SnapperGPS: Deployment of a low-cost snapshot GNSS receiver to track loggerhead sea turtles

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Location tracking is a valuable tool for ecologists. Typically, this is done using global navigation satellite systems (GNSS), like the GPS. However, GNSS signals do not travel underwater. This makes tracking marine animals like sea turtles challenging because they only surface for brief intervals, sometimes as short as one second.

Traditional GNSS receivers need to regularly be at the surface for at least 30 consecutive seconds to decode satellite orbit data from satellite signals. Assisted GNSS can reduce this time, but typically still requires several seconds to decode transmission timestamps. In contrast, snapshot GNSS is an approach that does not decode any satellite data and only needs to receive a few milliseconds of the signal to resolve a position fix. However, the few existing commercial snapshot GNSS systems for wildlife tracking are expensive. Furthermore, they are not always as accurate or reliable as traditional GNSS receivers.

Here we present the first deployment of SnapperGPS, a small, low-cost, low-power snapshot GNSS receiver. Jonas Beuchert, Amanda Matthes, and

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Alex Rogers developed SnapperGPS at the University of Oxford. The device captures low-resolution twelve-millisecond satellite signals snapshots whenever the turtle surfaces. The tag stores the snapshots until it is recovered from the turtle. Finally, the data is uploaded to the cloud via our public web application (`https://snapper-gps.herokuapp.com`) where we employ novel probabilistic signal processing algorithms to calculate the track of the turtle. All signal processing algorithms are open-source. The current receiver version has a component cost of under $30 (excluding enclosure) and can run for several years on two small LR44 coin cell batteries. SnapperGPS uses multiple GNSS constellations and our algorithms robustly provide median localisation accuracies around 10 m.

In summer 2021, we deployed SnapperGPS on nesting loggerhead sea turtles (Caretta caretta) on the island of Maio, Cape Verde. We tagged 20 nesting females on the beach and recovered nine of the tags two weeks later when the individuals returned. Due to an issue with the surfacing detection mechanism some tracks were not captured or incomplete. However, this problem is unrelated to the snapshot GNSS technique. The three successful tracks demonstrate that the snapshot positioning worked reliably, providing a position fix whenever the receiver collected data at the surface. The recorded tracks revealed diverse behaviour among the population, with some individuals travelling around the island and others staying close to their nesting beach. We deployed SnapperGPS alongside Arribada Horizon v4.1 assisted GPS tags that utilise preloaded satellite data downloaded from the uBlox Thingstream service to speed up the time-to-first-fix. We deployed both tag types on the same population during the same nesting season. SnapperGPS was able to compute positions from significantly shorter signal captures than assisted GPS (milliseconds instead of seconds), whilst being more affordable to manufacture and more energy-efficient.

Currently, we are working on making the SnapperGPS hardware open-source and available to other researchers.

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