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Source: Chelonian Conservation and Biology, 20(2) : 296-299

Published By: Chelonian Research Foundation and Turtle Conservancy

URL: https://doi.org/10.2744/CCB-1499.1

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Chelonian Conservation and Biology, 2021, 20(2): 296–299
doi:10.2744/CCB-1499.1
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Novel Use of Anchialine Ponds by Hawksbill Turtles in The Bahamas

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ABSTRACT. – **We present 4 observations of hawksbill turtles *Eretmochelys imbricata* found in anchialine ponds on 3 islands in The Bahamas. These ponds had no surface connection to the ocean, but they were connected by subterranean conduits that, in at least one instance, extended over 1.5 km in length. It is possible that the turtles were placed in these ponds by humans; however, it appears more likely that they accessed these habitats via the subterranean conduits suggesting that anchialine ponds may function as either novel habitat or a potential ecological trap.**

Hawksbill sea turtles *Eretmochelys imbricata* are often considered to be coral-reef specialists (León and Bjorndal 2002; Goatley et al. 2012). However, several studies have shown that the habitat preferences of this species may be more flexible than previously considered (Blumenthal et al. 2009; Gaos et al. 2012b). Indeed, hawksbill turtles in the Caribbean frequently inhabit seagrass meadows (Bjorndal and Bolton 2010) and in the Eastern Pacific they are commonly found in mangrove ecosystems (Gaos et al. 2012a). Here, we provide evidence of novel use of anchialine ponds by hawksbill turtles in The Bahamas.

During opportunistic snorkeling surveys in anchialine ponds throughout The Bahamas, we recorded 4 separate encounters with hawksbill turtles (Fig. 1). The first 2 encounters occurred on 20 June 2017 in Flamingo Pond on Acklins Island (22°12′30″N, 74°13′14″W), the next encounter occurred on 16 January 2019 in an unnamed pond on the island of Eleuthera (24°43′59″N, 76°12′17″W), and the final encounter occurred on 12 June 2019 in Clear Pond on the island of San Salvador (23°58′13″N, 74°32′53″W). We did not attempt hand-capture of these animals and so we do not have precise measurement data. Visual estimations, however, suggested that the turtles were all over 50-cm curved carapace length (CCL), and considering that hawksbill turtles reach sexual maturity around 78 cm CCL (Snover et al. 2013), were either subadults or adults. The ponds varied in size with Flamingo Pond, the unnamed pond on Eleuthera, and Clear Pond having approximate diameters of 200, 50, and 1000 m, respectively. The ponds all hosted substantial macro-algae communities, and an abundance of live sponge was observed lining the walls of the subterranean conduit feeding Clear Pond.

None of the 3 ponds had surface connection to the ocean; however, each pond had a visible underwater cave entrance suggesting subterranean connections with the sea. Salinity tests supported these marine connections as each pond had salinity comparable to that of seawater ($>$ 33 practical salinity units). Owing to the readily eroded calcium carbonate substrate that constitutes most of the islands of the Bahamian archipelago, such conduit-fed anchialine ponds are a common geological feature in the region (Mylroie et al. 1995; Cole 2020). As we do not know of any maps of the subterranean conduits for the ponds where the hawksbill turtles were encountered, we estimated the minimum length of these subterranean cave systems by measuring the shortest straight-line distance between the pond and the ocean using GoogleEarth (Fig. 2). The shortest distances were 1.51, 0.19, and 0.07 km for the unnamed pond in Eleuthera, Flamingo Pond, and Clear Pond, respectively.

One potential explanation for the presence of hawksbill turtles in these anchialine ponds is that they were placed there by humans. In support of this hypothesis, there are confirmed reports of people stocking inland ponds or lakes with wild-caught sea turtles at several locations in The Bahamas (N.J.R., *pers. obs.*). There has also been a resurgence in the trafficking of hawksbill turtle shells throughout the Caribbean in recent years (Miller et al. 2019). Nevertheless, 2 factors argue against the idea. First, hawksbill turtles are traditionally harvested for their shells instead of their meat (Fleming 2001). Considering that hawksbill turtles with a CCL over 50 cm grow only a few centimeters per year (Diez and van Dam 2002), it would make little sense to maintain live hawksbill turtles in captivity when the carapace could be immediately harvested and stored. Second, if the turtles were being harvested for their meat, it is more likely that people would focus their efforts on capturing green turtles *Chelonia mydas* given their far greater abundance in the shallow coastal waters of The Bahamas (Bjorndal and Bolton 1988, 2010).

