This report is published in partnership with MRF

GREEN TURTLE CONSERVATION PROJECT

FINAL SCIENTIFIC REPORT ARABIAN REGION

Published in December 2019 by Emirates Nature in Association with WWF (Emirates Nature-WWF), Abu Dhabi, United Arab Emirates

For more information please visit: www.emiratesnaturewwf.ae:

Email: emiratesnature@enwwf.ae

Pilcher NJ, C.J Rodriguez-Zarate, M Antonopoulou. 2019. Green Turtle Conservation Project 2016-2019: Final Scientific Report. Emirates Nature-WWF. Abu Dhabi, United Arab Emirates. 78 pp.

ABOUT EMIRATES NATURE-WWF

Emirates Nature-WWF is a UAE environmental non-governmental organisation, established in 2001 under the patronage of H.H. Sheikh Hamdan bin Zayed Al Nahyan, Ruler's representative in Al Dhafra Region and Chairman of Environment Agency - Abu Dhabi (EAD).

For almost two decades, Emirates Nature–WWF has been a prominent and active partner in environmental conservation in the region. Being part of the global WWF network, which has a 50-year legacy, Emirates Nature-WWF has implemented several conservation and education projects in the region since 2001. Emirates Nature-WWF works federally and in the region with offices in Abu Dhabi, Dubai and Fujairah and is governed by a local board of directors.

ABOUT THE MARINE RESEARCH FOUNDATION (MRF)

The Marine Research Foundation is non-profit research foundation based in Kota Kinabalu, Malaysia and is incorporated under the Malaysian Trustees Act of 1951. Established to further the understanding of marine ecosystems and their associated diverse flora and fauna in Southeast Asia and other Indo-Pacific sites, the Foundation carries out a number of projects related to biodiversity assessment and conservation and seeks to provide management-oriented solutions to Government administrations and conservationists.

EWS-WWF DISCLAIMER

The designation of geographical entities in this report, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of Emirates Nature-WWF concerning the legal status of any country, territory, or area, or of its authorities or concerning the delimitation of its frontiers or boundaries.

PROJECT PARTNERS

UNITED ARAB EMIRATES MINISTRY OF CLIMATE CHANGE & ENVIRONMENT

Environment Agency - ABU DHABI

Environment Protection & Development Authority

Five Oceans L.L.C.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

© VBK Photography / Emirates Nature-WWF

EXECUTIVE SUMMARY

INTRODUCTION

The Green Turtle Conservation Project (GTCP, or Green Turtle Project) is a project implemented by Emirates Nature – WWF in partnership with government agencies, NGOs and the private sector in the United Arab Emirates, and to a lesser extent in Oman. Project partners included the Ministry of Climate Change and Environment, the Environment Agency Abu Dhabi, the Environment Protection and Development Authority of Ras Al Khaimah, and the Environment and Protected Areas Authority of Sharjah. In Oman the project collaborated with the Ministry of Environment and Climate Affairs, the Environment Society of Oman and Five Oceans LLC. The Marine Research Foundation provided scientific advice and research expertise to the project.

Sea turtles play valuable ecological roles in marine ecosystems. They function as key species in marine habitats and are indicator species of the relative health of various ecosystems. Turtles also have non-consumptive values such as tourism, education and research. But being long-lived and of late maturation, sea turtles face a multitude of threats over long periods of time. Threats to marine turtles come from a wide array of sources, be they routine biological threats (predation, disease, loss of habitat) and unexpected natural threats (storm damage, erosion, etc.) and anthropogenic including habitat loss, accidental capture in fisheries, collection of eggs, pollution, lighting, ghost fishing, and climate change.

Following long-term global declines in population numbers, green turtles are globally classified as Endangered by the International Union for the Conservation of Nature (IUCN). At a regional level, the North Indian Ocean green turtle subpopulation is listed as Vulnerable. At a National level, the Red List status of green turtles is also Vulnerable, based on fewer than 10,000 mature individuals, a projected future continuing decline in mature individuals, and four primary threats: ingestion of marine debris, boat strikes, entanglement, and habitat loss.

While substantial information is available for nesting green turtles, in the Gulf region there is a lack of data on green turtle habitat connectivity that impairs management and conservation, and limited knowledge on the links at National and Regional levels with respect to sea turtle biology and life cycles – and in turn conservation opportunities. The Green Turtle Project was designed to inform management and conservation strategists, whereby the tracking information delivered by satellite transmitters deployed on green sea turtles provides information on nesting sites, foraging areas, and migration routes. These data highlight regional linkages between countries in which the turtles reside and nest and help identify additional Important Turtle Areas (ITAs) for green sea turtles in the Arabian Gulf.

METHODS

Between 2016 and 2019 the project tracked 51 green sea turtles using satellite transmitters to identify linkages between feeding grounds and nesting sites, along with migration routes and behavioural adaptations. The project deployed 45 transmitters from Bu Tinah, ~80km of the coast of Abu Dhabi, and off the Saraya sandbank south of Ras Al Khaimah, both in the United Arab Emirates. Six additional transmitters were deployed in Oman in 2016.

In Oman the project tracked post-nesting turtles from nesting beaches to foraging grounds. In the UAE the turtles were tracked in reverse, from their feeding grounds to their nesting sites. In Abu Dhabi the team caught the turtles in shallow water areas using a rodeo style technique. In Ras Al Khaimah the project worked with fishermen who use coastal seine nets to fish, collecting turtles as the nets were brought ashore. In order to select adults in breeding condition at these two foraging sites, a small surgical laparoscopic procedure was used to determine the sex and also the age class of the turtles, and importantly if they were in breeding condition. Once the sex and reproductive condition were determined, and the turtles selected for tracking, satellite transmitters were affixed to the carapace using epoxy adhesives.

Data were processed via the Argos system, and downloaded on a regular basis throughout the research period. All location fix data was filtered to exclude locations over land, and then further filtered for high quality location fixes with a speed of ≤ 10 km/h between fixes. To eliminate behavioural bias amongst migratory turtles, two fixes per turtle per day were selected: the highest quality fix close to midday, and the highest quality fix close to midnight. Location fixes were split into three categories (States) depending on turtle activity: for turtles deployed in Oman, all fixes prior to the departure point from the nesting site were categorised as internesting (the period post-deployment until departure from the nesting site. For turtles in the UAE, all points prior to departure were considered as foraging habitat. Subsequent location fixes until the commencement of foraging (in the case of Oman's turtles) or nesting (in the case of UAE turtles) were categorised as migration fixes (direct purposeful travel from the nesting site with minimal deviation from a straight path). After this, foraging or nesting activity was inferred by a reduction in travel rates and a shift from purposeful migration direction and unidirectional orientation to short distance movements with random heading changes.

The project employed a Kernel Density Analysis process within a Geographical Information System to determine the extent of key foraging grounds used by turtles, or Important Turtle Areas (ITAs).

RESULTS

Transmitter signal life ranged from 14 to 647 days and the project was able to reliably use 27,754 data points filtered from a total of 35,402 location fixes received, over a total of 6,939 tracking days between 2016 and 2019. In Oman all turtles were adults, and the project targeted larger turtles on the foraging grounds as the objective was to track adults in breeding condition, and thus the age class structure for turtles encountered by the project is biased toward the larger size classes. Including the six Oman nesting turtles, the project sampled 131 adult female turtles and 47 adult male turtles, of which 11 males (23% of adult males) and 36 females (27% of adult females) were found to be in breeding condition. These were tracked with satellite transmitters.

The migration data provide some of the most important results from this work. They reveal linkages between nesting sites and foraging areas, general routes taken by turtles, and use of important foraging habitats. Turtles from Oman all undertook purposeful movements towards foraging grounds after several additional nesting emergences. A number of turtles from Bu Tinah and Ras Al Khaimah did not move far from the deployment points, due to loss of signals before the turtle undertook any migration (either through transmitter failure or simply that the turtles did not move). There were long distance (>1,000km) movements by two turtles from Oman, and one long distance (~2,500 km) foraging-nesting-foraging loop by a turtle from Bu Tinah, but in general the movements were of 100s of km rather than 1,000s of km.

The two long distance movements by turtles from Oman involved one turtle moving eastward to the Gulf of Kutch in India and the second moving southwest along the Yemen coast, entering the Red Sea, and taking up residence in the Dahlak archipelago off Eritrea. Both of these locations are known foraging grounds for green sea turtles. A third foraging destination was the United Arab Emirates, with two turtles moving into the Arabian Gulf, one of these settling off the coast west of Abu Dhabi and the second settling on the known foraging grounds off Ras Al Khaimah. These movements confirm linkages between nesting grounds in Oman and foraging grounds in the United Arab Emirates that should be considered in conservation and management planning. One turtle from Ras Al Khaimah moved southwest towards Abu Dhabi and then back to Ras Al Khaimah, and given this turtle was deemed to be in breeding condition, this behaviour suggests that adult turtles can use more than one foraging ground.

The project also recorded four movements from Bu Tinah to the northeast up into the Gulf that looped back to Bu Tinah, although neither of the turtles appeared to stop at any point – suggesting a lack of feeding or courtship or foraging behaviour. At present it remains unclear why the turtles are behaving in this manner. One of the Bu Tinah male turtles migrated to an area in the vicinity of the Daymaniyat islands in Oman and spent a substantial amount of time there, suggesting this might be a courtship area for turtles that subsequently nest on mainland beaches. Given however that the Daymaniyat islands host sporadic green turtle nesting, and there is the small possibility that this male was part of the Daymaniyat breeding turtles. One additional male turtle from Bu Tinah headed north to the Straits of Hormuz before signals were lost, and it is possible this turtle may have also been headed for Oman or to a courtship area off Musandam. The project also recorded the movements of another male turtle that spent a considerable time off the coast of Dubai. Due to the fact he was in breeding condition, it is possible that this is also a courtship area.

Among the most notable findings, six female turtles from Bu Tinah undertook extensive migrations to nest at Ras Al Hadd in Oman, with three of these sending signals until they returned to Bu Tinah five to six months later. These are some of the first tracks of their kinds amongst the scientific community, having been purposefully captured, inspected for

DEPLOYED
51
TRANSMITTERS

35,402
LOCATION POINTS WERE RECEIVED

MAXIMUM MIGRATION DISTANCE
2,167 KM

breeding condition and tracked with a view to documenting round-trip behaviour. In two of the cases the migrations were relatively straightforward, with turtles travelling up the UAE coast, moving to the Iran coast as they rounded the Straits of Hormuz, and moving south along the Iranian coastline before crossing the Gulf Oman on a southerly heading until reaching the Omani coast until reaching nesting grounds in the vicinity of Ras Al Hadd. The third turtle had a less direct route, turning east and tracking along the Iran and Pakistan shores, and south to the Gulf of Kutch in India. She then turned westwards and swam in a straight line towards the Oman nesting site, crossing waters in excess of 5000m deep, before eventually reaching Ras Al Hadd. At the completion of nesting the turtles followed the Omani coast into the Arabian Gulf and swam nearly directly to Bu Tinah to complete the round-trip nesting migrations.

Several Bu Tinah turtles never left their foraging grounds, and the project also gathered data from the turtles deployed at Bu Tinah before they departed on nesting migrations. Between 2016 and 2019 a total of 31 turtles remained in the vicinity of Bu Tinah for periods ranging from 0 to 647 days, and a total of 5,156 location points were acquired during this time. These data indicate that turtles deployed with tags from Bu Tinah used the Marawah Marine Biosphere Reserve and also habitats outside of this area, primarily in waters <10m deep along the western sand northern sides of Abu Al Abyad, off Saadiyat island, and south of Bu Tinah.

A subset of 3,901 location fixes were from inside of the Marawah Marine Biosphere Reserve, representing approximately 76% of all locations for green turtles deployed from Bu Tinah, and a good coverage of important seagrass feeding grounds within the Marawah Marine Biosphere Reserve.

Similarly, at Ras Al Khaimah the project collected data on foraging green sea turtles, and these data will assist in further delineating Important Turtle Areas at this site. A total of 3,408 location points were received from all turtles in the vicinity of Ras Al Khaimah and the Saraya sandbak and at a location between Al Marjan Island in Ras Al Khaimah and Al Rafaah in Umm Al Quwain. The foraging ground data may also assist in enhancing the current mapped seagrass areas, as the turtles spent substantial portions of time in areas where seagrasses have yet to be mapped.

A lone male turtle tracked in 2019 (headed northwest towards Qatar after remaining on the foraging grounds for several months. This was the only record of a turtle deliberately heading northwest, possibly in an attempt to reach the Saudi Arabian nesting islands. However, he only reached the northern shores of Qatar before turning south, and it is believed that the turtle was somehow incapacitated based on the quality of the signals in the last week of transmissions.

No turtles tracked from Ras Al Khaimah undertook nesting migrations, but this is in part due to the fact that fewer of the turtles were found in breeding condition at this site. No turtles were tracked to any other nesting destination in the region. The preference of Oman as a nesting destination is closely related to nesting stock size: Oman hosts around 5000 nesters per year and Saudi Arabia hosts about 1000 nesters per year. The UAE has recorded only one nesting event in recent history, and Kuwait records four to ten nests a year, with similar or slightly higher numbers in Iran. Given this there is roughly an 80% chance that a green turtle comes from Omani stock, a 20% chance it comes from the Saudi stock, and very low chance that it would come from the UAE, Iran or Kuwait.

With the exception of the two loops in the Gulf and one turtle that crossed from Oman to Pakistan on her way to India (where water depth exceeded 3000m), all turtles tracked in 2016 stayed in shallow waters (generally less than 20m deep) indicating a preference for shallow coastal waters rather than deep oceanic passages.

DISCUSSION

After four years of work Emirates Nature – WWF, the Marine Research Foundation and the project partners have amassed the most robust data on migrations and linkages between feeding grounds and nesting grounds for sea turtles ever assimilated for the Gulf region. By tracking 51 green sea turtles between 2016 and 2019 the project gathered a wide range of information related to biology and ecology of green turtles in the Gulf region. These new findings support National and regional conservation and management activities, and provide added information related to the extent of foraging areas in Abu Dhabi and Ras Al Khaimah waters.

Sea turtles are mostly protected at their nesting beaches across the region, but less is done about protecting sea turtles at sea, where they spend the vast majority of their time. The delineation of the extent of the foraging grounds used by green turtles via this project are useful data sets that will allow the design of practical and targeted management and conservation action by the relevant government agencies in each Emirate that can further extend the level of protection afforded to sea turtles in the UAE.

Several key habitats that are currently not protected or managed were revealed through this study (the Gulf of Kutch in India and the Dahlak archipelago in Eritrea, along with the northeast coast off Masirah in Oman), and it is likely that additional studies at these sites, or additional tracking from other sites would reinforce the value of these locations (and potentially identify additional locations) as green turtle foraging habitat.

In addition to the Marawah Marine Biosphere Reserve in Abu Dhabi and the Khor Mazhani protected area in Ras Al Khaimah, the project also identified additional foraging habitats that fall outside current marine protected areas: waters outside of the recently declared Khor Mahzani wetlands reserve in Ras Al Khaimah; the region south west of Al Marjan Island and northeast of Al Rafaah in Umm al Quwaim; the waters off Saadiyat island east of Abu Dhabi; and the waters surrounding the western extent of Abu Al Abyad Island in Abu Dhabi. These sites may warrant some level of protection and/or management.

The project has drawn together partners from multiple backgrounds and interests, has influenced national policy, and ignited a passion for sea turtles throughout the UAE. This work contributes to setting National policy in the UAE, and at the same time forms the backbone to a number of international conservation initiatives, spearheaded by the UN Convention on Biological Diversity, the UN Convention on Migratory Species, and the International Union for the Conservation of Nature and Natural Resources (IUCN). The results of this work features in decisions made at the Convention on International Trade in Endangered Species (CITES), and at regional fora looking to promulgate protected areas.

The data generated by this project have already been incorporated into the UAE's National Plan of Action for the conservation of sea turtles and their habitats and have also been used to update the status of turtle species on the UAE Endangered Species List. The project has also led to improved awareness at a National and international level and has also led to enhanced collaboration amongst multiple local agencies and stakeholders. The project has improved our understanding of biology and ecology of green sea turtles, unraveling some of the mysteries with regards to biology of green turtles in the Arabian region. We now have a much better understanding of where they nest, what habitats they use to forage, possible courtship areas, and where these areas overlap with human expansion and industrial development. We know more about nesting frequency, about nesting beach fidelity, and about genetic and we are better prepared to be more effective at sea turtle conservation.

The results from this project can inform management agencies and conservation practices in a region home to one of the most climate-challenged marine habitats on the planet, subject also to immense urban expansion, shipping and local industry pressures, and which supports large nesting and foraging populations or endangered sea turtles. Armed with this information, management agencies will be better able to target effective and efficient conservation action to ensure the preservation of sea turtles.

1. INTRODUCTION

The Green Turtle Conservation Project (GTCP, or Green Turtle Project) is an initiative led by the Emirates Nature – WWF, in partnership with government agencies, NGOs and the private sector in the United Arab Emirates, and to a lesser extent in Oman following deployment of a single batch of tags in 2016. The Marine Research Foundation has provided scientific advice and research expertise to guide the project. Over the course of four years (2016-2019) the project has tracked 51 green sea turtles to identify linkages between feeding grounds and nesting sites, along with migration routes and behavioural adaptations.

