using a 400,000 candlepower Q-beam spotlight and 12-volt headlights. All crocodiles sighted were classified by total length (TL) as hatchlings (TL < 30 cm), juveniles (TL = 30-90 cm), subadults (TL = 90-180 cm), or adults (TL > 180 cm). Crocodiles that submerged before TL could be determined were classified as 'eyeshine only' (EO). The beginning and endpoints of each survey route, and the distance traversed was determined with a Garmin®GPS 12. Encounter rates were calculated as the number of crocodiles observed per kilometer of survey route (Platt & Thorbjarnarson, 2000a).

We revisited nesting areas identified during previous surveys (Platt & Thorbjarnarson, 1996, 1997) and searched for recently hatched nests during July of 2002 and 2004. American crocodile

Table 1. Counts of American crocodile (*Crocodylus acutus*) nests found at various beaches in the Turneffe Atoll (1994 to 2004). Data from Platt & Thorbjarnarson (1997) and present study. Note that 1995 counts are based on incomplete survey data. NA = Not available. Location numbers correspond to Figure 1.

eggs hatch from late June to mid-July following the onset of the annual wet season (Platt & Thorbjarnarson, 2000b). Female crocodiles typically excavate nests to remove neonates, leaving a readily obvious hole containing eggshell fragments and membranes (Figure 2). In addition to known nesting areas, during both years of this survey we searched potentially suitable beaches where nesting has yet to be documented.

RESULTS

Spotlight surveys

We conducted spotlight surveys along the eastern and western shores of Blackbird and Calabash Cays in 2002. Beginning and endpoints, and a description of each survey route are contained in field notes archived in the Campbell Museum (Clemson University, Clemson, South Carolina, USA). We observed a total of 49 *C. acutus* along 40.1 km of survey route (encounter rate = 1.2



Figure 2. An American crocodile nest recently excavated by female to release hatchlings. Note eggshell membranes remaining in hole. Blackbird Cay, Turneffe Atoll (12th July 2002). All photographs © Steven G. Platt.



Figure 3. American crocodile nesting beach on Northern Cay, Turneffe Atoll (21st July 2004). This beach is the most significant American crocodile nesting site in Belize.



Figure 4. Shallow mangrove lagoon adjacent to the crocodile nesting beach on Northern Cay, Turneffe Atoll (28th June 2002). This lagoon provides critical nursery habitat for hatchling American crocodiles .



Figure 5. American crocodile nesting beach on Calabash Cay, Turneffe Atoll (22nd July 2004). Note the elevated beach ridge and cay littoral forest vegetation. Such sites are rare in Turneffe Atoll and constitute critical nesting habitat for American crocodiles.

crocodiles/km). Of these, 16 (32.6%) were classified as EO, and 33 (67.3%) were approached closely enough to estimate size; these included 1 (3.0%) juvenile, 17 (51.5 %) subadults, and 15 (45.4%) adults. Additionally, we observed a pod of 12 to 15 hatchlings during a spotlight survey of Bull Bay (Calabash Cay) on 11th July 2002. A large (TL ca. 120 cm) *Boa constrictor* (*Boa constrictor*) appeared to be attempting to prey on the small crocodiles; it was found about 2 m away and moving towards the hatchlings in shallow water. The following day some of the hatchlings were relocated in an eroded, water-filled hole at the base of a Coconut palm (*Cocos nucifera*).

Nest counts

We found eight and 20 recently excavated nests in 2002 and 2004, respectively, at four sites in Turneffe Atoll (Table 1). The GPS coordinates of each nest are contained in field notes archived in the Campbell Museum. Although mound nesting has been reported among *C. acutus* in the Turneffe Atoll (Platt & Thorbjarnarson, 2000b), we found only hole nests during the current study. Of the 28 nests found during 2002 and 2004, 17 (60.7%) occurred at a single beach on Northern Cay (Fig. 3). We also observed two large adult crocodiles and approximately 20 to 30 hatchlings in a nursery lagoon (Fig. 4) adjacent to this beach on 21st July

2004. Neither adults nor hatchlings were observed at this site in 2002, although tracks and drag marks indicated crocodiles were indeed present at that time.

Additional nesting areas occur on Calabash Cay (Fig. 5) and at several sites on Blackbird Cay. Previous surveys (Platt & Thorbjarnarson, 1997) found no evidence of crocodile nesting on Calabash Cay, but we documented a single nest here in 2002 and found two nests at the same location during 2004. An old excavation containing dried eggshells was also present at the site, most likely dating from the 2003 nesting season.

