

Post breeding migratory tracks of three species of marine turtles from Bonaire and Klein Bonaire, Dutch Caribbean

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Figure 1. Female hawksbill 'Nautla', the first turtle tracked from the nesting beach at Klein Bonaire in 2003.

Of the four species of marine turtles commonly observed breeding in the Caribbean, three species, the loggerhead (*Caretta caretta*), the green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*), regularly nest on the beaches of Bonaire and Klein Bonaire, Dutch Caribbean.

Whereas juvenile green and hawksbill turtles can be observed year-round in the neritic waters surrounding Bonaire and Klein Bonaire, adult marine turtles are only rarely seen outside of the breeding season, which combined for the three species lasts from May to December. In-water surveys of marine turtles conducted in all potential foraging habitats around the islands indicate that adult marine turtles are seasonal visitors and do not reside permanently in the islands' waters.

We used satellite telemetry starting in 2003 to address the question of where the foraging grounds are located of the turtles breeding at Bonaire and Klein Bonaire. Our principal objectives were to identify the migratory pathways and the foraging ground locations of post-reproductive marine turtles, in order to deepen our understanding of the potential threats facing these animals.

MATERIALS AND METHODS

This study was carried out during the period 2003-2010 at the marine turtle breeding areas of Bonaire and Klein Bonaire, Dutch Caribbean. Breeding turtles were encountered and held for tagging, measurement and transmitter application on the nesting beaches (females, after oviposition) or in the waters immediately adjacent to the beaches (males). All animals participating in this study were double-tagged on the front flippers and measured (straight or curved carapace length taken from the nuchal notch to the posteriormost marginal scute tip). Turtles were kept on the beach in a custom-built box or at sea were constrained in a small boat. Transmitters used were models ST-20 (Telonics, Mesa AZ, USA), Spot4 and Spot5 (Wildlife Computers, Redmond WA, USA). Prior to transmitter attachment, turtles' carapaces were cleaned by removing interfering external commensals such as algae and barnacles. Transmitters were applied to the highest point on the carapace using a silicone or latex elastomer base and covered with resined fiberglass. A fiberglass reinforcement strip was placed anterior to the antenna attachment point to help limit abrasion damage to the transmitter's antenna. A slapping piece of fiberglass was placed before the flat frontal area of the ST-20 transmitters to reduce the devices' hydrodynamic drag. Turtles were released at the location of capture (recorded by GPS receiver) after the 2-4 h transmitter application procedure. Whenever possible, study animals were recaptured in subsequent years and had their transmitters removed. See Table 1 for transmitter deployment and recovery details.

Location data for instrumented turtles was received through Service Argos. The online Satellite Tracking and Analysis Tool was used for creating base maps and data parsing for the 2004-2010 deployments. Final maps were produced with MapInfo 10.0 software. Turtle migration was measured primarily by examining coordinates with Argos location classes (LC 0, 1, 2, and 3). Further detail was then obtained by selectively adding data points with LC's A and B, ensuring that these less precise locations did not imply unrealistic swim speeds (i.e. >5 km/hr; Lutcchi et al. 1998). Navigational efficiency was calculated for each migration path as the quotient of the shortest possible in-water distance between start and end points and the turtle's actual distance traveled as measured by telemetry.

RESULTS

Loggerhead turtles. Four female loggerhead turtles were fitted with transmitters and tracked during 2004-2008 from the breeding grounds at Klein Bonaire. Turtles departed 1-27 d after transmitter application, then took 14-27 d to reach their foraging grounds 547-1529 km from Bonaire (Table 1). Loggerheads were tracked to offshore banks near Honduras ('Extra') and Nicaragua ('Wiske'), and areas close to the islands of Vieques, Puerto Rico ('Happy') and Margarita, Venezuela ('Greggy Girl' (Fig. 2). Part of the foraging habitat used by 'Happy' off the west coast of Vieques Island was examined in September 2005 and was found to consist at 5-12 m depth of mixed-composition seagrass beds (dominated by *Thalassia testudinum* and *Syringodium filiforme*) interspersed with a variety of macroalgae and fairly abundant queen conch (*Strombus gigas*).

Green turtles. Three female green turtles were tracked from nesting beaches on Bonaire, 'Stinapa' in 2004 and 'Carice' in 2010 both from Playa Chikitu on the northeast coast, and 'Darwina' in 2007 from an unnamed beach along the southwest coast (Table 1). 'Stinapa' was intercepted on her estimated fifth nesting of the season and departed Bonaire immediately after transmitter application. 'Carice' laid one more nest at Playa Chikitu before departing. 'Darwina' was encountered during her second nesting and after transmitter application returned to nest another four times on beaches within a range of 2 km. 'Stinapa' and 'Darwina' departed towards the northwest, whereas 'Carice' headed eastwards. 'Stinapa' and 'Carice' were tracked to foraging grounds near Nicaragua and Los Roques Archipelago (Venezuela), respectively (Fig. 3). Transmitter signals were lost for 'Darwina' before locations stabilized, indicating that she may have not yet reached her foraging grounds at her last measured location.