The Green Turtle Project is a continuation of the successful Hawksbill sea turtle tracking project conducted by Emirates Nature – WWF (then Emirates Wildlife Society – WWF) between 2010 and 2014. During that project phase, EN-WWF and partners across the Gulf region tracked 75 post-nesting hawksbill sea turtles to identify their migration routes and their foraging grounds. As a side benefit the project also learnt all about a new phenomenon never before observed in sea turtles: summer migration loops. These movement 'loops' occurred when waters warmed up in the southern part of the Arabian Gulf, forcing turtles off their feeding grounds and out into deeper, cooler water for a few months each year. It was notable to see how the sea turtles adapted to warmer climates, possibly as a way to combat the long-term effects of climate change. The data from that project was used to inform managers on potential Marine Protected Area boundaries and size, and was an important layer of information in delineating regional Ecologically and Biologically Significant Areas (EBSAs) under the auspices of the Convention on Migratory Species (CMS), amongst many other uses. It also served as a major awareness-raising platform, garnering millions of hits on electronic media, thousands of dollars worth of printed press coverage, and valuable broadcast media coverage.

Unlike the first phase of this project that studied hawksbill turtles, the green turtle project has presented a few challenges to finding out where the turtles go to, and come from. We know, for instance, where some of the key foraging grounds are: adults forage along the southern shores Gulf bordering the UAE, and between Masirah Island and Oman. Juvenile green turtles forage pretty much throughout the region suggesting a very widespread distribution. But green turtles do not nest in many places in the Arabian region: for instance, Oman has extensive nesting along substantial stretches of the southern coastline. Saudi Arabia has four islands that host green turtles, but none nest in neighbouring Bahrain or Qatar. Only two known sites are known in Iran, but no nesting takes place in the UAE. This makes tracking post-nesting females problematic. At those places where green turtles do not nest, we have to collect turtles on their foraging grounds, and track them in reverse to what scientists have typically done: from feeding grounds to nesting areas, instead of tracking turtles after they left the nesting beaches. A great advantage of this approach has allowed us to track male turtles also – which is never done from nesting beaches because only female turtles lay eggs.

1.1 CONSERVATION STATUS OF GREEN TURTLES

Green turtles are globally classified as Endangered by the International Union for the Conservation of Nature (IUCN)[1]. However, this global listing is somewhat misleading: a global assessment basically looks at total numbers of animals around the world. If the numbers are going up, the species is deemed to be doing well. But when the numbers go down – often precipitously – then the assessment will point to some level of endangered status. The challenge in this approach is that assessing a species that is widely distributed across the planet and under varying threats and facing differing conservation outlooks, does not reflects local conservation challenges and population status.

Because marine turtles face varying pressures from human consumption, bycatch in fisheries, climate change, marine debris, loss of nesting beaches through urbanization and industrialization, and myriad other hazards, we really need to look at those animals that nest in a particular region to provide a realistic assessment for that region - while taking genetic diversity into account, and including the vast distances the turtles travel to provide a more realistic to assess populations at regional levels.

1 http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en.
Downloaded on 29 November 2019.

At a regional level then, the North Indian Ocean green turtle subpopulation was listed as Vulnerable on 08 October 2018. This is the first Red List assessment of this green turtle subpopulation, and the status (Vulnerable) resulted from observed population declines and continuing threats. At a National level, the Red List status of green turtles is also Vulnerable, based on the following criteria: it is suspected that the overall number of mature individuals occurring within UAE territorial waters is less than 10,000, and while the current population trend is not known, a future continuing decline in the number of mature individuals is projected based on four primary threats: ingestion of marine debris, boat strikes, entanglement, and habitat loss from a range of drivers. Populations outside the UAE are impacted by light pollution at nesting sites in Oman (resulting in declines in recruitment), whilst the impact of other threats such as bioaccumulation of heavy metals, the long-term impacts of oil pollution, mortality of hatchlings in beach debris, and increased storm and other climatic change, require ongoing research.

The take home message from this is that while in some parts of the world sea turtles may not be doing at all well, in the Northwest Indian Ocean, and in the UAE, things are not so dire. However, it is still worth noting that all sea turtles are vulnerable. They are subject to predation and poaching on nesting beaches, they are subject to accidental entrainment in fishing nets, and they are subject to numerous other threats that have not ceased. So while Vulnerable may sound better than Endangered, there remains a significant uphill battle to get them to a Least Concern status.

Green Turtle *(Chelonia mydas).*

1.2 THREATS TO SEA TURTLES

Being long-lived and of late maturation, sea turtles face a multitude of threats over long periods of time, including, among others, mortality in mechanized and artisanal fisheries, egg and turtle consumption, and habitat degradation and loss. They are evolutionarily prepared to suffer high mortality rates in the early life stages, but large juveniles and adults have substantially high reproductive and population value. The loss of a small proportion of eggs or hatchlings may be compensated by their demography in the short-term, but the loss of older animals can have substantial negative effects on population size. Compounding this, turtles comprise distinct genetic stocks that preclude substantial interaction of stocks, restricting gene flow. This means turtle populations that have been decimated will not rebound through immigration from outside populations. When they're gone, they're gone.

Threats to marine turtles come from a wide array of sources, be they anthropogenic, routine biological threats (predation, disease, loss of habitat) and unexpected natural threats (storm damage, erosion, etc.). Key threats to sea turtles include:

- **Habitat Loss.** As human populations expand, and industries expand alongside them, beach front property is rapidly taken away from turtles and overrun by hotels, industrial complexes, and beach-front homes. As dredging takes place to create new coastal properties, valuable seagrass habitats are destroyed – and along with them the primary food source for green turtles. With landfilling, many valuable coastal feeding areas, from coral reefs to seagrass beds, are lost, again limiting turtle feeding potential.
- **Accidental capture in fisheries.** More and more, fisheries are having a massive impact on turtle mortality, and this is no less the case in the Gulf region. As fishers set their nets and leave them in the water overnight, turtles get caught accidentally and drown. Sometimes they swim into fish traps set on the seafloor, looking for food, and sometimes they get entangled in the float lines fishers use to recover the traps. Turtles also get caught in gill nets and drown, as they can not come to the surface to breathe. On the high seas, turtles accidentally get entangled in long-line gears, or go after the bait and get hooked just like the target fish.
- **Collection of eggs.** By far one of the biggest problems is collection of eggs on beaches. When turtles emerge their eggs are literally defenseless and particularly vulnerable to poaching. People collect the eggs as food, as also as aphrodisiacs (although there is absolutely no 'secret' chemical in turtle eggs and they are pretty much the same in content as a chicken egg).
- **Pollution. Pollution comes in many forms.** It can be in the form of chemicals that are spilt into the ocean, and which damage coral reef and seagrass habitats. It can also be in the form of plastics - turtles which feed in the open seas can mistake a floating bag for a jellyfish; juvenile and adult turtles also ingest plastics as they feed on floating materials, and they can also get entangled in plastics which litter the seas. Pollution also comes in the form of light: turtle hatchlings are guided to the ocean by the brighter horizon out to sea compared to the darker horizon inland.

- **Lighting.** Although technically considered a form of pollution, lighting is a major threat to turtles and is considered here separately. Turtle hatchlings are attracted to bright horizons, and lights deter adult turtles). As coastal development continues, and industrial installations are co-located with turtles, misorientation of hatchlings and decreased nesting is inevitable. When hotels, industries and homes have bright lights behind the beach, hatchlings get attracted inland instead, and are frequently lost to predators and dehydration. Adult turtles also avoid bright beach sectors when selecting a nesting spot.
- **Ghost Fishing.** Nets discarded at sea by fishers or lost in storms continue fishing long after they leave the boat. Hundreds upon hundreds of turtles die each year drowning in nets which are no longer of any use to people.
- **Climate Change.** Warming global temperatures can lead to feminization of stocks and loss of nesting beach habitat. As sea levels rise, beaches become narrower and shallower. A narrower beach offers less nesting area. A shallower beach means turtles may not be able to deposit their eggs as deep as they would like, or abandon the site altogether.

1.3 ECOLOGICAL ROLES OF SEA TURTLES

Sea turtles play valuable ecological roles in marine ecosystems as consumers and prey among other roles, and they are indirectly linked to seabed and fisheries stability. They function as key individuals in a number of habitats, and can be indicator species of the relative health of habitats that have a tangible value to society. Turtles also have non-consumptive uses such as tourism, education and research. Sea turtles are associated with a number of ecological processes on land and at sea and provide services in marine ecosystems that are often irreplaceable. Some examples of ecological roles of sea turtles include:

- **Maintaining sea grass pastures.** Green sea turtles provide a clear example of links to human welfare, as their herbivorous diet contributes to the well-being of seagrass habitats. These habitats are also valuable nursery grounds for commercial shrimp and fish species that can be lost or degraded in the absence of sea turtles. As sea turtles crop seagrasses they maintain the health and promote regrowth of the seagrasses themselves, providing refugia for juvenile shrimp and fish.
- **Maintaining coral reefs.** Hawksbill turtles are generally spongivores – feeding on a variety of species of sponge. This habit keeps sponges in check and prevents overgrowth that could smother coral species, and also opens up the harder exoskeleton of the sponges to smaller and delicate fish species that are not able to do this alone.
- **Protecting beach dunes.** Eggs that do not survive on beaches provide nutrients for vegetation which in turn helps retain the very dune systems that sea turtles rely on for nesting.

1.4 SEA TURTLE LIFE CYCLE

Sea turtles are characterised by a complex life history whereby all species undertake significant migrations between nesting, mating and foraging grounds, and the choice of these habitats has been determined over evolutionary timescales – as habitats opened up or were lost with rising and falling sea levels over millennia, turtles roamed farther and farther in search of the perfect combination (Figure 1). The life cycle can be described in brief generic terms as follows: turtles migrate from distant feeding grounds to different nesting areas and once the males and females arrive, they mate during a period of 1 - 2 months, although individual females are only receptive for 2-3 weeks. Males mate with several females, and females mate with several males. Fertilization of eggs is often by multiple males, likely as an evolutionary tactic to maximize genetic diversity. After mating it generally takes 2 - 4 weeks for a female to lay the first clutch of eggs, and after this the females may return 2 - 8 more times in the same season to nest. Nests typically contain 80-120 eggs. The eggs take approximately 45-65 days to incubate, and invariably hatch after dark, when the sand surface cools. Hatchling sex ratios are correlated to nest temperatures, whereby warmer nests produce higher proportions of female hatchlings.

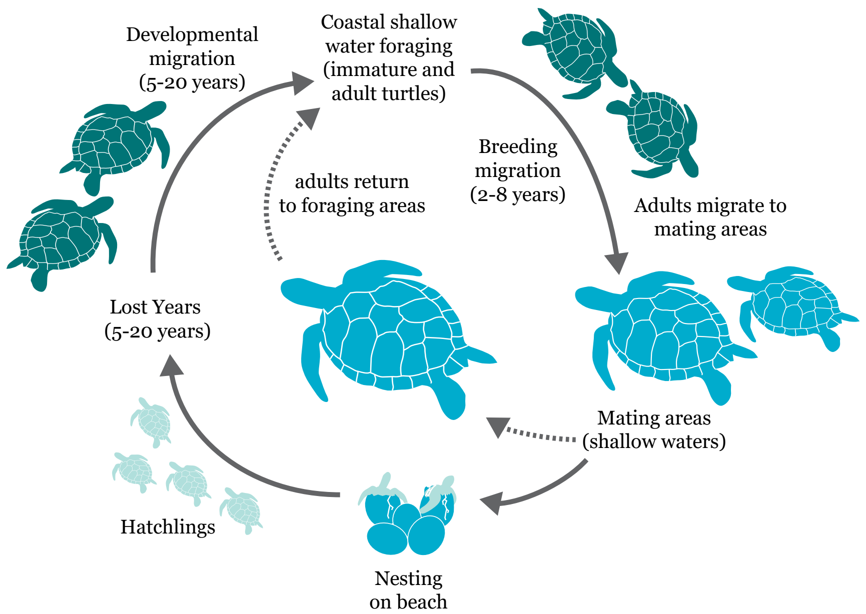


Figure 1: Generalised life cycle of sea turtles.

Temperatures during incubation are often a function of sand colour and nest placement, whereby nests in darker sands incubate at higher temperatures, as do those deposited under the open sun, and are likely to produce more females. The hatchlings dig through the sand for two or three days before emerging, then crawl down the beach and head in an offshore direction using (primarily) light to reach the shore, then waves through the nearshore waters and finally magnetic fields for guidance and orientation as they reach offshore areas. They swim for 1 - 2 days in what is known as a 'swimming frenzy' to get as far offshore as possible and after this they generally float on the surface among convergence zones and weed lines for several years until they recruit as small 20-40 cm juveniles from oceanic waters to nearshore shallow feeding areas. They typically remain at one or multiple feeding grounds for 5 - 10 or more years until they reach sexual maturity, and undertake their first migration to the mating and nesting areas, whereupon the cycle is repeated. Sea turtles are generally long-lived and most species are late maturing, with maturity reached at between 30 to 50 years of age in green turtles.

1.5 PROJECT RATIONALE

In the Gulf region there is a lack of data on green turtle habitat connectivity that impairs management and conservation, and limited knowledge on the links at National and Regional levels with respect to sea turtle biology and life cycles – and in turn conservation opportunities.

The Green Turtle Project is a research project designed to inform management and conservation strategists, whereby tracking information delivered by satellite transmitters deployed on green sea turtles provides information on nesting sites, foraging areas, and migration routes. Importantly, these data highlight regional linkages between countries in which the turtles reside and nest. The data derived from this second (green turtle) project phase help identify additional Important Turtle Areas (ITAs) for green sea turtles in the Arabian Gulf region and migration linkages to other countries, which in turn will enable management agencies to better protect them in the future. For instance, knowledge of where turtles spend substantial periods of time at sea can help in the design of marine protected areas, or in the development of management strategies such as fishery closures or gear changes, minimising impacts to turtle populations.

In the Arabian Gulf region just about every remaining nesting beach is protected or under some form of management (many have been lost to industrial development). But this is not the case for the areas at sea, where turtles spend over 95% of their lives. EN-WWF and its partners believe that protecting or managing those marine areas, and reducing anthropogenic risks is vital to sea turtle populations' wellbeing in the Arabian Gulf – indeed even at a regional level, and that the insights on turtle habitat use, gathered through this research effort, are an indispensable first step in the process.

The data generated by this project has already been incorporated into the UAE's National Plan of Action for the conservation of sea turtles and their habitats, and has helped identify regional Ecologically and Biologically Significant Areas (EBSAs), in a process coordinated by the UN Convention on Biological Diversity (CBD). More recently the data has also been used to update the status of turtles species on the UAE Endangered Species List, allowing far more accurate assessments than had these been conducted based on older data sets that relied on only nesting data.

The project has also led to improved awareness at a National and international level, as sea turtles have the ability to evoke a wide range of passionate and emotive reactions amongst the general public, and has also led to enhanced collaboration amongst multiple local agencies and stakeholders. The project has improved our understanding of biology and ecology of green sea turtles, unraveling some of the mysteries with regard to biology of green turtles in the Arabian region. We now have a much better understanding of where they nest, what habitats they use to forage, possible courtship areas, and where these areas overlap with human expansion and industrial development. We know more about nesting frequency, about nesting beach fidelity, and about genetic connectivity than we ever did in the past. In short, we are better prepared to be better at sea turtle conservation.

1.6 GEOGRAPHICAL SCOPE

While the original scope of this project envisioned working with partners in multiple countries in the region, the project eventually focused on deployment of transmitters from Bu Tinah, some 80km of the coast of Abu Dhabi, and off the Saraya sandbank south of Ras Al Khaimah, both in the United Arab Emirates. There was also one deployment trip to Oman in 2016. However, while these are the locations where the transmitters were deployed, they represent a very limited geographical scope given the migration range of green turtles, as indicated by project findings.

To understand dispersal patterns of foraging turtles in the Arabian region it was worthwhile taking a look at regional nesting sites, to be in a position to predict where turtles might go. The most significant nesting aggregations of nesting green turtles in the Arabian region historically have been found along the eastern Arabian peninsula, where over 15,000 females are estimated to nest annually. Two key sites, Ras al Hadd (in Oman) and Mukallah / Ras Sharma (in Yemen) contained approximately 90% of all abundance for the North Indian Ocean subpopulation of green turtles. However, recent annual estimates have suggested potential declines by of up to 10% to 40% at each of these locations.

Today, Oman hosts around 5000 nesters each year and Saudi Arabia hosts about 1000 nesters each year on Karan & Jana Islands. The UAE has recorded only one nesting event in recent years, although in the past there were records of nesting along the eastern coast. In Kuwait there are four to ten nests deposited each year, and similar numbers in Iran. So a reasonable probability for where a green turtle will travel to when tracked from a foraging ground in the UAE can be based on the size of regional nesting stocks: There's roughly an 80% chance that a green turtle would be from Omani stock, a 20% chance it was from the Saudi stock, and negligible chances that it would be from the UAE, Iran or Kuwait. This is not to say that it couldn't – of course it could – but in a numerical sense, the chance that one would run into one of the very few turtles that nested elsewhere in the region would be so low as to be negligible. Based on migration routes detected through 51 tracks of post-nesting and foraging green turtles in the Arabian region, Figure 2 provides a graphic indicative extent of dispersal.