An alternative hypothesis to explain the appearance of hawksbill turtles in these ponds is that the turtles were swept into these habitats during the extreme tidal surges associated with hurricane events. While hurricanes are

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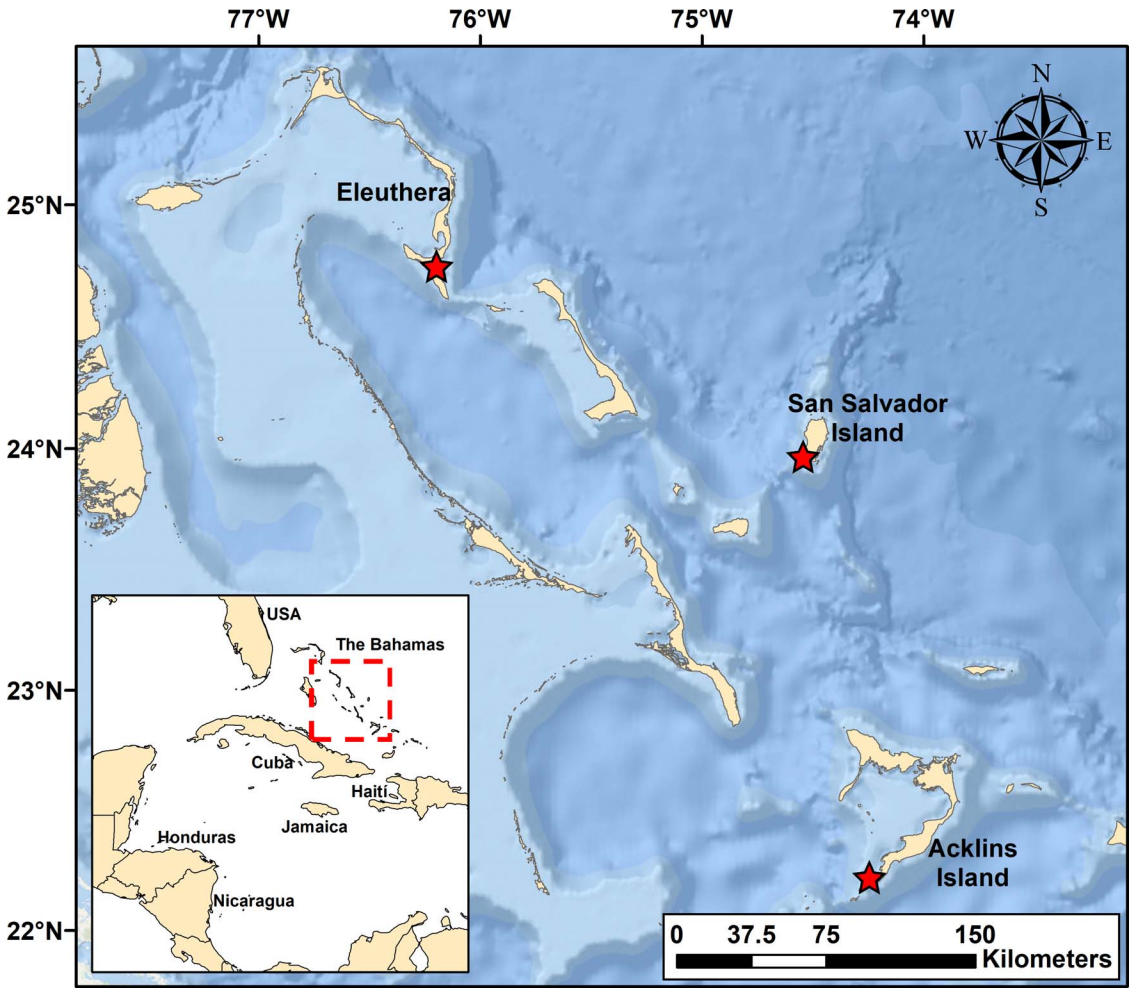

Figure 1. Map of The Bahamas including red stars to indicate the location of the 3 anchialine ponds (Flamingo Pond on Acklins Island, an unnamed pond on Eleuthera, and Clear Pond on San Salvador) where we discovered hawksbill turtles. The map inset shows the location of the larger map (red dashed box) from the perspective of the wider Caribbean region. (Color version is available online.)

relatively common in The Bahamas, and becoming more so (Winkler et al. 2020), it seems unlikely that a hurricane could transport a turtle over 1.51 km of heavily forested land as would have been the case on Eleuthera. Furthermore, hawksbill turtles are generally found in rocky offshore reef environments (Reisser et al. 2013), while green turtles are more common in shallower close-coastal habitats (Robinson et al. 2020). Thus, if turtles were being swept into these ponds during hurricanes, you would again expect to see more green turtles than hawksbills.

One other possible explanation is that hawksbill turtles crawled overland from the shore. There are anecdotal reports worldwide of nesting turtles emerging from the ocean and accidentally entering freshwater ponds or lakes. That said, there is only sporadic nesting of hawksbill turtles in The Bahamas (Meylan 1999) and most of the individuals we observed were likely subadults based on their size, and not yet ready to conduct nesting behaviors. For these reasons, we argue that one must consider the possibility that hawksbill turtles entered the anchialine pond systems under their own agency via the subterranean conduits connecting them to the sea.

