RESEARCH SUMMARY

SEA TURTLE MOVEMENTS IN THE ARABIAN REGION

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Issues 28 and 29 of the Indian Ocean Turtle Newsletter published in 2018 and 2019 respectively did an outstanding job of highlighting sea turtle satellite tracking efforts in the Indian Ocean and Southeast Asian region. In addition to the tracks described in the special issues of IOTN are 15 tracks of post-nesting turtles in Pakistan (Khan, 2013); 11 from Qatar, two from Oman and two from the United Arab Emirates (UAE; Pilcher *et al*., 2014); 14 from Qatar (Marshall *et al*., 2020) and 30 from Saudi Arabia (Maneja *et al*., 2018). Combined, these studies have identified habitat connectivity and linked nesting areas with foraging areas, expanding our understanding of sea turtle movements and opening up conservation opportunities. With few exceptions however, sea turtle tracking efforts have focused on nesting female turtles (908 out of 994 or 91% of tracks described in IOTN28 and IOTN29). The exceptions were four rehabilitated turtles tracked in Kuwait (Rees *et al*. 2018), and 15 rehabilitated and 67 non-nesting deployments on turtles in Australia (Waayers *et al*., 2019). More recently, Robinson *et al*. (2021) reported on movements of 26 rehabilitated turtles tracked from the United Arab Emirates. Overall, Indian Ocean region picture points to a dearth of information on movements of turtles in foraging habitats. As highlighted also by Phillott & Rees (2019), key gaps in knowledge on movements of male turtles, juvenile turtles, and non-breeding (foraging) turtles remain.

To partially address this knowledge gap, a recent project conducted between 2016 and 2019 tracked 44 adult green turtles (13 male and 32 female) and one female sub-adult turtle from two UAE foraging areas (Pilcher *et al*., 2021) in an attempt to identify linkages from known foraging areas to unknown nesting areas (in reverse of the tracking norm). This is not quite as easy as it sounds! Simply affixing a satellite transmitter on any foraging turtle would not work, as there would be no guarantee that the turtle would depart on a nesting migration within the transmitter battery lifespan. Also, the selected turtle might not be a mature adult, or might be a mature adult but not in reproductive state. Other considerations include the complex at-sea capture of the turtles, timing of captures (close enough to the onset of the nesting season but not so far away as be limited by battery life once the turtles depart, while also taking into consideration a nesting migration of unknown duration), along with the potential for tag loss during courtship and mating. The solution to a few of these challenges lay in combining in-water captures from boat and jet-ski, the use of laparoscopy (a form of keyhole surgery) to determine turtle sex, age class, and reproductive status, and an immense amount of luck. I say luck because simply identifying that a turtle was in reproductive state did not provide information on *when* he or she might depart on a nesting migration.

In this landmark study (Pilcher *et al*., 2021), laparoscopy identified which turtles were in reproductive state (44 out of 233 captures), and enabled tracking of not only female turtles, but also 13 adult males. The project documented that the primary destination of foraging turtles from the UAE was the Ras Al Hadd nesting site in Oman, with nine turtles (eight females and one male) undertaking breeding migrations linking the UAE and Oman. The project also managed to track three turtles in complete round-trip events, from foraging areas to nesting areas, and all the way back (Pilcher *et al*., 2020). These round-trip reproduction migrations lasted from 175 to 354 days. Highlighting the complexity of tracking these types of movements, the time spent at the foraging grounds before departing ranged from seven to 119 days (as noted above, laparoscopy does not indicate when the turtles will depart). The average swim distance to and from Ras Al Hadd in Oman from Bu Tinah in the UAE was around 2,700km, with time at the nesting site ranging from 91 to 117 days, indicating the turtles deposited between four and seven clutches of eggs.

Some other new and interesting satellite telemetry work has been documenting the extent and use of inter-nesting habitat for 30 green turtles to identify factors driving habitat use at two major rookeries (Shimada *et al*., 2021). This work was aimed at understanding the in-water habitat use by green turtles in light of several mega-developments that are taking place along the northeast Red Sea coastline of Saudi Arabia. The study found that green turtle nesting success was slightly below 70% (that is, the rate of beach emergences that resulted in successful nests), and that the turtles displayed high fidelity to nesting beaches (mean distance between successive nesting attempts was only 150m) and also to the adjacent in-water habitats between successive nesting events (the center of these habitats lay between <1 and 64km from the nesting sites). Shimada *et al*. (2021) also found that renesting intervals were somewhat influenced by ambient water temperature, with longer intervals at lower temperatures. This work has refined our understanding of beach emergence/nesting success, inter-nesting intervals, and how temperature can impact both of these factors, potentially of concern given rising global temperatures.

Rees *et al*. (2021) also recently reported on inter-nesting habitats and intervals, and particularly diving behaviour, among olive ridley turtles in Oman. Tracking two turtles with satellite transmitters equipped with dive sensors and data loggers, Rees *et al*. (2021) found that olive ridleys performed fewer and deeper dives per day while away in the inter-nesting habitat (that were some 50-75km distant from the nesting area), and that the frequency of dives per day increased, and the average dive depth decreased, when the turtles returned to nest. They suggest that this behaviour accounts for turtles surfacing more frequently to look for a suitable site to emerge and nest over one to several days, which interestingly was also recorded in Australia by Hamel *et al*. (2008).

Marshall *et al*. (2020) also recently investigated sea turtle movements, but with a focus on environmental drivers of habitat use in hawksbills in the Arabian Gulf. Many of their findings mirrored those by Pilcher *et al*. (2014) but new aspects of their work revealed that hawksbills spent substantial time in waters 30 to 50m deep and, much as was found by Shimada *et al*. (2021) for inter-nesting turtles, and they also detected strong site fidelity to foraging areas after turtles returned form summer looping migrations into deeper, cooler waters. Their study found that hawksbills generally did not occupy waters with a sea surface temperature (SST) > 32^{o}C, and that water depth was the greatest driver of habitat selection, likely due to cooler temperatures at depth, with movements to deep-water habitats driven by a weakening of wind stress coupled with seasonally high chlorophyll levels.

While these studies are localised and relatively small compared to the massive number of post-nesting migration tracks, they do start to address some of the information gaps identified by Phillott & Rees back in 2019. Additional in-water studies on sea turtles that can combine laparoscopy, genetics, and satellite tracking are needed, as well as the use of stable isotopes (Seminoff & Phillott, 2020), as these can reveal more about reproductive migrations compared to open-ended tracks, providing insights into total migratory movements (and therein an indication of energy expenditure), fidelity to foraging areas, clutch frequency, as well as illustrating other behavioural traits.

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