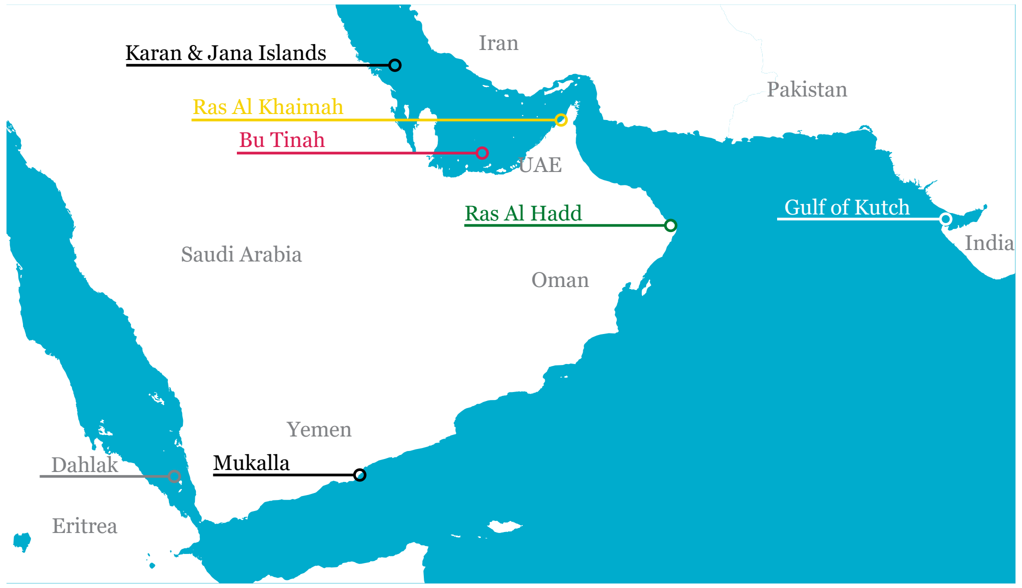


Figure 2. Geographical scope of the Green Turtle Project between 2016 and 2019. Key nesting sites depicted include Ras Al Hadd in Oman (green circle), Karan & Jana Islands in Saudi Arabia, and Mukalla in Yemen (black circles). Key foraging grounds where transmitters were deployed include Ras Al Khaimah (yellow circle) and Bu Tinah (red circle) in the United Arab Emirates. Key foraging destinations identified through this project include the Gulf of Kutch in India and the Dahlak archipelago in Eritrea. Country names point to the general location and do not constitute any indication of political borders.

1.7 PROJECT OBJECTIVES

The key objectives of the Green Turtle Project were to identify linkages between foraging grounds and nesting grounds, and better understand the migration routes taken by sea turtles, so that effective conservation measures can be developed to include the wide range of habitats used during the various development and reproductive phases. Between 2016 and 2019 the project tracked 51 green sea turtles and identified linkages between feeding grounds and nesting sites, along with migration routes and behavioural adaptations. These data help identify important areas for sea turtles in the Northwest Indian Ocean region, which in turn will enable management agencies to better protect them in the future. For instance, knowledge of where turtles spend substantial periods of time at sea can in the design of marine protected areas, or develop management strategies such as fishery closures or gear changes, and minimise impacts to turtle populations.

1.8 PROJECT PARTNERS

The Green Turtle Project was led by Emirates Nature – WWF in partnership with government agencies, NGOs and the private sector in the United Arab Emirates, including the Ministry of Climate Change and Environment, the Environment Agency Abu Dhabi, the Environment Protection and Development Authority of Ras Al Khaimah, and the Environment and Protected Areas Authority of Sharjah. Regionally the project collaborated with Oman's Ministry of Environment and Climate Affairs, the Environment Society of Oman and Five Oceans LLC. For scientific guidance and support, the project has relied on the Marine Research Foundation, which brings three decades of sea turtle research and conservation experience in the Gulf region to the project. At a global level, the project has contributed to initiatives under the UN Convention on Migratory Species and the UN the Convention on Biological Diversity.

2. METHODS

Satellite transmitters are usually attached to the turtles right after they finish laying eggs on nesting beaches. This allows scientists to follow them from their nesting grounds back to their normal feeding grounds. But this green turtle project presented a few logistical challenges, because the United Arab Emirates (UAE) is not home to nesting green turtles – it is however home to thousands of feeding green sea turtles. Tracking turtles from Oman was fairly straightforward – the team waited on the beaches until the turtles had finished laying eggs, and from there could track them to their feeding grounds. But in the UAE the project needed to catch the turtles on feeding grounds, and track them in reverse to their nesting beaches.

2.1 PROJECT LOCATIONS

Transmitters were deployed on sea turtles from Bu Tinah, off the coast of Abu Dhabi, and from the Saraya sanbank in Ras Al Khaimah, from 2016 to 2019. These two sites were identified as foraging grounds for green sea turtles by the Environment Agency Abu Dhabi and the Environment Protection and Development Authority of Ras Al Khaimah. One field trip also dispatched satellite transmitters from Ras al Hadd Turtle Reserve (Ras Al Hadd) in Oman, in 2016.

Bu Tinah Island, some 80 km off Abu Dhabi, is a protected private nature reserve that lies within the Marawah Marine Biosphere Reserve (Figure 3). Bu Tinah is a small, low-lying sandy cluster of islands and shoals with mangroves on the eastern side, and sandy beaches on the west and northwest coasts, surrounded by a fringing coral reef extending tens of meters to hundreds of meters offshore. Encompassed within this fringing reef structure are some of the most extensive seagrass beds in the southwestern Arabian Gulf, which are home to thousands of foraging and development stage green sea turtles.

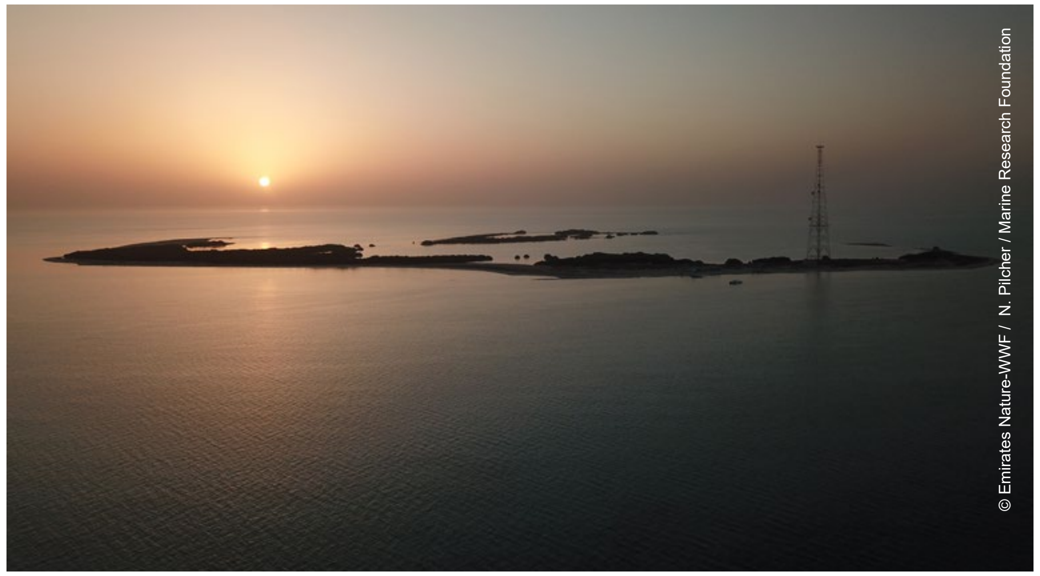


Figure 3. An aerial view of Bu Tinah Island – Marawah Marine Biosphere Reserve, looking eastward at sunrise.

The Saraya sandbank lies about 5km south of Ras Al Khaimah and protects valuable wetlands on the landward side, while fronting many acres of pristine seagrass beds offshore where green sea turtles congregate to feed. The sandbank provides important coastal erosion protection, while stabilizing the nearshore soft-sediment marine environment where seagrasses thrive.

In Oman transmitters were deployed at Ras Al Hadd, the region's largest green turtle nesting rookery. Ras Al Hadd hosts thousands of nesting green turtles year-round, with a peak from June to September. The multitude of turtles leaves a kaleidoscope of bulldozer-like tracks in the sand each night, only to be replaced with a new pattern the following day.

2.2 TURTLE CAPTURE AND SELECTION

In Oman the turtles were tracked from nesting beaches to foraging grounds, and in the UAE the requirement was to track turtles in reverse, from their feeding grounds to their nesting sites. In Abu Dhabi the team caught the turtles at sea using small speedboats and a jet ski - seeking sea turtles in shallow water areas. When a turtle was spotted, it was followed until the boat or jet ski were in just the right position, and then one of the team jumped in and caught the turtle by hand (Figure 4). The turtle was then lifted into the boat, and taken to a base vessel for processing.

In Ras Al Khaimah the team worked with fishermen who use coastal seine nets to fish. These nets measure hundreds of meters in length, and are pulled by two boats from about one km offshore onto the beach, over shallow seagrass areas where green turtles are feeding. Working with the fishermen and the Government agencies, the team waited on the beach and collected any turtles that were herded along by the nets. The nets did not harm the turtles as they could still surface to breathe, and it was a simple case of picking up the turtles and processing them on the beach.

For the six turtles the project tracked from Oman, transmitters were attached after the turtles had finished laying eggs, placing a restraining box over them to prevent them from moving while the transmitter was affixed.

From a nesting beach it is a relatively straightforward process to select a turtle and deploy a transmitter. But considering their Life Cycle only adult male and female turtles undertake breeding migrations, therefore a requirement at all sites was to find adult female (or male) turtles that were in breeding condition. On Oman's nesting beaches the team could be guaranteed that the turtles would be females (only the females lay eggs) and adults (again, only adults lay eggs), but at the foraging grounds things were far more complicated. The team needed to catch and tag turtles in breeding condition, so that they could be tracked when they migrated to nest. To do this the team needed to be able to identify which turtles were adults and, among these, which were reproductively active.

Figure 4. Catching sea turtles on foraging grounds off Bu Tinah. A turtle can be distinguished under the jumper.

Sea turtles can spend ten to twenty years growing from immature turtles into turtles that are ready to breed, and all of these turtles (adults and sub-adults and juveniles) can all share the same feeding areas. Sea turtles also do not differ in shape and size between males and females until reaching reproductive maturity - and then only males show any form of differentiation. That is, two small turtles could be male or female and from outside appearance there would be no way to tell the difference. Only when male turtles undergo pubescence do their tails elongate to 50 to 70 cm in length while female tales remain in the region of 15-20 cm range, allowing some form of external differentiation (the reason for this physical adaptation is important during mating: the male turtles hook the long tail up and under the female's tail providing a secure point of contact).

This knowledge still left us with a need to identify which were truly males and which were truly females, which were adults, and which were in reproductive condition. The reason behind this last requirement is that sea turtles do not breed every year nor do they do so year-round. Females normally breed every three to five years, while males breed a bit more frequently –on the order of every two to three years. However the satellite transmitters used on this project were programmed to last between nine and 12 months. If the team caught a turtle at random and put a transmitter on it, there would be no guarantee that it would be an adult, or more precisely, that it would migrate to nest that year, and therefore the project might not get any migration data or be able to link feeding and nesting sites.

The project used a small surgical procedure called laparoscopy to solve this problem. This allowed the team to determine the sex and also the age class of the turtles, and importantly if they were in breeding condition. Laparoscopy is a delicate procedure that involves making a small incision close to the rear flippers, and inserting a scope with a fiber optic light supply to look at the reproductive organs (Figure 5). Once the sex and reproductive condition were determined, and the turtles selected for tracking, the incision was sewn up with two stitches and the turtles were ready for the attachment of satellite transmitters.

Figure 5. A laparoscopic inspection of a green sea turtle on the beach at Ras Al Khaimah.

2.3 SATELLITE TRANSMITTER ATTACHMENT PROTOCOLS

When the laparoscopy revealed that the turtle was an adult, and preferably in reproductive condition, a satellite transmitter was affixed. If the turtle was not an adult, or in reproductive condition, we simply affixed metal flipper tags and took a skin sample for genetic analysis, and released the turtle back into the sea. The genetic studies will allow us to determine what general area the turtles originated from, so that we can also link their habitats to natal beaches via ancestral DNA histories.

The project deployed 38 SPOT-352B transmitters manufactured by Wildlife Computers (https://wildlifecomputers.com) and 13 KG376E transmitters manufactured by Sirtrack (https://www.sirtrack.co.nz). Attaching the satellite transmitters was a relatively straightforward procedure: we cleaned the upper part of the carapace with sandpaper and acetone, and then applied a small amount of epoxy adhesive. Once the transmitter was settled onto the adhesive, additional layers of adhesive were added to expand the attachment base and make the unit streamlined (Figure 6). At Ras Al Khaimah and at Ras Al Hadd the turtles were temporarily restrained in an open wooden box until the attachment process was complete. On Bu Tinah we processed the turtles on a small landing craft anchored a short distance offshore, minimising handling and transport. At Bu Tinah the turtles were not restrained in any way, other than by virtue of being on the landing craft hull. After approximately two hours the epoxy was set, and the turtles were released back into the sea.

Figure 6. Affixing a satellite transmitter to a green sea turtle using epoxy.

2.4 DATA ACQUISITION & PROCESSING

It is important to review some of the issues related to the data that can be obtained from satellite transmitters. There are substantial variations in the quantities of location points and also on the quality of the data, due to some inherent logistical and technological constraints: First, not all turtles got fitted with their transmitter on the same day, and not all transmissions last the same amount of time, resulting on different transmission duration from each turtle. The transmitters are fitted with salt-water switches, which automatically turn the units off when the turtle submerges, which then come on again when the turtle surfaces. If a particular turtle spends longer times on the surface, we get more transmissions but a shorter overall transmission duration because the battery drains faster. Conversely, if the turtle spends more time on the seabed, we get fewer transmissions, but the battery lasts. Moreover, not all batteries perform the same way or last exactly the same length of time. Some will burn out faster, and others will last for months. The transmitters we use in this study are rated for at least six months of signals.

Another aspect that is important to consider is signal quality. When the turtles surface, the transmitters send a signal to an orbiting satellite. But these are not stationary satellites like those used by GPS applications - they are constantly circling the planet, and not always visible from a given spot on earth. If a turtle surfaces and there is no satellite visible in the sky, we simply get no signal. But if the turtle surfaces when a satellite is in range, there is then an issue of how long they overlap and thus how clearly the signal is received. If the turtle is up on the surface for half a minute taking a few breaths as the satellite passes overhead, we get a very good signal. But if the satellite is just coming over the horizon when the turtle is on the surface, the angle of incidence is so low that the accuracy of the data diminishes. Also, if the turtle surfaces or dives just when the satellite is overhead, the contact might not last long enough to get a very accurate fix.

2.5 DATA ANALYSIS & FILTERING

It is also important to understand how the location data are classified: Class 3 location signals are the most accurate; whereby the marker sits at the center of a potential location circle less than 150 m in diameter. That is, the turtle could be anywhere inside that circle and the location marker is merely the mathematical center – not necessarily the turtle's location. Class 2 location signals have an accuracy of 150 to 350 m (i.e. the turtle could be anywhere inside a circle of 350 m in diameter). Locations get less and less accurate as the scale goes on, to about 1000 m for a Class 0 location, to the point that Z Class signals are ignored completely. In general though, if several location plots in a row show a fairly straight obvious movement from one place to another, there is a good chance this is indeed what the turtle is doing. So while the mathematical accuracy is based on areas (of accuracy circles), the turtle's relative movements are those of the circles themselves. When interpreting the individual plots for each turtle presented at the end of this report, the clusters of spots indicate the turtle is likely foraging across a relatively small range, while obvious linear plots indicate the turtle is purposefully moving from A to B.

All location fix data was filtered to exclude locations over land, and then further filtered for location fix qualities 3, 2, 1, 0, A, and B, with a speed of ≤ 10 km/h between fixes (following standard scientific protocols). The A and B data were included due to the low latitude that limits the number of locations due to fewer Argos passes.

Secondly, given that turtles send different numbers of signals based on behaviour differences, there is also a need to standardize data sets amongst all turtles to minimise bias in results. For example, data interpretation is confounded when one turtle spends a long time sending many signals from one location, compared to five turtles sending fewer signals each but all from a single location. To eliminate behavioural bias, only two fixes per turtle per day were selected, choosing the highest quality fix close to midday, and the highest quality fix close to midnight. The data were also filtered for implausible data such as landlocked fixes, and positions 1000s of km from the previous fix.

To calculate total distance covered by each turtle during each activity, minimum distances were calculated assuming straight-line movements between the location fixes sets taking into account the spherical shape of the planet. The minimum distance travelled was calculated assuming straight-line movements, and where tracks crossed landmasses the shortest route around the land mass was extrapolated using straight sectors. Average swim speeds per activity were determined by dividing total displacement by the time interval between start and end points for each activity.

2.5.A STAGE-STATES

Given the changes in turtle behaviour with time, location fixes were split into several categories depending on turtle activity, or States, as follows: In the case of Oman, the turtle tracks were visually analysed and all points prior to the departure point from the nesting site were categorised as internesting (the period post-deployment until departure from the nesting site). Within these data sets, each approximate two-week block during of internesting behaviour was considered a subsequent nesting event based on known internesting interval for green turtles in Oman. For turtles in the UAE, all points prior to departure were considered as foraging habitat. Subsequent location fixes until the commencement of foraging (in the case of Oman's turtles) or nesting (in the case of UAE turtles) were categorised as migration fixes (direct purposeful travel from the nesting site with minimal deviation from a straight path). After this, foraging or nesting activity was inferred by a reduction in travel rates and a shift from purposeful migration direction and unidirectional orientation to short distance movements with random heading changes. Thus the three States into which turtle behaviour was categorised were Internesting, Migrating, and Foraging.