Hawksbill turtles can dive for over 2 hrs between breaths (Hill et al. 2017). Thus, it would only require a swimming speed of 0.75 km/hr to cross 1.51 km, the longest minimum distance observed in this study between an anchialine pond and the ocean. This is well within the hawksbill's normal swimming velocity, demonstrating that hawksbill turtles would be physiologically capable of traversing this distance on a single breath. While turtles would have to negotiate these channels in complete darkness, their passage would be facilitated by the strong tidal currents associated with the cave systems feeding the anchialine ponds (Martin et al. 2012). If turtles are entering these anchialine ponds via subterranean conduits, this could also explain why hawksbill turtles appear more prevalent in these systems than green turtles. This is because the marine connections to these subterranean conduits are typically found in karst outcrops (Mylroie et al. 1995) that are more commonly utilized by hawksbills turtles (Reisser et al. 2013) than green turtles (Robinson et al. 2020).

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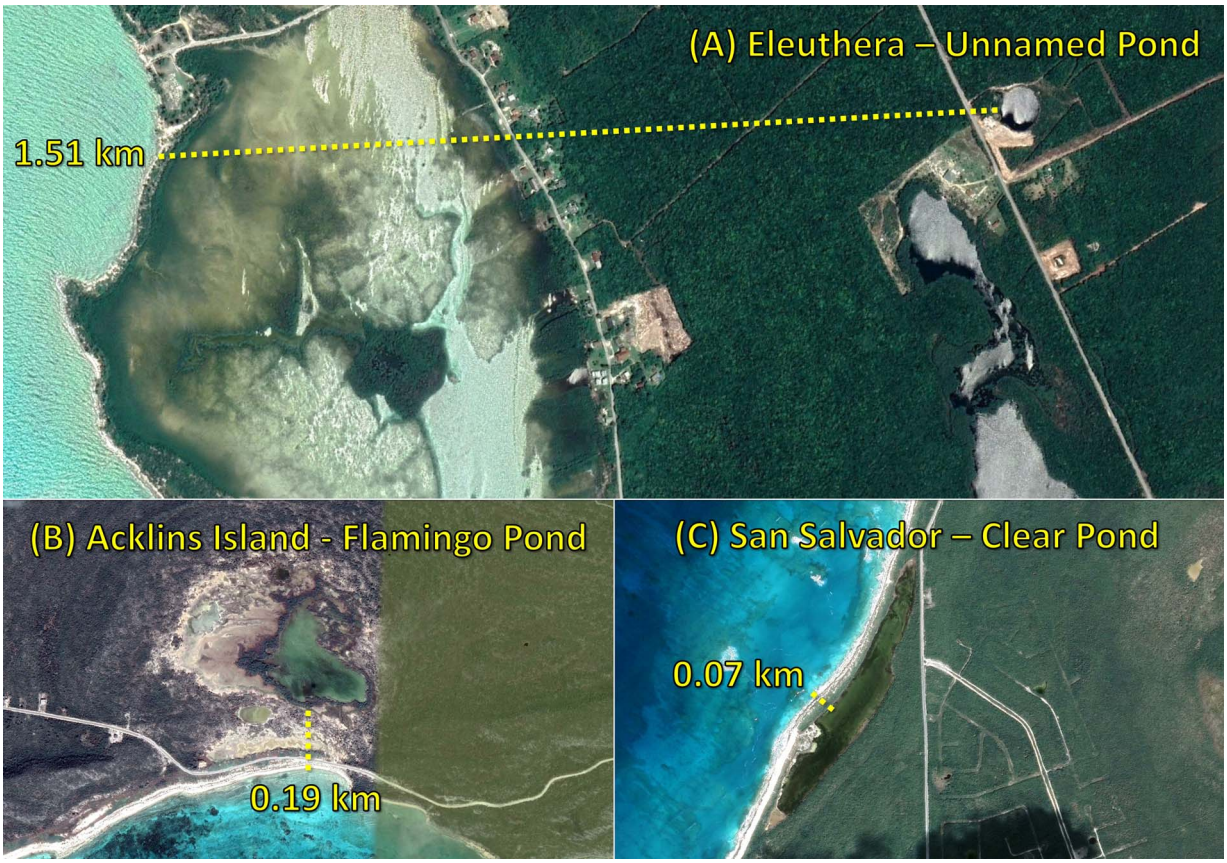

Figure 2. Close-up maps of (A) an unnamed pond on Eleuthera, (B) Flamingo Pond on Acklins Island, and (C) Clear Pond on San Salvador indicating the shortest straight-line distance (dotted yellow line) between each pond and the ocean. (Color version is available online.)

If hawksbill turtles are naturally entering anchialine pond systems, the next question is whether these animals can also leave these habitats. If not, anchialine ponds may function as ecological traps for this critically endangered species. Nevertheless, it should be noted that no skeletal remains or carapaces were observed at any of these locations. Alternatively, hawksbill turtles may actively seek such environments as valuable foraging areas that are largely free from large predators. Indeed, none of the turtles observed in this study exhibited any visible signs of malnutrition. Answering the question of whether anchialine ponds serve as beneficial foraging areas and refugia from predators or ecological traps will require long-term observations of the behavior, health, and movements of turtles from these ponds.

Acknowledgments. — We thank the Cape Eleuthera Institute for providing essential support. Travel funding for R.D. was provided by Florida International University. St. Olaf College provided travel support for E.S.C.

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Received: 24 March 2021
Revised and Accepted: 9 July 2021
Published Online: 29 October 2021
Handling Editor: Jeffrey A. Seminoff

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