We found nests at two sites on Blackbird Cay during the current investigation. Nests occurred on a high beach ridge along the eastern shore, approximately 3 km north of Blackbird Resort in 2002 and 2004, and in 2004 we located an additional nesting area at the northern tip of Blackbird Cay, adjacent to Turneffe Flats Resort. The latter site is located on a densely vegetated ridge adjacent to an open marsh. Several crocodile wallows were found in the marsh, and one of us (SN) encountered a female crocodile with neonates in a wallow during 2000 and 2001. Crocodiles apparently no longer use a nesting area on the western shore of Blackbird Cay. This low, poorly drained beach ridge is composed largely of peat rather than coarse sand, and is the only site where mound nesting by *C. acutus* has been observed in Belize (Platt & Thorbjarnarson, 1997, 2000b). Likewise, no evidence of nesting activity has been found on Deadman's Cay since 1995, although the site appears to remain suitable habitat.

DISCUSSION

The encounter rate in Turneffe Atoll during 2002 was somewhat greater than previously reported (0.96 crocodiles/km; Platt & Thorbjarnarson, 1997), although this difference was not significant ($\chi^2 = 2.03$; $df = 1$; $p > 0.05$). Because of the variability inherent in spotlight counts, long-term monitoring is generally required to detect population changes (Bayliss, 1987). The high proportion of subadults and adults noted during our

investigation is likely due in part to sampling bias; juveniles remain concealed in mangrove vegetation and escape detection during spotlight surveys (Platt & Thorbjarnarson, 2000a).

The 20 crocodile nests we found in 2004 exceed the previous maximum count of 15 nests in 1997 (Table 1). These data suggest that recruitment of breeding females is occurring in Turneffe Atoll, and possibly reflect an overall population increase since the previous surveys were conducted. However, given the small number of breeding females in the atoll and the annual variability in nesting effort, these data should be interpreted with caution.

Our current and previous (Platt & Thorbjarnarson, 1996, 1997, 2000a) investigations underscore the importance of the Northern Cay nesting beach to the Turneffe Atoll crocodile population. Indeed, Platt & Thorbjarnarson (1997) regarded it as the most significant *C. acutus* nesting site in the entire coastal zone of Belize. This beach consists of a high ridge composed of coarse sand, with an adjacent shallow brackish lagoon that provides excellent nursery habitat for hatchlings, and undoubtedly enhances neonate survival (Platt & Thorbjarnarson, 2000a, 2000b). This beach was greatly improved by Hurricane Keith in 2000 when tidal over-wash deposited large amounts of sand at the eastern end of the nursery lagoon and created additional nesting habitat.

Our recent surveys indicate that with the exception of Northern Cay, crocodile nesting beaches in Turneffe Atoll remain relatively undisturbed with little sign of human disturbance other than occasional visits by fishermen and coconut collectors. However, the Northern Cay nesting area is now in imminent danger of destruction due to the proposed development of a tourist resort. If this project is allowed to proceed an irrevocable loss of critical nesting habitat will occur. Given that Northern Cay hosts the largest concentration of *C. acutus* nesting activity yet identified in Belize, this development constitutes a grave threat to the continued viability of the crocodile population in Turneffe Atoll. Even more importantly, because Turneffe Atoll appears to serve

as a source population for *C. acutus* in other areas of the coastal zone (Platt & Thorbjarnarson, 2000a), destruction of the Northern Cay nesting beach has potentially devastating consequences for this endangered species elsewhere in Belize. Therefore it is imperative that development be immediately halted. Additionally, some form of permanent legal protection is urgently needed for Northern Cay, as well as other nesting beaches in the atoll, to avoid future conflicts with development interests.

Our observations provide further evidence that mound nesting occurs infrequently among *C. acutus* in Turneffe Atoll. During a previous study (1994-1997) only 6 of 41 (14.6%) nests found in the Turneffe Atoll were mound nests (Platt & Thorbjarnarson, 1997). In general, mound nesting appears to be rare among *C. acutus*, and largely confined to populations in southern Florida, USA (Beard et al, 1942; Ogden, 1978; Kushlan and Mazzotti, 1989; but see Russell [1929] for an account of mound nesting in the Yucatan region of Mexico). Mound nesting is thought to be an adaptive response to waterlogged soils (Thorbjarnarson, 1989). Significantly, the only site in Belize where we found mound nests is a low-lying beach composed of shallow and often wet peat soil.

Finally, to our knowledge predation by *Boa constrictor* on hatchling *C. acutus* has not been previously reported (Thorbjarnarson, 1989). *Boa constrictor* are common throughout Turneffe Atoll and frequently feed on *Ctenosaura similis* (Platt et al., 1999a); thus consumption of hatchling crocodiles is not unexpected.

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