2.5.B GIS MAPPING & HOME RANGE DENSITY ANALYSIS

This study employed a Kernel Density Analysis process to determine key foraging grounds used by turtles, or Important Turtle Areas (ITAs). Kernel density analysis is a nonparametric statistical method for estimating probability densities from a set of points (in this case the location fixes for each turtle). In effect, the analysis paints a density probability plot whereby the dense parts are where turtles spend most of their time, and the less-dense parts are where turtles spend small proportions of their time (Figure 7). Home range estimates can then be derived by drawing contour lines at different probability levels of turtles occurring in any one area. In this study home ranges were classified as areas where turtles were likely to spend 95% of their time, while core areas were calculated as those where turtles were likely to spend 50% of the time. Kernel density analysis used all filtered data available and were calculated for the area within ~50Km surrounding the foraging ground, using an unweighted Gaussian analysis, with set to Bandwidth=8, and k=3.

In its simplest form, "home range analysis" involves the delineation of the area in which an animal conducts its "normal" activities. Given the accuracy of location fixes whereby these might differ slightly from actual turtle location, and occasional short departures from normal foraging grounds, not every point that was visited, nor the entire area used by each turtle during the tracking period, was representative of the most important areas for each turtle. Instead, the project focused on Home Ranges, which can be likened to "areas traversed by a turtle in its normal foraging, exploratory, and development activities". Occasional forays outside of these areas, perhaps exploratory in nature or as flee reactions to predators, were not considered as part of the home ranges. In this context, these home range analyses describe the probability of finding an animal in any one place.

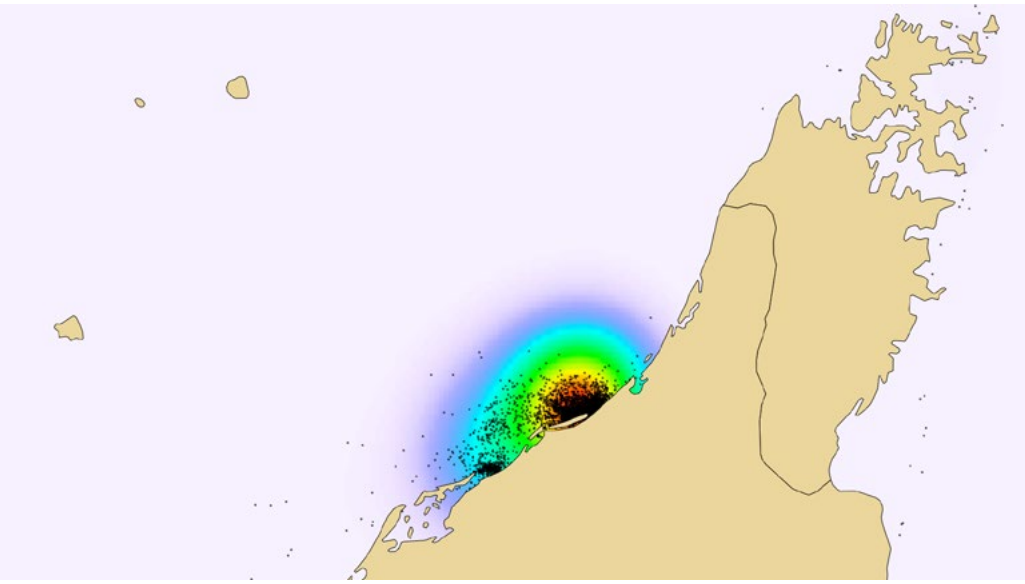


Figure 7. An example of a 'heat ramp' depiction of location point density for foraging turtles off Ras Al Khaimah, with the most dense accumulation of points in the red zone and the least accumulation of points out toward the blue and purple zones.

2.5.C HABITAT BATHYMETRY

Coarse bathymetry data sets were obtained from the General Bathymetric Chart of the Oceans (GEBCO; http://www.gebco.net), which is a publicly available bathymetric chart of the world›s oceans. However, the data are coarse and generally do not address areas shallower than 20m. For this, fine scale bathymetry was obtained from the Navionics Chart Viewer platform (https://www.navionics.com/) and digitized for use in analysis of turtle habitat use in relation to depth profiles in the Gulf (Figure 8). Seagrass habitats mapped under a separate Emirates Nature-WWF project were overlaid with these bathymetric data and generally occurred in waters <10m deep (Figure 8).

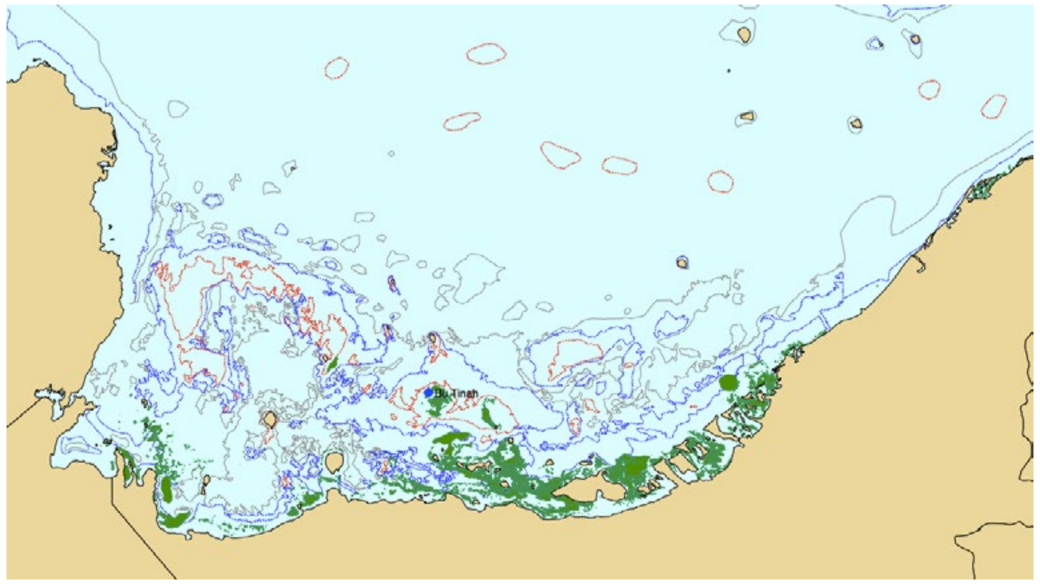


Figure 8. Fine-scale bathymetry of the southwestern Arabian Gulf, depicting the 20 m (grey), the 10 m (blue), and the 8 m depth contours (red). Green polygons represent known and mapped seagrass habitats.

3. RESULTS

3.1 DATA QUALITY & LIMITATIONS

This project made use of the latest science and technology to determine foraging-to-nesting and post nesting migrations of green turtles in the Arabian region, using the data to identify migration corridors, connectivity across nesting and foraging sites, conservation bottlenecks and important turtle areas (ITAs) for conservation.

In 2016 we had some substantial problems with tag retention, and the deployment periods for the first batch of tags was in the order of weeks rather than months. Even the second deployment trip in 2016 was not as successful as we would have hoped, but by 2017 we had resolved most of the issues – related to adhesive compounds and methods. By 2018 our tags were staying on long enough to record migrations from foraging grounds to nesting sites and back.

3.2 TRACKING DATA LONGEVITY

Transmitters signal life recoded by this project ranged from 14 to 647 days (Table I). Of the 51 units tracked by this study, three were still active in October 2019. A subset of 13 units (~26%) transmitted for less than 50 days, while 20 units (~40%) transmitted for longer than 150 days and 22 of these transmitted for longer than 200 days. A and B quality location fixes accounted for 88.6% of all signals received. From project inception up to the cutoff date in October 2019 (for inclusion of data into the final analysis), the project was able to reliably use 27,754 data points filtered from a total of 35,402 location fixes received (77.6%). A total of 6,939 tracking days of data were recorded by the 51 green sea turtles between 2016 and 2019.

Table I. Turtle tracking metadata 2016-2019. Deployment locations: BT = Bu Tinah; RAK = Ras Al Khaimah; RAH = Ras Al Hadd.

Year	Location	Sex	Tag	Locations	3	2	1	0	A	B	Date Deployed	Last Signal	Days at Large
2016	BT	F	160228	279	2	1	2	1	17	256	16-May-16	31-Jul-16	76
	RAK	M	160229	302	6	3	1	2	22	268	25-Jul-16	14-Mar-17	232
	BT	F	160230	257	2	3	6	8	32	206	16-May-16	21-Jun-16	36
	BT	F	160231	177	5	8	3	2	25	134	16-May-16	22-Feb-18	647
	BT	F	160232	194	-	1	5	6	22	160	17-May-16	07-Jun-16	21
	BT	F	160233	145	1	2	2	-	8	132	17-May-16	14-Mar-17	301
	BT	M	160234	191	3	4	1	4	14	165	17-May-16	31-Aug-16	106
	RAK	M	160235	609	16	5	10	5	85	488	25-Jul-16	09-Oct-16	76
	RAK	F	160236	512	7	7	6	17	77	398	25-Jul-16	14-Mar-17	232
	RAK	M	160237	478	2	1	2	5	23	445	27-Jul-16	18-Nov-16	114
	RAK	F	160238	841	2	1	7	5	38	788	27-Jul-16	07-Feb-17	195
	RAK	F	160239	1,977	23	27	15	24	179	1,709	27-Jul-16	20-May-17	297
	BT	F	160240	269	2	2	4	1	31	229	02-Aug-16	31-Aug-16	29
	BT	F	160241	718	11	5	6	6	70	620	02-Aug-16	21-Nov-16	111
	BT	F	160242	378	12	11	12	9	59	275	02-Aug-16	12-Sep-16	41
	BT	F	160243	536	9	10	10	8	64	435	02-Aug-16	16-Dec-16	136
	BT	F	160244 Tappy	1,369	16	11	18	11	149	1,164	02-Aug-16	23-Jun-17	325
	BT	F	160245	429	4	10	8	11	49	347	02-Aug-16	22-Sep-16	51
	RAH	F	160246 Mauzna	386	6	9	5	8	28	330	07-Nov-16	09-May-17	183
	RAH	F	160247 Zamzam	549	4	8	13	7	37	480	07-Nov-16	26-Jan-17	80
	RAH	F	163501	1,585	13	14	30	26	167	1,335	07-Nov-16	04-May-17	178
	RAH	F	163502 Nouf	928	21	8	10	12	67	810	08-Nov-16	10-Apr-17	153
	RAH	F	163503	936	13	8	10	12	82	811	08-Nov-16	25-Apr-17	168
	RAH	F	163504 Thuraya	243	4	3	8	1	25	202	08-Nov-16	09-Dec-16	31
2017	RAK	F	163500	250	10	2	-	3	10	225	30-Apr-17	22-May-17	22
	BT	F	169432	237	8	21	15	19	50	124	24-Apr-17	07-Jun-17	44
	BT	M	169433 Habibi	674	19	26	53	54	143	379	24-Apr-17	28-Jun-17	65
	BT	M	169434	203	7	4	9	11	29	143	25-Apr-17	09-May-17	14
	BT	M	169435	258	15	17	14	2	54	156	25-Apr-17	14-May-17	19
	BT	M	170117	419	9	15	6	3	41	345	25-Apr-17	23-Jun-17	59
	BT	F	170118	154	8	4	7	2	16	117	24-Apr-17	12-May-17	18
	BT	F	170119	98	18	10	4	1	6	59	25-Apr-17	09-May-17	14
	BT	F	170120	278	14	10	12	6	26	210	26-Apr-17	04-Jun-17	39
	BT	F	170121 Bradee	611	7	12	12	5	39	536	26-Apr-17	31-Aug-17	127
	BT	F	170122	379	18	9	10	4	20	318	30-Apr-17	04-Jul-17	65
2018	RAK	F	169431	221	8	9	18	21	37	128	21-Apr-18	10-Jul-18	80
	BT	M	169436 Farnek	706	22	39	45	35	129	436	11-Mar-18	29-Jun-18	110
	BT	F	169437 Lola	587	52	33	43	23	136	300	12-Mar-18	03-Sep-18	175
	BT	F	169438 Wisdom	636	25	35	64	67	151	294	13-Mar-18	30-Sep-18	201
	BT	F	169439 Respect	691	22	21	28	26	131	463	11-Mar-18	08-Jul-18	119
	BT	F	170124 Yas	126	19	6	3	2	8	88	18-Apr-18	28-Feb-19	316
	BT	F	170125	140	10	5	4	2	10	109	18-Apr-18	19-Dec-18	245
	BT	M	170126 Ibby	323	17	13	6	3	9	275	12-Mar-18	01-Jan-19	295
	BT	F	170129 Sophie	260	11	8	2	4	15	220	13-Mar-18	29-Jun-18	108
	BT	M	170130 Leonardo	185	13	7	6	1	9	149	13-Mar-18	14-Sep-18	185
	BT	F	170131 Dora	262	11	5	4	3	21	218	11-Mar-18	04-Oct-18	207
2019	BT	M	169440	1,251	89	63	93	108	279	619	08-May-19	08-Jul-19	61
	BT	F	169442	577	43	36	32	14	114	338	08-May-19	31-Oct-19	176
	BT	F	169443	1,236	77	62	50	46	257	744	08-May-19	22-Jun-19	45
	BT	F	169445	2,115	162	98	93	59	468	1,235	08-May-19	03-Nov-19	179
	BT	M	170128 Half Flipper	589	3	6	7	5	17	551	08-May-19	17-Sep-19	132
Total				**27,754**	**901**	**738**	**834**	**720**	**3,595**	**20,966**			**6,939**

3.3 TURTLE MORPHOMETRICS

This project captured 247 turtles from which it selected 51 on which to deploy satellite transmitters. While the project targeted adult turtles primarily, we also recorded data for other age classes of turtles as and how they were encountered. Curved Carapace Length data for all turtles for which sex and age class were both recorded are summarised in Table II.

Table II. Summary of curved carapace length for different age classes and sex groups among green turtles.

	Juvenile		Subadult		Adult	
	Male	Female	Male	Female	Male	Female
Average	59.08	55.20	79.81	83.27	91.75	97.02
SD	10.532	13.052	8.645	11.908	3.788	6.235
Min	46.6	33.4	65.3	62.9	85.35	72.5
Max	75.8	76.75	90.9	101.5	101.4	110.2
n	6	11	14	30	26	131

There was a significant difference (ANOVA: $F_{1,177}=17.257$, $p<0.0001$) in curved carapace length between adult male and female turtles with males being, on average, around 6 cm smaller than females. There were no statistical differences between sizes of males and females in the juvenile and subadult size classes, and this likely indicates there is some sexual differentiation as turtles reach adulthood. The sizes of adult female turtles are consistent with previous findings in Oman and Saudi Arabia nesting sites (there are no previously reported data for male turtles).

3.4 SEX RATIOS & AGE CLASSES

The majority of turtles were inspected via laparoscopy to determine sex and age class. The project targeted larger turtles on the foraging grounds as the objective was to track adults in breeding condition. Smaller turtles were generally avoided while searching for larger turtles, and thus the age class structure for turtles encountered by the project is biased toward the larger size classes (Table II, Figure 9). At Ras Al Khaimah the team sampled all the turtles entrained in the seine net regardless of size, and in Oman the team only sampled six adult female turtles; therefore there is a mix of adult (primarily), subadult and juvenile turtles in the project data set.

Table III. Summary of age class structure and male : female distribution among green turtles.

Juvenile		Subadult		Adult	
Male	Female	Male	Female	Male	Female
6	11	14	30	47	131

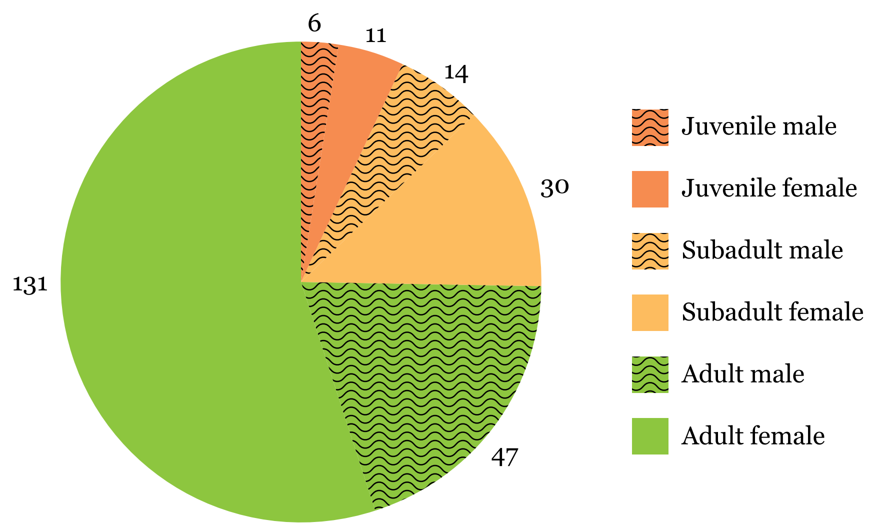


Figure 9. Age class and sex ratios for green turtles. Patterned lines represent males. Green = adult; Yellow = subadult; Orange = juvenile.