Turtle	Species	Sex	Date	Location	Distance (km)	Duration (d)	Notes
Extra	Loggerhead	Female	2004	Honduras	547	14	
Wiske	Loggerhead	Female	2004	Nicaragua	1529	27	
Happy	Loggerhead	Female	2004	Vieques, Puerto Rico	1000	14	
Greggy Girl	Loggerhead	Female	2004	Margarita, Venezuela	1000	14	
Stinapa	Green	Female	2004	Nicaragua	1000	14	
Carice	Green	Female	2010	Los Roques Archipelago, Venezuela	1000	14	
Darwina	Green	Female	2007	Los Roques Archipelago, Venezuela	1000	14	Signals lost before reaching foraging grounds
Schillie	Hawksbill	Female	2005	Monito Island, Puerto Rico	1000	14	

Table 1. Deployment data and results for transmitters placed on three species of marine turtles at Bonaire and Klein Bonaire.



Figure 2. Postbreeding tracks and foraging ground destinations of four female loggerhead turtles departing from Klein Bonaire.



Figure 3. Postbreeding tracks of three female green turtles departing from Bonaire. Signals were lost for turtle 'Darwina' before she reached her foraging grounds.



Figure 4. Postbreeding tracks and foraging ground destinations of thirteen hawksbill turtles departing from Klein Bonaire. Signals were lost for turtle 'Tom' before he reached his foraging grounds.



Figure 5. Female hawksbill 'Schillie' upon release at Klein Bonaire in 2010 (left) and subsequent recapture on her foraging grounds at Monito Island, Puerto Rico, in 2005 (right).

Hawksbill turtles. Two male and 11 female hawksbill turtles were tracked in the period 2003 to 2010 from the breeding grounds of Klein Bonaire (Table 1). Males 'Tom' and 'Albert' remained for 93 and 151 days near (< 3 km) their capture locations before departure, then were tracked for 14 and 24 d, respectively, before signals were lost. The females departed the breeding grounds 1-50 d after transmitter attachment, traveling for 10-120 until reaching their foraging grounds. Hawksbills were tracked to destinations 193-1416 km (mean 933 km) away from Klein Bonaire (Fig. 4). Five of the 11 hawksbill turtles were tracked to the vicinity of the Serranilla Bank, an extensive offshore area between Honduras and Jamaica, and established themselves on foraging grounds with separation <150 km.

Female hawksbill 'Tina' departed Klein Bonaire towards the south on 17 September 2009, then began swimming erratically, swimming in large loops around and north of the Los Roques and Orchilla Islands, Venezuela (Fig. 4). This turtle traveled for 120 d before reaching her foraging grounds off the west side of the Paraguaná Peninsula, Venezuela.

Female 'Schillie' was tracked to waters between Mona and Monito Islands, Puerto Rico, where she arrived early January 2004. On 12 August 2005 she was seen and captured during in-water turtle surveys at Monito Island and had her now antenna-less transmitter removed (Fig. 5). Adult hawksbill foraging habitat at Monito Island consists at 15-40m depth of a hard bottom seafloor interspersed with sand patches and limestone boulders, with the favored prey sponge *Geodia neptuni* highly abundant.



Figure 6. Female green turtle 'Carice' released in 2010 at Playa Chikitu, Bonaire.

DISCUSSION & CONCLUSIONS

The migratory paths obtained in this study reveal the wide geographic range of all the three marine turtle species breeding at Bonaire and Klein Bonaire. None of the 20 tracked turtles remained in the nearshore waters around Bonaire and Klein Bonaire beyond the breeding season. Turtles moved 192-2930 km to reach foraging areas encompassing multiple jurisdictions and therefore highlighting the need for concerted international efforts in the management and conservation of marine turtle stocks.



Figure 7. Female loggerhead 'Extra' released at Klein Bonaire in 2004.

The long distances traversed by turtles leaving the breeding area on small, isolated islands and foraging grounds have been documented in several other studies as well. Green turtles, for example, swam on average 1968 km from Ascension Island, and 1073 km was reported for Hawaii green turtles. Similarly, hawksbills in the Caribbean traveled 500 km from Barbados, and females 867 km from Mona Island. For the turtles studied, no single migratory destination or obvious pathways or migratory corridors can be discerned from the tracks. Such behavior is consistent with most other tracking studies with the three species, with the exception of the Ascension Island rookery, where green turtles depart only westwards towards Brazil.

Areas of particular importance to marine turtles breeding on Bonaire are located off Nicaragua and Honduras (n=8 turtles), Venezuela (n=4) and Puerto Rico (n=2). Eight out of the 20 turtles (40%) tracked from Bonaire and Klein Bonaire forage in the area comprised by extensive shallow-water banks that lie between the coasts of Honduras, Nicaragua and Jamaica, and include areas such as the Rosalind Bank, Serranilla Bank, Quita Sueño Bank, Thunder Knoll, and Isla San Andres to the south. Many adult loggerhead, green, and hawksbill turtles have also been tracked to this area from Puerto Rico, the Cayman Islands, and Costa Rica. Clearly, this relatively remote foraging area is of prime importance for marine turtle populations breeding throughout the Caribbean region.

Marine turtles are charismatic species and some of the largest vertebrate animals in the waters surrounding Bonaire and Klein Bonaire. Community interest in this satellite tracking study has been substantial and has provided numerous and continuing opportunities for enhancing local awareness of marine turtle biology and relevant conservation issues. School curricula, for example incorporated extensive information on marine turtles during a campaign based on the tracking effort with the first two hawksbill turtles in 2003-2004. Whereas satellite tracking of marine turtles can appear costly, it is a highly effective and cost-efficient method for expanding our understanding of marine turtle behavior while providing great opportunities for sharing the knowledge gained with the public in order to increase awareness of important conservation issues.

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