3.5 PROPORTION OF ADULT TURTLES READY TO BREED

Over the four years of sampling the team encountered a total of 131 adult female turtles and 47 adult male turtles (74.4% of all encounters for which age class information was available). Age class and sex was not determined in only 7 of 247 (2.8%) cases – often because the turtles were in poor condition and laparoscopy would not have been appropriate. Of those turtles for which sex and age class data were available, a total of 11 males (23% of adult males) and 36 females (27% of adult females) were found to be in breeding condition (Figure 10). This is a high proportion of adult turtles in breeding condition – elsewhere in the world this number is generally closer to 5-10% of the adult stock in any given year – and was likely biased by the high proportion of females in breeding condition in 2016 (18 of 42 adult females, or 43%) and the high proportion of male turtles in breeding condition in 2017 (4 of 10 turtles, or 40%; Table IV).

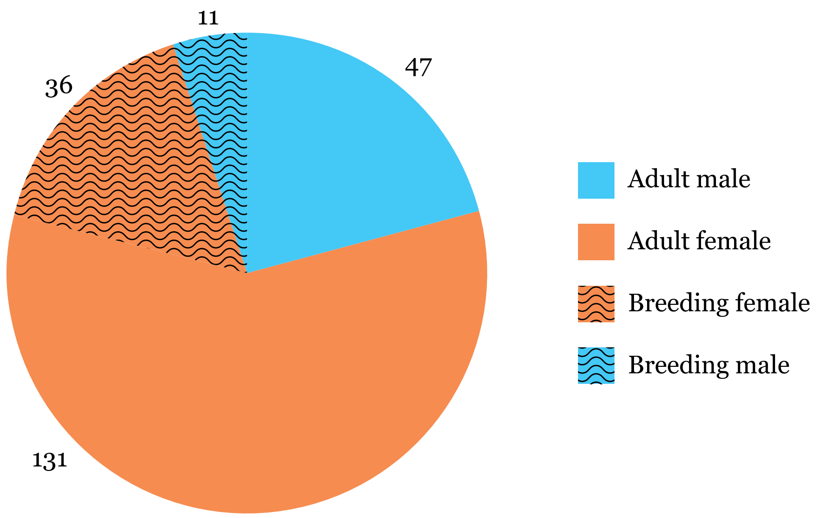


Figure 10. Proportion of adult turtles in breeding condition. Orange = female; Blue = male.

Table IV. Proportion of male and female turtles in breeding condition by deployment year.

	Adult males	Breeding males		Adult females	Breeding females	
2016	8	1	13%	42	18	43%
2017	10	4	40%	28	7	25%
2018	15	3	20%	32	8	25%
2019	14	3	21%	29	3	10%

3.6 MIGRATIONS

The migration data provide some of the most important results from this work. They reveal linkages between nesting sites and foraging areas, general routes taken by turtles, and use of important foraging habitats. Given the three different deployment locations there are, naturally, various general patterns of movements by turtles from each location. Turtles from Oman stayed at the nesting site during remigration intervals and then all undertook purposeful movements towards foraging grounds. A number of turtles from Bu Tinah and Ras Al Khaimah did not move far from the deployment points, due to loss of signals before the turtle undertook any migration (either through transmitter failure or simply that the turtles did not move, even after most of these had been assessed to be in breeding condition). There were long distance (>1000km) movements by two turtles from Oman, and one long distance (~2500 km) foraging-nesting-foraging loop by a turtle from Bu Tinah, but in general the movements were of 100s of km rather than 1000s. In the coming sections we present key aspects of the migration events, highlighting particular behaviour patterns and movements. General descriptions for each year are provided below, and individual graphics for each turtle using only the single best day and night location fixes are presented in Annex A.

MIGRATIONS FOR TAGS DEPLOYED IN 2016

All migrations for turtles deployed in 2016 are depicted in Figure 11 (tracks in red). This graphic incorporates the two long distance movements by turtles from Oman, with one moving eastward to the Gulf of Kutch in India (163503), and the second moving southwest along the Yemen coast, entering the Red Sea, and taking up residence in the Dahlak archipelago off Eritrea (163502). Both of these locations are known foraging grounds for green sea turtles.

The map also indicates a number of localised movements along the UAE coast, with several turtles from Bu Tinah moving northeast towards the Musandam peninsula and back, and a turtle (160239) from Ras Al Khaimah moving southwest towards Abu Dhabi and then back to Ras Al Khaimah. Given this turtle was deemed to be in breeding condition this movement indicates that turtles can use more than one foraging ground. One of the Bu Tinah turtles headed north towards Ras Al Khaimah before turning back, but did not stop for long before returning to Abu Dhabi waters. In addition the project recorded one track from a female post-nesting turtle from Oman moving into the Gulf and taking up residence at the main foraging ground off Ras Al Khaimah (160246). This migration route is depicted in reverse by a male turtle in 2017, confirming that nesting turtles from Oman use Ras Al Khaimah waters as foraging grounds, and that the movement includes both male and female turtles.

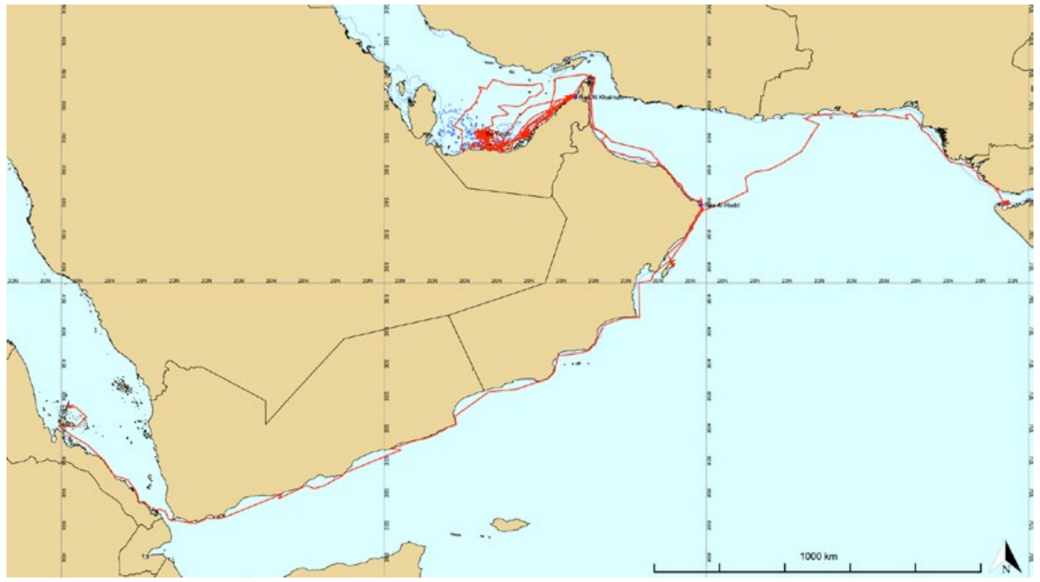


Figure 11. Composite graphic of all post-nesting migrations from Oman (6) and movements within and from foraging grounds from Ras Al Khaimah (6) and Bu Tinah (12). Thin blue line depicts the 10m depth contour.

The project also recorded two movements in 2016 to the northeast up into the Gulf that looped back to Bu Tinah, although neither of the turtles appeared to stop at any point – suggesting a lack of feeding or courtship behaviour. Unlike the summer loops that were detected with hawksbill turtles in 2010-2014, whereby they moved into deeper and cooler waters in the hottest part of the year, it is not clear that this was the same behaviour by the two green turtles as they were back on the foraging grounds by the end of August.

With the exception of the two loops in the Gulf and one turtle that crossed from Oman to Pakistan on her way to India (where water depth exceeded 3000m), all turtles tracked in 2016 stayed in shallow waters (generally less than 20m deep). Figure 11 clearly indicates this behaviour with the turtles (particularly those that travel long distances) staying extremely close to shore. In those instances where it appears the turtles are slightly further offshore during these long distance migrations the graphic effect is likely reflective of data gaps rather than purposeful movements into deeper waters. The preference for shallow waters has also been confirmed at multiple other sites around the world when turtles have had the option of staying in coastal waters or crossing deep oceans.

MIGRATIONS FOR TAGS DEPLOYED IN 2017

Migration tracks for nine turtles deployed from Bu Tinah and two turtles deployed from Ras Al Khaimah in 2017 are depicted in Figure 12 (blue lines). One of the Bu Tinah female turtles undertook a northward loop into the Gulf in August, much as happened in 2016, raising the possibility that this might not have been a random event. One of the Bu Tinah male turtles (169433) migrated to an area in the vicinity of the Daymaniyat islands in Oman and spent a substantial amount of time there, suggesting this might be also be a courtship area for turtles that subsequently nest on mainland beaches. While the Daymaniyat islands are better known as hawksbill nesting sites, there is also sporadic green turtle nesting on the islands, and there is the small possibility that this male was part of the Daymaniyat breeding turtles – however no female turtles tracked in this project went to the Daymaniyat islands suggesting this would be a rare event.

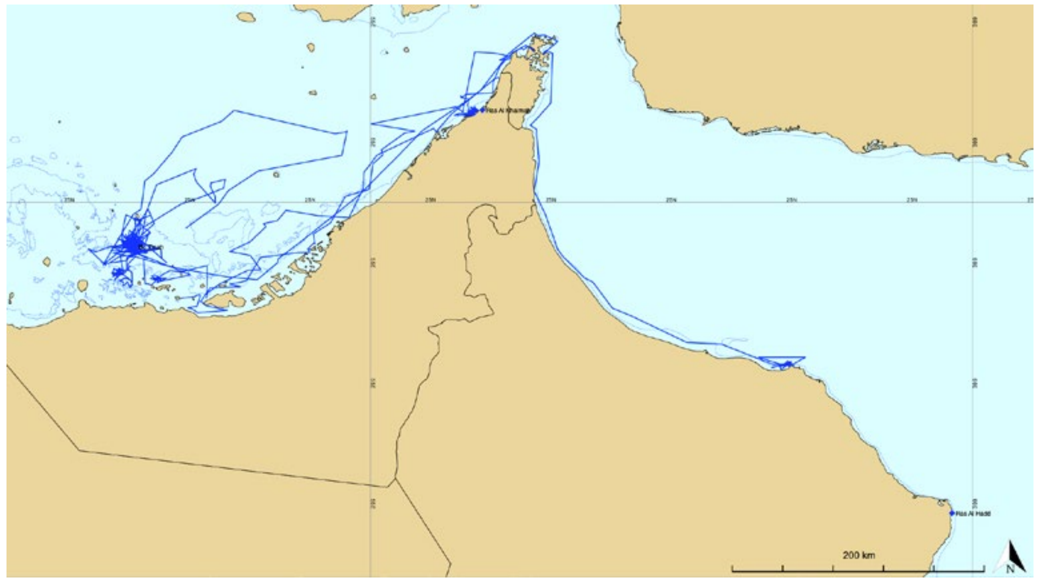


Figure 12. Migration tracks for 10 turtles deployed from Bu Tinah and Ras Al Khaimah in 2017. Thin blue line depicts the 10m depth contour.

One additional male turtle from Bu Tinah headed north to the Straits of Hormuz before signals were lost, and it is possible this turtle may have also been headed for Oman or to a courtship area off Musandam. One of the Ras Al Khaimah female turtles spent a substantial amount of time off Ras Al Khaimah before moving southwest towards Abu Al Abyad island west of Abu Dhabi (170122), mirroring the similar movements by a turtle from Ras Al Khaimah in 2016 (163501).

MIGRATIONS FOR TAGS DEPLOYED IN 2018

Migration tracks for ten turtles deployed from Bu Tinah and one turtle deployed from Ras Al Khaimah in 2018 are depicted in Figure 13. The single turtle tracked from Ras Al Khaimah was not in breeding condition and was not expected to undertake any migration, but the data set obtained from the foraging grounds is valuable for delineating Important Turtle Areas for this region.

Two females and one male turtle stayed in the vicinity of Bu Tinah, with the male turtle undertaking a short loop to the north during August (170126) as was found in 2016 and 2017. Investigations into water temperatures at the time did not point towards any substantive differences that would be the drivers behind this migration loop, and similarly the turtle did not stop during the short excursion northwards. At present it remains unclear why the turtles are behaving in this manner. The remaining six turtles from Bu Tinah were all females and all undertook extensive migrations to nest at Ras Al Hadd in Oman, with three of these (169438, 170124 and 170125) sending signals until they returned to Bu Tinah five to six months later (see Section 3.6a, below).

One of the male turtles deployed from Bu Tinah migrated to the northeast and spent substantial time off the coast of Dubai, suggesting this also may be a courtship area. What is apparent from the movements of several males is that the courtship areas are not necessarily in close vicinity to the nesting beaches (at Ras Al Hadd in Oman, for instance) but rather that the turtles may stop at courtship areas along the way.

The three complete migration loops are some of the most substantive findings within the migration data sets. Scientists have been able to document similar movements (from foraging grounds to nesting grounds and back) in several other places, but always in an opportunistic manner. That is, the turtles were fitted with a satellite transmitter but with no information on maturity status or impending nesting migrations.

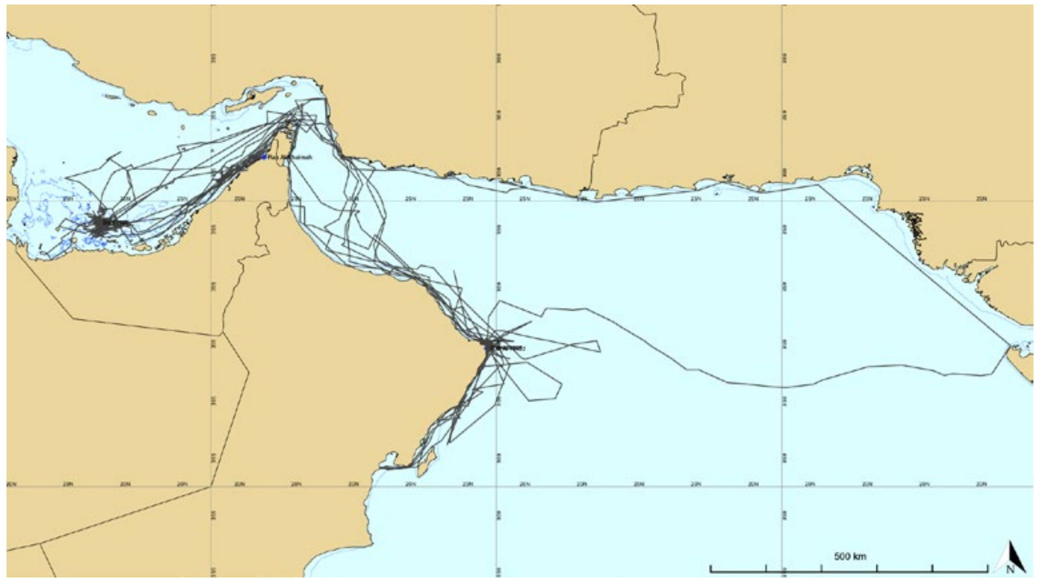


Figure 13. Migration tracks for 11 turtles deployed from Bu Tinah and Ras Al Khaimah in 2018. Thin blue line depicts the 10m depth contour.

This project successfully combined laparoscopic examinations with satellite tracking with the specific purpose of documenting these types of movements. In two of the cases the migrations appeared to be relatively straightforward: Turtles 169438 and 170125 both travelled up the UAE coast, moving to the Iran coast as they rounded the Straits of Hormuz. They then travelled south along the Iranian coastline before crossing the Gulf Oman on a southerly heading until reaching the Omani coast. At this point they headed southeast along the coast until reaching nesting grounds in the vicinity of Ras Al Hadd (incidentally this migration path was also followed by turtles 169437, 169439 and 170131, bringing the use of this 'turtle migration highway' up to six turtles in 2018).

Turtle 170124 appeared to take a much more complicated route to do the exact same thing as the two round-trip turtles above: She mirrored the movements of the turtles until the Gulf of Oman but at this point she turned to the east and tracked along the Iran and Pakistan shores, turning south to the Gulf of Kutch in India (much as did turtle 163503 in 2016). However, given that she was in breeding condition, and not supposed to be headed to a foraging ground, it is unclear quite why she took this route. However, she made an instant correction in India and turned westwards, swimming in a straight line towards the Oman nesting site, crossing waters in excess of 5000m deep. Upon reaching Oman she appeared to overshoot the nesting site, reaching as far southwest as Masirah island before correcting the course and returning to nest at Ras Al Hadd – as in the case of the five other females tracked to this site in 2018. As she completed the nesting season and commenced her return trip t Bu Tinah, she again travelled erroneously towards Masirah, before once again correcting herself, turning around, and following the Omani coast into the Arabian Gulf and swimming nearly directly to Bu Tinah. It is unclear why the turtle took so many poor navigational decisions, but it is possible that this was a first time nester that had not yet acquired the fixes to undertake more straightforward movements between foraging and nesting grounds. Interestingly while all outward migrations appeared to hug the UAE coastline, the return migrations were all much more of a straight line from the Straits of Hormuz to Bu Tinah.

MIGRATIONS FOR TAGS DEPLOYED IN 2019

Migration tracks for five turtles deployed from Bu Tinah in 2019 are depicted in Figure 14. Three of these turtles (all females) never left Bu Tinah foraging grounds, and the data will assist in further delineating Important Turtle Areas for this site. These data may also assist in enhancing the current mapped seagrass areas, as the Bu Tinah turtles spent substantial portions of time in areas where seagrasses have yet to be mapped.

A fourth female turtle (169445) undertook a northwards migration loop, and also a loop to the west and another to the east. The two last loops were continuous – the turtle did not stop at Bu Tinah between loops – and it is unclear why the turtle was moving a substantial distance off the foraging grounds (by ~50-100 km each time) only to return within seven to 14 days.

The lone male turtle tracked in 2019 (169440) headed northwest towards Qatar after remaining on the foraging grounds for several months, possibly in an attempt to reach the Saudi Arabian nesting islands. However, he only reached the northern shores of Qatar before turning south, but it is believed that the turtle was somehow incapacitated based on the quality of the signals in the last week of transmissions. There are no know green turtle nesting sites along the shores of Qatar that the turtle may have been aiming towards.

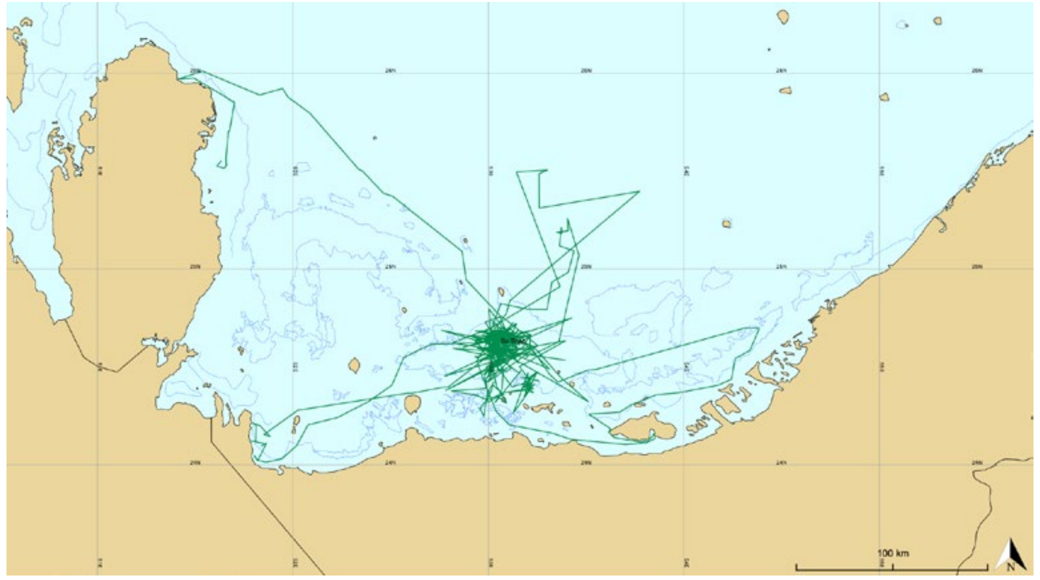


Figure 14. Migration tracks for five turtles deployed at Bu Tinah in 2019 (blue line depicts the 10m depth contour).

In the following sections we present highlights and key examples of turtle behaviour and movement patterns that are worthy of consideration in future conservation and management planning.

3.6A NESTING MIGRATIONS

A total of six turtles made purposeful migrations to Ras Al Hadd in Oman to nest, all of these from Bu Tinah (Figure 15). No turtles tracked from Ras Al Khaimah undertook nesting migrations, but this is in part due to the fact that fewer of the turtles were found in breeding condition at this site. No turtles were tracked to any other nesting destination in the region.

The preference of Oman as a nesting destination is closely related to nesting stock size: Oman hosts around 5000 nesters per year and Saudi Arabia hosts about 1000 nesters per year. The UAE has recorded only one nesting event in recent history, and Kuwait records four to ten nests a year, with similar or slightly higher numbers in Iran. Given this there is roughly an 80% chance that a green turtle comes from Omani stock, a 20% chance it comes from the Saudi stock, and very low chance that it would come from the UAE, Iran or Kuwait. The tracks depicted in Figure 15 highlight the generally coastal nature of the migration tracks, with the exception of travelling from Iran down to Oman and the single turtle that travelled over from the Indian coast (170124).

A possible additional reproductive migration by a male turtle was displayed by turtle 169440 that travelled north towards Qatar (possibly with Saudi Arabia as a destination). This turtle headed towards Qatar after 109 days on the foraging grounds, potentially on his way to the nesting beach islands in Saudi Arabia (Karan and Jana Islands, primarily). Unfortunately the transmitter stopped sending signals prematurely and following an in-depth look at the signal quality and patter we believe the turtle may have been injured as it neared Ras Laffan Industrial city in Qatar.

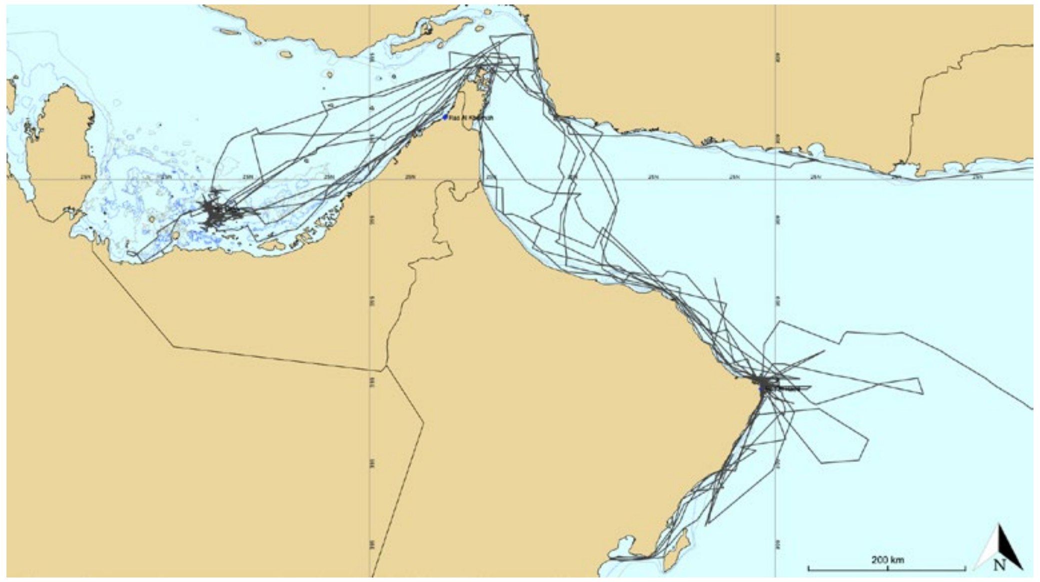


Figure 15. Migration tracks for six turtles deployed from Bu Tinah in 2018 that nested in Oman (partial track for turtle 170124 is excluded for simplicity). Depth contours are shown for 10m (blue) and 20m (grey).

3.6B POST-NESTING MIGRATIONS

For those turtles undertaking post-nesting migrations from Oman, foraging grounds were identified by a sudden reduction in travel rates and a shift from purposeful, rapid and unidirectional orientation to short distance movements with random heading changes. Foraging grounds were also identified as all those location points at the deployment areas prior to purposeful migrations. These foraging grounds constitute Important Turtle Areas (ITAs) that warrant consideration in National and Regional conservation programmes.

This project tracked six post-nesting turtles from Ras Al Hadd in Oman to identify linkages with key foraging grounds. Unfortunately after the first year the project was not able to deploy additional transmitters and so the sample size is insufficient to draw substantive conclusions from the tracks obtained. However, from the restricted post-nesting tracking data available, the project identified linkages with foraging grounds in three countries (India, Eritrea and the United Arab Emirates).

One of the turtles (163503) departed nearly immediately after having a tag affixed and headed towards Pakistan, crossing waters ~3,000m deep in the Gulf of Oman, then moving eastwards along the coast past Karachi and ending up at a feeding ground in the Gulf of Gujarat, India (Figure 16).

A second turtle (163502) departed Oman shortly after being deployed with the transmitter and headed southwest down the Oman and Yemen coastline, rounding the Bab Al Mandeb and entering the Red Sea, eventually settling at a foraging ground in the Dahlak archipelago, off the Eritrean coast (Figure 17).

The third foraging destination was the United Arab Emirates, with two turtles moving into the Arabian Gulf, one of these settling off the coast west of Abu Dhabi (163501; Figure 18) and the second (160246) settling on the known foraging grounds off Ras Al Khaimah (Figure 19). These movements confirm linkages between nesting grounds in Oman and foraging grounds in the United Arab Emirates that should be considered in conservation and management planning. One of the two remaining turtles (160247; see Annex A) tracked from Oman remained in Oman, taking up residence on the northeast coast of Masirah Island, while transmissions ceased on the final transmitter (163504) before the turtle reached a foraging state, too soon in the track to be indicative of the potential eventual destination.

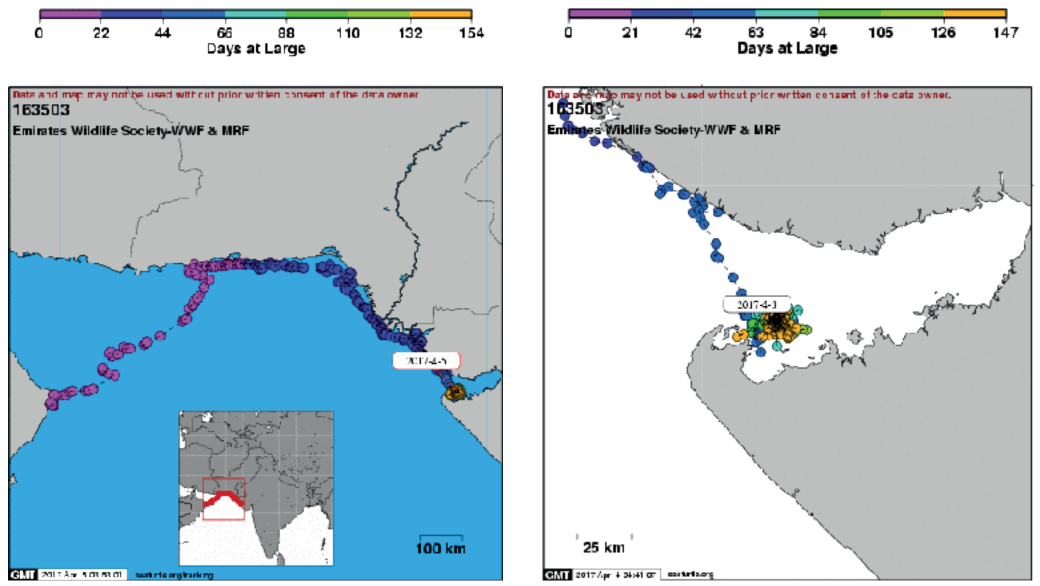


Figure 16: Complete movement track (left) and close up (right) of final foraging ground for green turtle 163503.

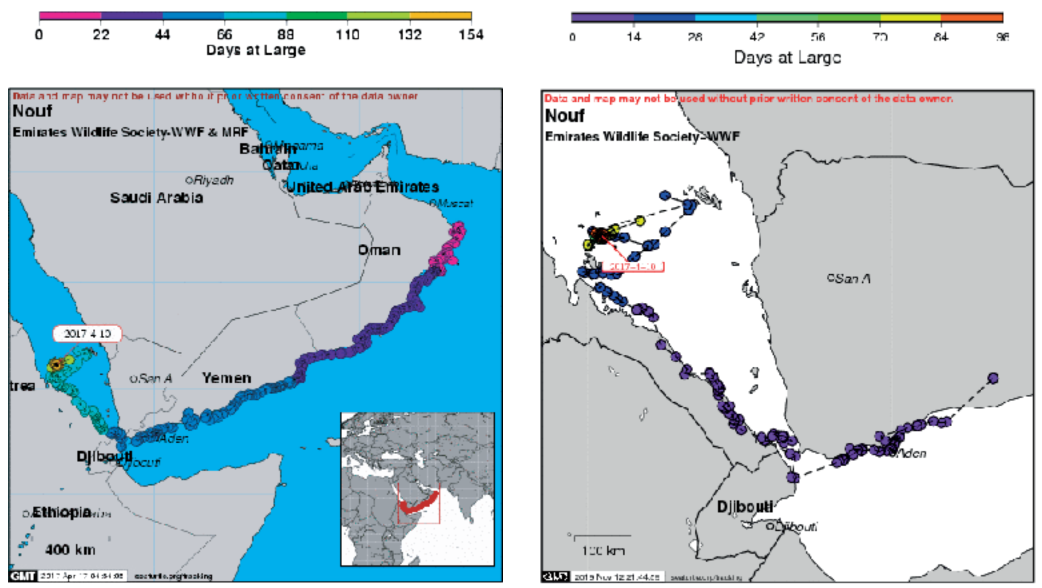


Figure 17: Complete movement track (left) and close up (right) of final foraging ground for 163502.

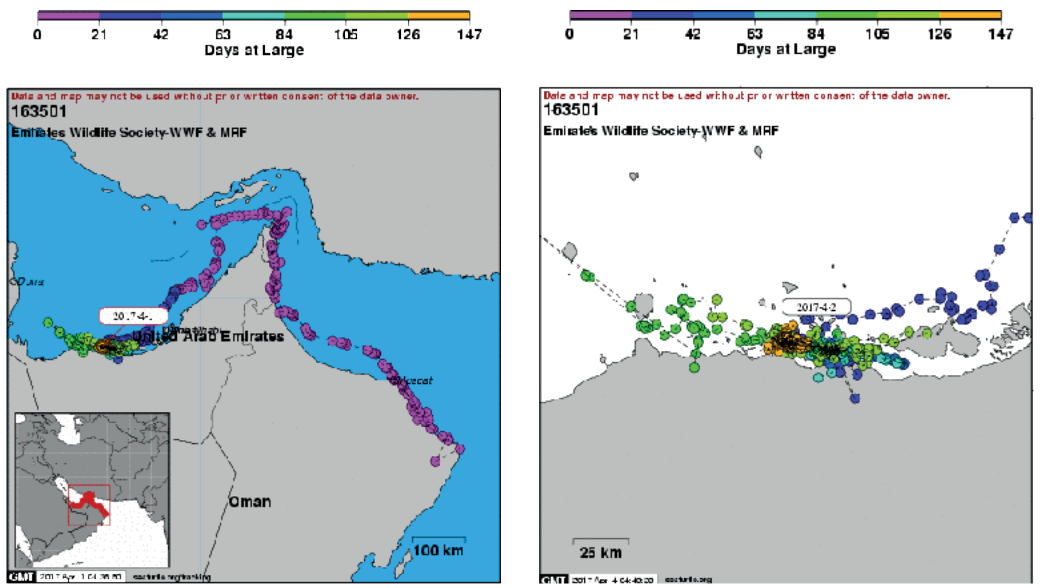


Figure 18: Complete movement track (left) and close up (right) of final foraging ground for green turtle 163501.

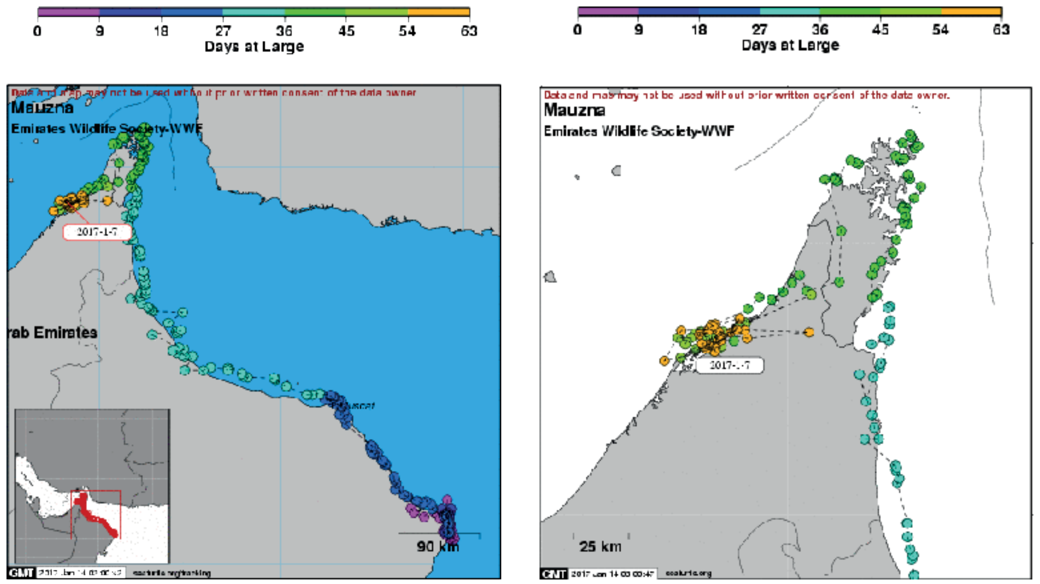


Figure 19: Complete movement track (left) and close up (right) of final foraging ground for turtle 160246.

3.6C FORAGING-NESTING-FORAGING MIGRATION LOOPS

Figure 20 presents the tracks of the three round trip loops recorded during this project. As highlighted above, the ability to track a turtle from foraging grounds to nesting areas and back is a complex technological feat – particularly when considering the challenges that turtle biology adds to the equation. For instance, when female turtles reach the courtship areas they generally mate with multiple male turtles. Male turtles often try to outcompete other male turtles and will bite and harass male turtles that are already coupled with females. During the mating process there is the possibility of the tag being dislodged by the mounted male, or for the antenna to be bitten off.

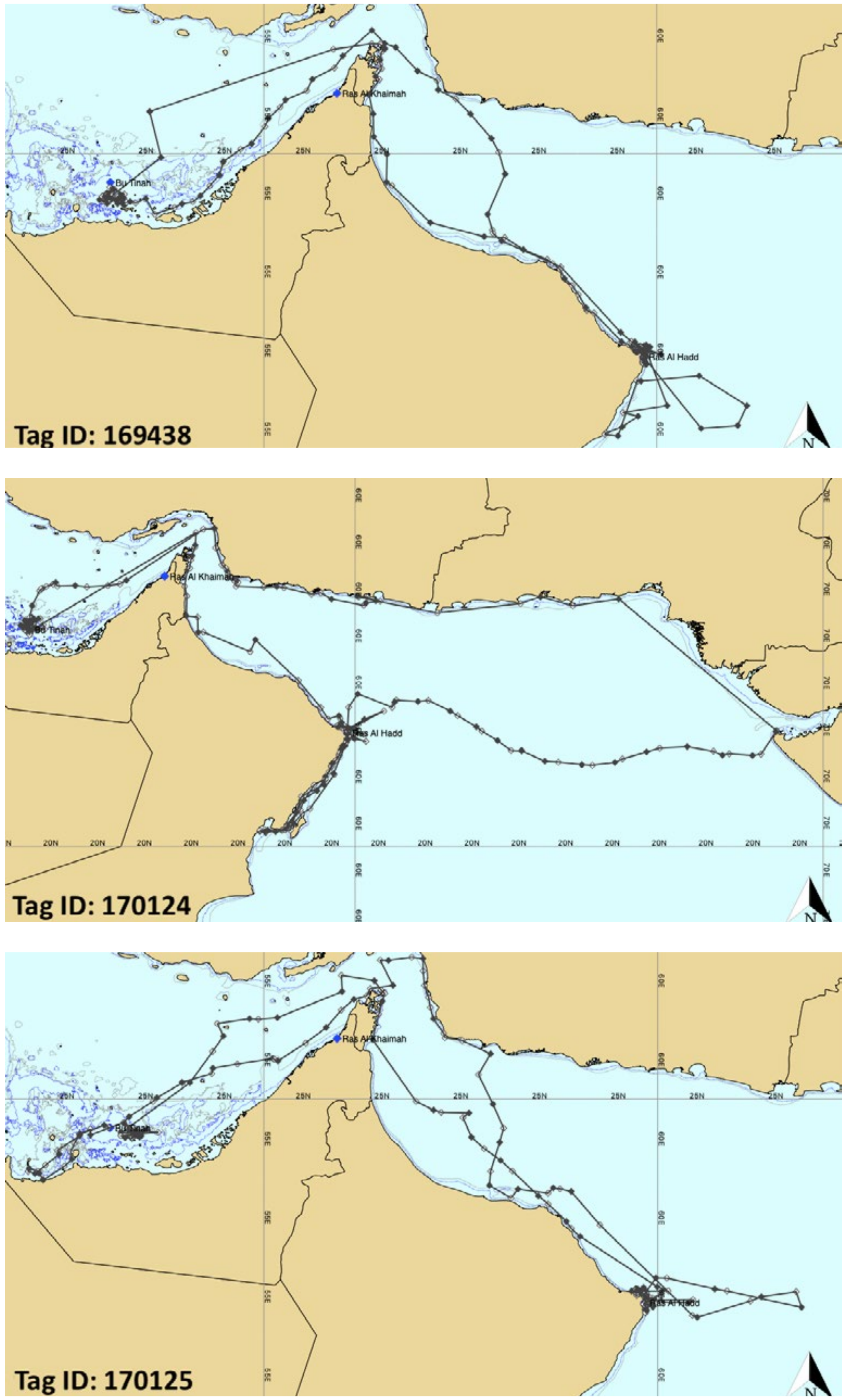


Figure 20. Migration loops for three turtles deployed from Bu Tinah in 2018 that nested in Oman.

The natural reproductive cycle in sea turtles further complicates this process: female turtles start developing egg follicles in readiness for the nesting season some six to nine months in advance. During laparoscopy we can determine that they have developing follicles, but not how far advanced this process is. Thus we affix a tag to a turtle that is only a few months into the process, and that turtle might not depart for at another three or four months, draining the batteries on the transmitter without providing any migration data. This likely explains the number of turtles that were assessed to be in breeding condition but which did not move off the feeding grounds before the satellite transmitters stopped sending signals.

In addition, turtles may spend several weeks at the courtship areas, and several additional weeks readying the first clutch of eggs, further draining the transmitter batteries. Once they start nesting, the female turtles may deposit four to six clutches of eggs at two-week intervals, extending their stay at the nesting grounds. Finally, there is the need for a ~500km return journey in order to complete the round trip, bypassing threats such as bycatch in fishing nets, boat strikes, and pollution. The challenges of complex biology, assorted threats during migrations, battery longevity and potential damage to the transmitter means that successfully tracking a turtle in a full circuit from foraging to nesting grounds and back is a rather unique feat.

The loops that can be seen in the vicinity of Ras Al Hadd in Oman in Figure 20 are movements during the internesting period – when female turtles were readying the next batch of eggs, and interestingly show some of the only movements into deeper waters. This is likely a way for the female turtles to evade over-amorous male turtles once their mating period is over and the focus is on nesting and egg development.

3.6D LOOPING MIGRATIONS

During the course of the project several turtles undertook some looped swims to the north and east of Bu Tinah that warrant investigation. Some clear examples of these were demonstrated by turtles 160243, 160245, 170121 and 169443 (Figure 21).

An additional turtle (169445) undertook looping movements, but in this case the turtle looped north in August 2019, then looped east in early September 2019, and finally looped west in September/October 2019 before returning to Bu Tinah. The loops lasted 10, 15 and 19 days respectfully, with only days in between each of the loops (2 days between north and east, and four days between east and west).

These looping movements were not associated with warm waters as was the case during the Hawksbill project, and generally were completed within one to two weeks. During 2010-2014 we detected movements by hawksbills out into the deeper and cooler parts of the Gulf that lasted for two to three months and the turtles only returned to the foraging grounds once water temperatures had dropped by several degrees. The movement patterns displayed by green turtles during the current phase were shorter and did not take advantage of significant temperature differentials.

There was also no clear pattern in relation to tag deployment timing – suggesting that the tagging process was not the driver of the looping migration – as in several cases the turtles remained at Bu Tinah for several months before looping out (generally) to the north east and returning shortly thereafter. At present the behaviour and intention of these looping movements remains unexplained.

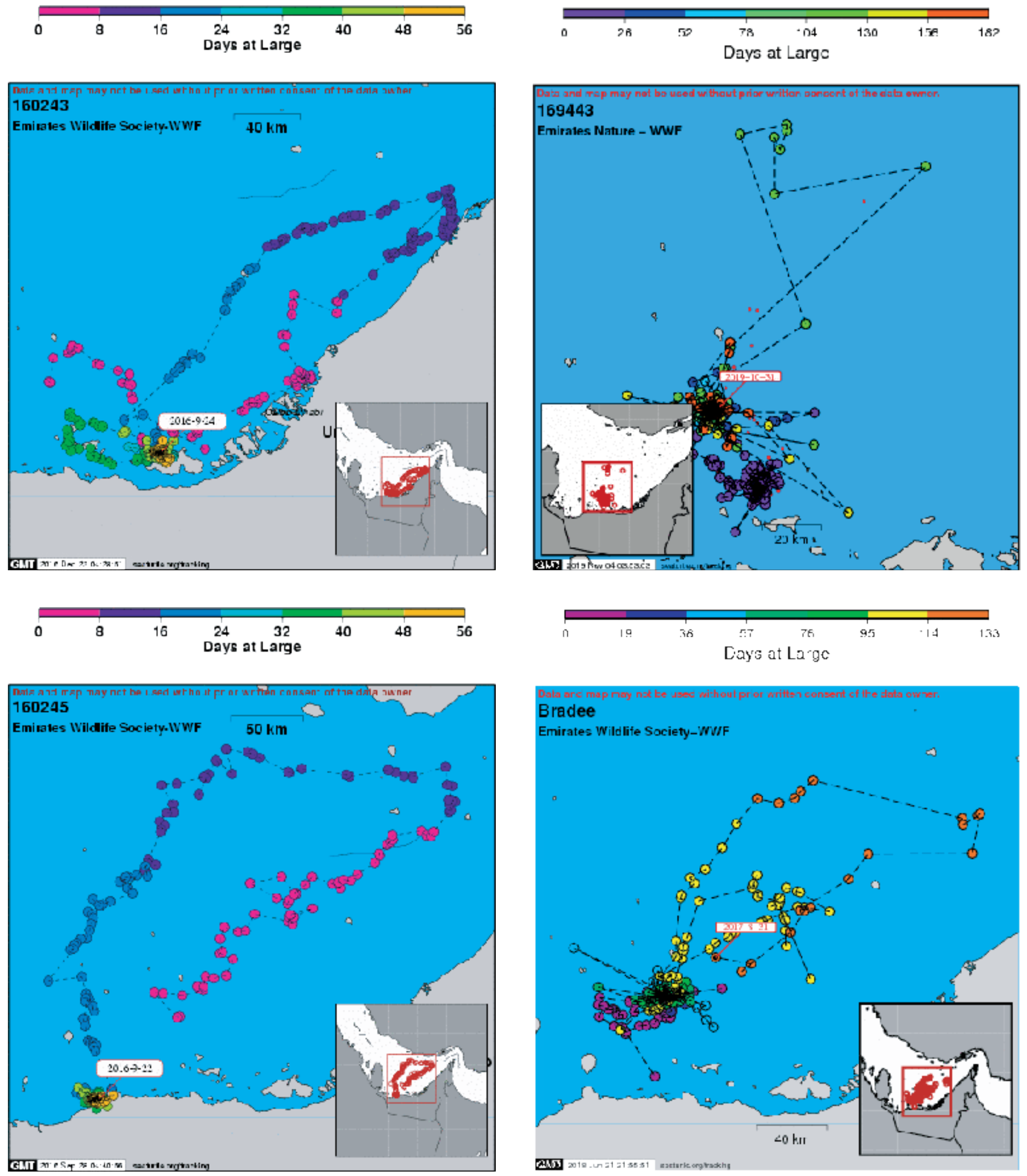


Figure 21: Looping movements by green sea turtles in the Arabian Gulf that did not stop at either secondary foraging grounds, courtship areas or nesting sites.

3.6E COURTSHIP MIGRATIONS

This project identified two potential courtship areas in addition to the waters close to Ras Al Hadd. One of these was close to the Daymaniyat islands in Oman, and the second was roughly 20km off the coast of Dubai (Figure 22).

Both of these movements were by male turtles confirmed to be in breeding condition and neither reached the Ras Al Hadd nesting grounds, but they did spend considerable amounts of time in specific locations, tentatively identified as courtship areas. In both cases the turtles spent at least 20 days at these sites (light green and orange location markers, Figure 22) contrasting considerably with the purposeful and daily progress movement to these areas from Bu Tinah.

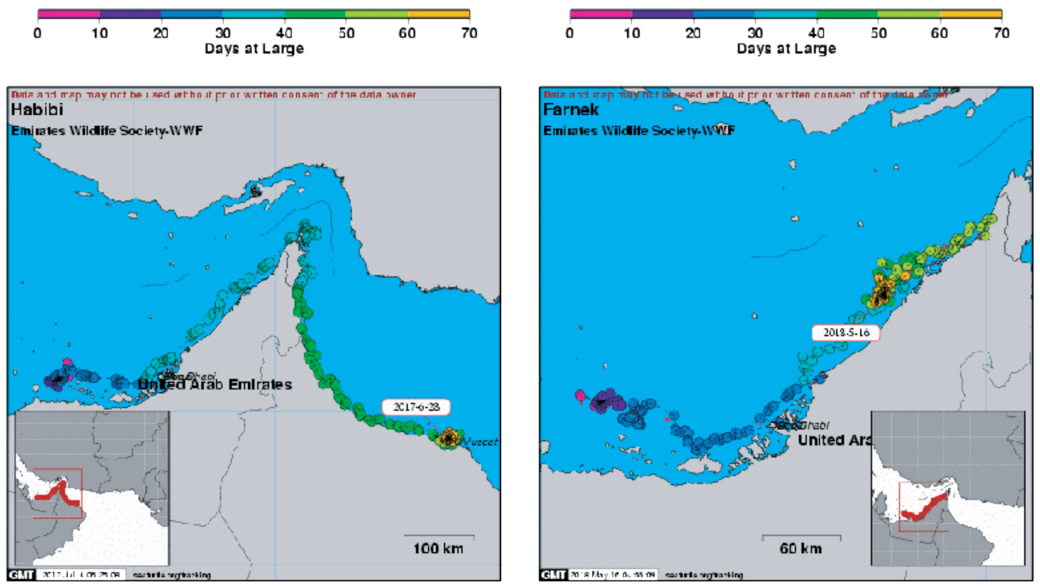


Figure 22: Movements of turtles 169433 (left) and 169436 (right) that may be indicative of courtship areas.

3.7 FORAGING GROUNDS

3.7.A ABU DHABI FORAGING GROUNDS

Another of the key objectives of this project was to refine our knowledge of Important Turtle Areas (ITAs) in the United Arab Emirates, which are those areas at sea where we know less about turtle habitat use than we do on land.

In addition to the foraging grounds identified via post-nesting migrations from Oman, the project also gathered data on foraging grounds from the turtles deployed at Bu Tinah before they departed on nesting migrations. Between 2016 and 2019 a total of 31 turtles remained in the vicinity of Bu Tinah for periods ranging from 0 to 647 days, and a total of 5,156 location points were acquired during this time (Figure 23). These data indicate that turtles deployed with tags from Bu Tinah used the Maraah Marine Biosphere Reserve and also habitats outside of this area, primarily in waters <10m deep along the western sand northern sides of Abu Al Abyad, off Saadiyat island, and south of Bu Tinah.

Given that the area is home to the Marawah Marine Biosphere Reserve, it was of additional interest to determine what proportion of location markers fell within the Reserve (out of all the localised foraging location fixes and excluding those location points from migrations and from other locations) – as a measure of effectiveness of the Reserve in protecting Important Turtle Habitat (ITA).

A subset of 3,901 location fixes were from inside of the Reserve, representing approximately 76% of all locations for green turtles deployed from Bu Tinah, and a good coverage of important seagrass feeding grounds within the Marawah Marine Biosphere Reserve. The majority of the location markers outside of the Reserve boundary originated from just three turtles: two in the vicinity of Abu Al Abyad island (163501 & 160241), and one more turtle (170117) foraging just south of Zirku Island. Thus the majority (97%) of all turtles (most of which were deployed at Bu Tinah with transmitters) stayed within the Marawah Marine Biosphere Reserve boundary even though a substantial proportion of location fixes produced by just three turtles made up the bulk of the 76% of markers laying outside of this area. The overlap between location fixes and the Marawah Marine Biosphere Reserve are presented in Figure 23.

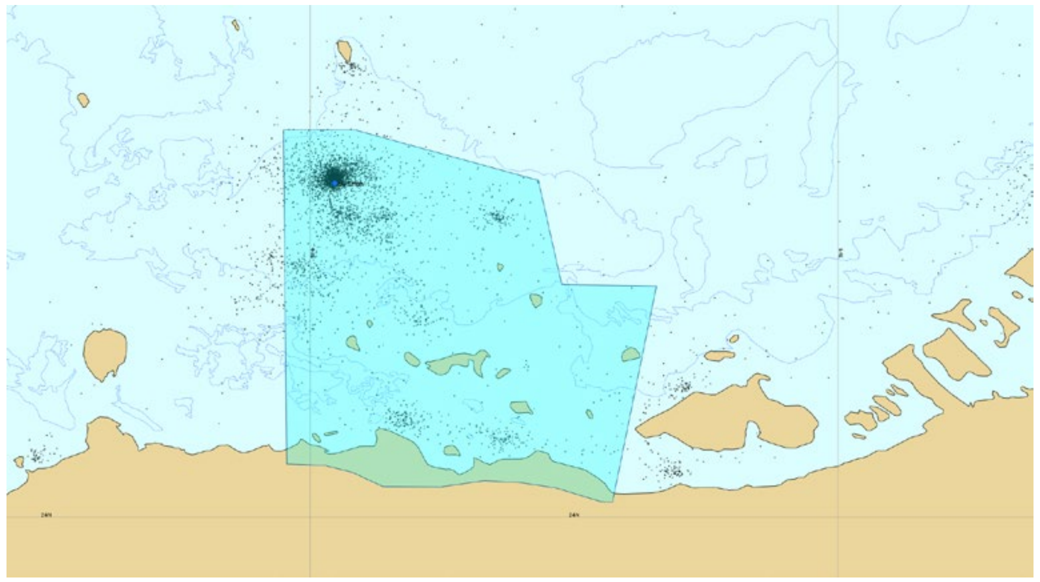


Figure 23: Location markers for turtles in the vicinity of Marawah Marine Biosphere Reserve between 2016 and 2019. Light blue shape depicts the Reserve and the dense accumulation of points is close to Bu Tinah.

3.7.B RAS AL KHAIMAH FORAGING GROUNDS

In 2016 five of the turtles deployed with transmitters from Ras Al Khaimah stayed very close to the area they were caught, and this is unsurprising given the lateness of the season when tags were deployed, and when nesting migrations were generally already underway. In 2017 we deployed an additional tag at Ras Al Khaimah, and one more in 2018 (on a female adult turtle that was not quite in breeding condition). All of these turtles spent most of their time in the vicinity of the release point and somewhat to the south, in areas where types of fishing that could harm turtles are generally prohibited. A total of 3,408 location points were received by all turtles in the vicinity of Ras Al Khaimah and the Saraya sandbak, including turtles deployed in Oman and Bu Tinah, and at a location between Al Marjan Island in Ras Al Khaimah and Al Rafaah in Umm Al Quwain (Figure 24). These two areas appear to be of great importance to green turtles in the region.

To narrow down the extent of these important areas it is useful to consider the data in the form of home ranges and core areas. Home ranges are typically those ranges where turtles are generally expected to disperse and be found during 90% of their time, while core areas are those key areas where turtles spent 30% of their time and are critical habitats for sea turtles – such as foraging grounds, for instance. Focusing on these areas also eliminates those points with lower data accuracy. Figure 25 shows the 90% home range for all foraging location points close to Ras Al Khaimah, while the dark blue shading shows the 30% core areas, which are of absolute importance to green sea turtles. These data to allow a good delineation of important feeding areas in Ras al Khaimah, and will be of great use to the Environmental Protection and Development Authority at Ras Al Khaimah.

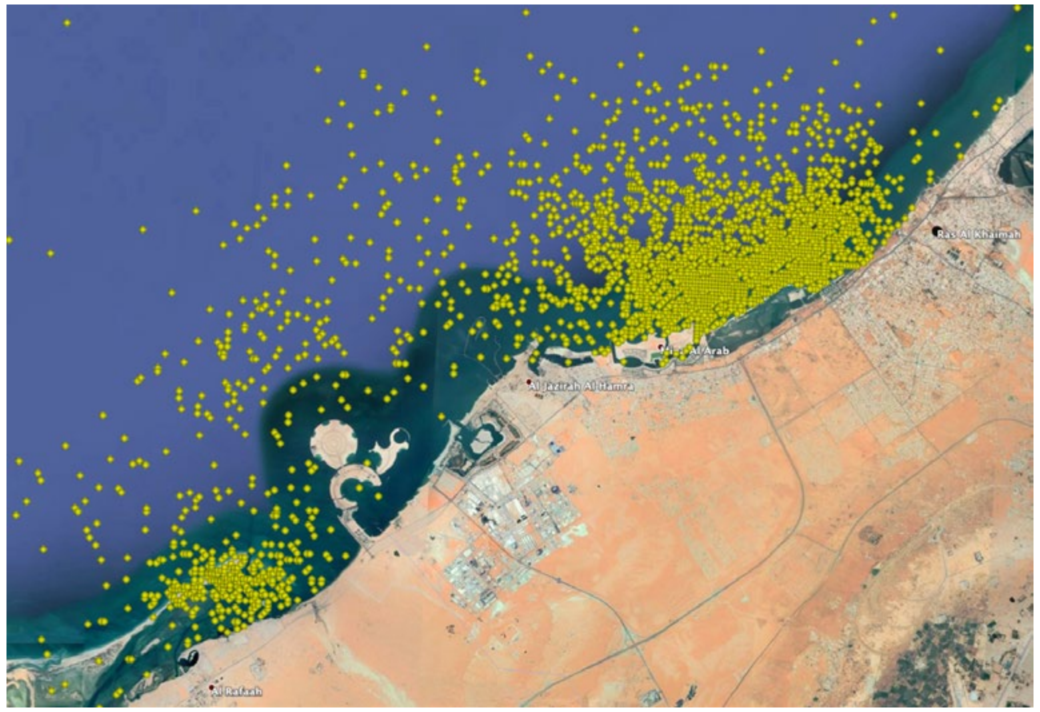


Figure 24: Foraging area location all markers off Ras Al Khaimah showing two important feeding areas (clusters).

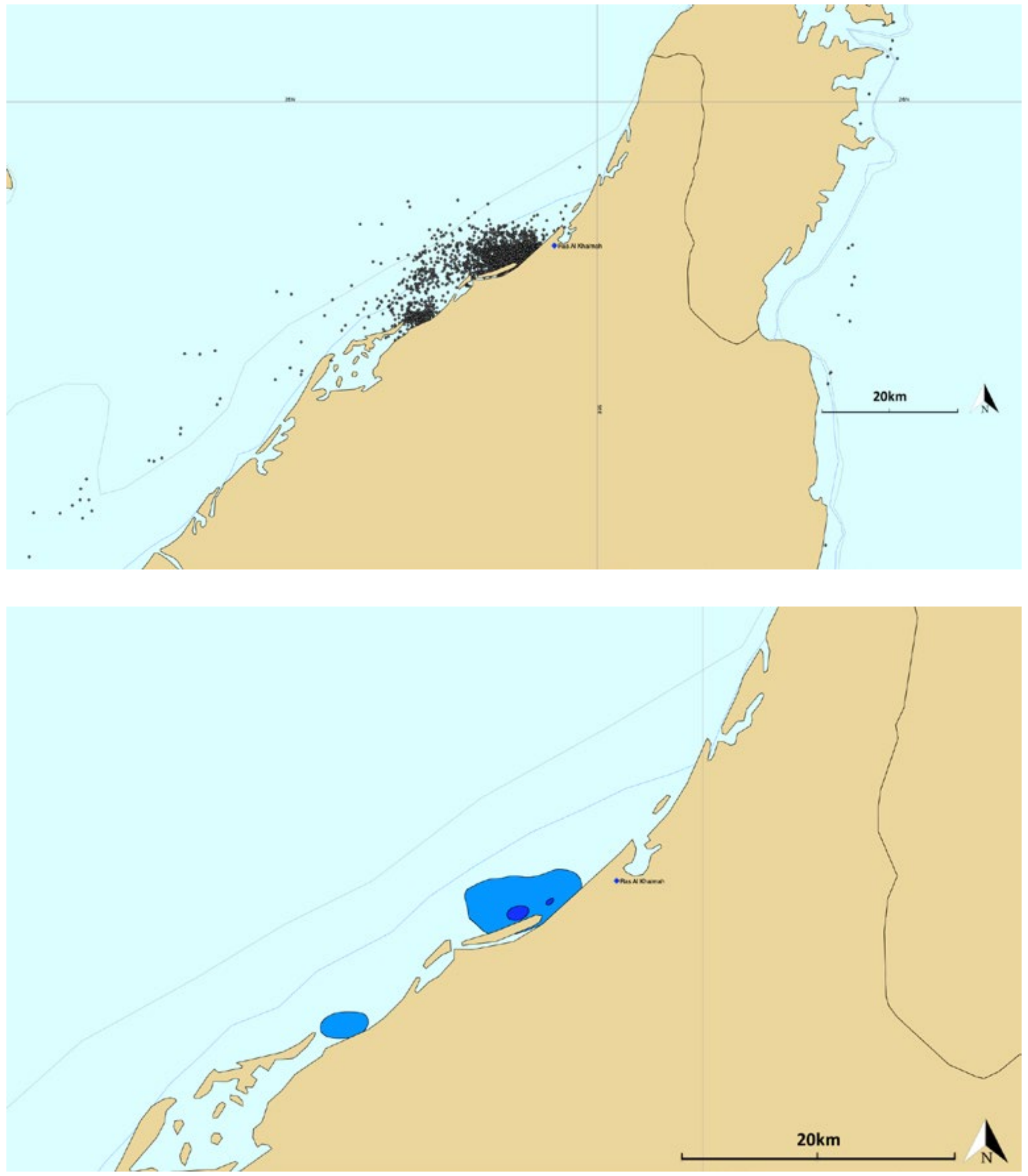
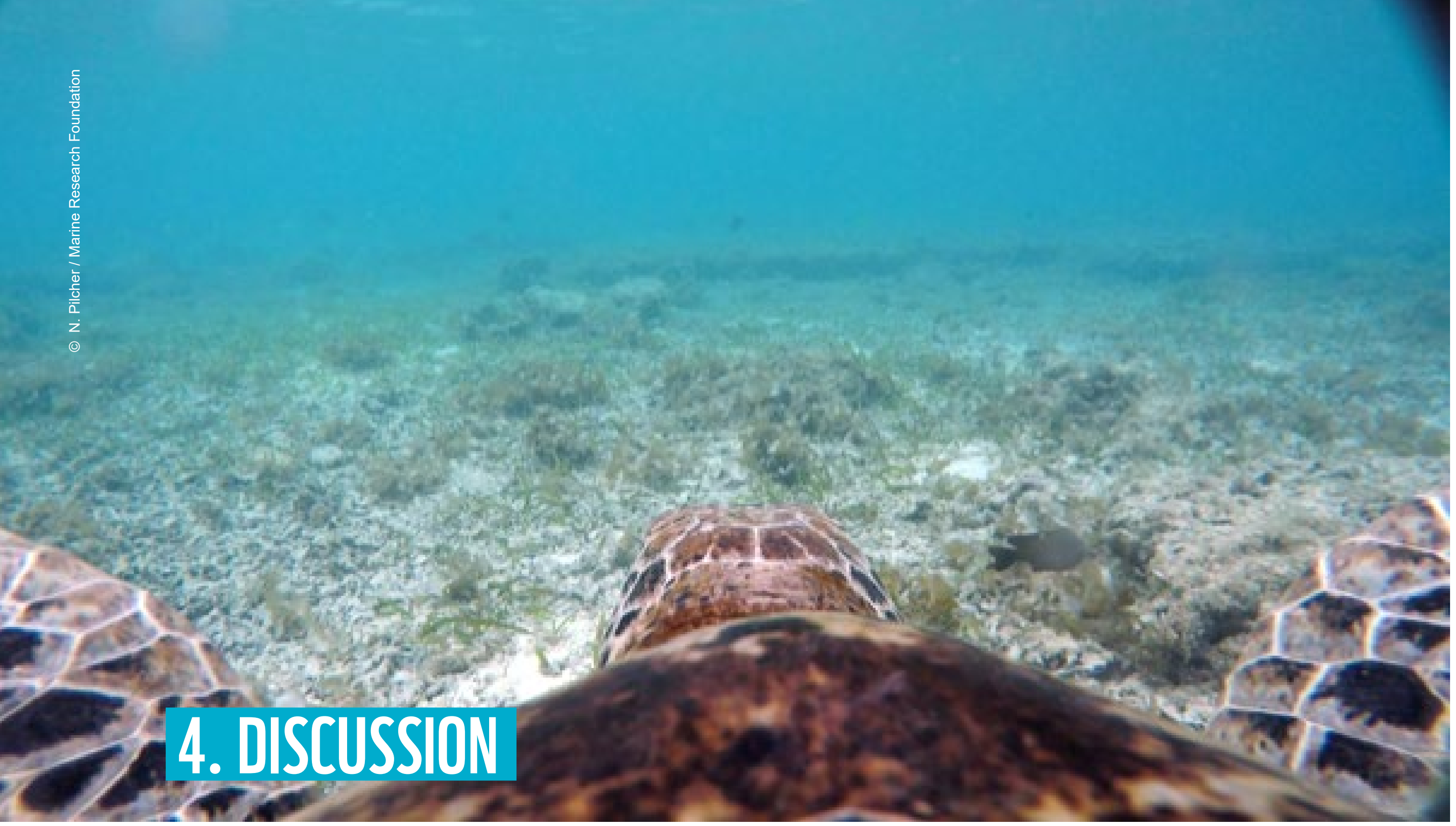


Figure 25: Locations of foraging grounds off Ras Al Khaimah Top panel: raw data showing all points from foraging turtles. Bottom panel: 90% home range (50.1 km²) and 30% core habitat (1.84 km²).



4. DISCUSSION

Sea turtles are vulnerable to anthropogenic threats when they emerge to nest. They are also vulnerable to fishing nets drifting aimlessly at sea and can be entangled in fishing lines. In some countries they are hunted as food, and the hawksbill turtle is hunted for its shell to supply a curio trade. Being long-lived and of late maturation they face these multiple threats over long periods of time. The green turtle is listed as Endangered globally, and Vulnerable in the Gulf region.

To protect sea turtle populations it is necessary to 1) understand their biological needs; 2) determine key threats; 3) design measures to mitigate those threats; 4) assign turtles a suitable level of value at a societal level (both public and private) to garner support for conservation measures, and; 5) implement the conservation initiatives over a suitable time frame (multiple decades in the case of green turtles).

To address some of the information needs in support of conservation action, understanding the location of critical turtle habitats, migration corridors, courtship areas and the times turtles spend at these, along with an understanding of the linkages between foraging grounds and nesting sites is essential for the design of effective and efficient conservation programmes.

The results from this project provide the first evidence of migration pathways for green turtles in the Gulf region; linkages between foraging grounds in the United Arab Emirates and nesting sites in Oman; international movements of post-nesting turtles from Oman to India, Eritrea and the UAE, and expanded our knowledge of foraging ground extent and use in the UAE. These data can inform management agencies and conservation practices in a region home to one of the most climate-challenged marine habitats on the planet, subject also to immense urban expansion, shipping and petrochemical industry pressures, and which supports large nesting and foraging populations or endangered sea turtles. Armed with this information, management agencies will be better able to target effective and efficient conservation action. Individual findings from this project are addressed in the following sections.

4.1 CONSERVATION STATUS

It is complicated to assess the conservation status of a species that is widely distributed across the planet and under varying threats and facing differing conservation outlooks. Under these conditions it is not possible to arrive at a robust global picture of the conservation status of all individuals within that species, but which reflects local conservation challenges and population status. The challenge is that marine turtles are spread throughout virtually all tropical and sub-tropical waters of the planet. They nest across thousands of nesting beaches, and often migrate thousands of km from feeding grounds to nesting sites. They occupy differing habitats as hatchlings, juveniles and adults, have migratory bottlenecks (like when they round the Straits of Hormuz) and disparate feeding strategies. And they face pressures from human consumption, bycatch in fisheries, climate change, marine debris, loss of nesting beaches through urbanization and industrialization, and myriad other hazards. If all turtle populations of the planet were treated as equals the resulting assessment would not be a realistic indication of conservation status at local levels.

So when assessing the conservation status of a species, such as the green turtle, it is more useful to focus more specifically on the assemblages of animals that nest in a particular region, while taking genetic diversity into account, and the vast distances the turtles travel. The IUCN SSC Marine Turtle Specialist Group – the authority tasked with assigning species status to sea turtles - resolved this through an innovative approach that considered all of the above points, and more, to break global assemblages of populations of one species into more manageable components, and called these Regional Management Units, or RMUs. The RMU approach is accepted by IUCN as an equally valid way of looking at what the Red List process considered ‘subpopulations’.

RMUs basically group nesting turtles by genetic similarities, and then expand their range to include nesting beaches, migratory routes and foraging ground ranges, so that all individuals which are ‘linked’ are assessed as a unit. That is, Indian Ocean green turtles are assessed separately from, say, Pacific Ocean green turtles. One of the improvements brought about by this process is that it allows for different genetic stocks overlapping in their range, but considered as separate units. For example, Atlantic and Caribbean green turtles might use some of the same foraging grounds, but this does not mean they are linked and need to be assessed jointly.

Under the new assessment process green turtles were assessed as being Vulnerable in the northwest Indian RMU, as the region is still propped up by robust population numbers in Saudi Arabia, Oman and Yemen. While this suggests that there are fewer concerns, at the local level green sea turtles continue to face substantial pressures. This is exemplified by the loss of a turtle off Qatar, likely as a result of a boat strike or an accidental capture in fisheries. Turtles face pressures from fishing fleets, particularly from trawling (where it is still legal in Bahrain, Iran and Saudi Arabia). Beach seines in Ras Al Khaimah and Sharjah also entrain hundreds of sea turtles but it is understood that most of these are released unharmed. Threats also exist from boat strikes, and habitat degradation. Habitats can be degraded or lost via landfilling and dredging operations, through chlorinated hyper brine effluents from industrial facilities, and from oil spills. Thus while the conservation status is not elevated as in the case of the hawksbill turtle (which is listed as Critically Endangered) there remain a mountain of challenges for sea turtles in the Gulf region.

4.2 POPULATION DYNAMICS

The sampling regime for turtles at Ras Al Hadd in Oman was straightforward: all turtles were adult females, identified as such by selecting only those turtles that emerged to lay eggs. In contrast the sampling regime at Ras Al Khaimah resulted in a random mix of juvenile, subadult and adult turtles caught indiscriminately by the long beach seine. Different yet to these was the sampling regime at Bu Tinah, where the rodeo capture technique targeted primarily larger turtles, many of which were subadult turtles and a handful of which were juveniles. This led to a biased overall 'structure' of the green turtle population sampled during this project. There are significantly greater numbers of juveniles caught at Ras Al Khaimah but only three caught at Bu Tinah, and there was a higher proportion of subadult turtles caught at Ras Al Khaimah (Table V). It is likely that an unbiased sampling regime at Bu Tinah would yield a greater proportion of juveniles and subadult turtles – indeed many were seen but not caught during the fieldwork- however this was not an objective of the current project. It would be a useful exercise to better understand population dynamics at these two foraging grounds, via long-term projects using mark-recapture and laparoscopy to identify recruitment rates into the different age classes and changes to population structure over time.

Table V. Proportional capture of turtle age classes by location.

Ras Al Khaimah	Bu Tinah	Ras Al Hadd
14	3	0
19	25	0
23	149	6

4.3 DATA QUALITY AND INTERPRETATION

This project used over 20,000 data points collected over more than 6000 transmission days to understand the linkages between foraging and nesting sites, migration routes, habitat connectivity and green sea turtle behaviour in the Arabian Gulf region. One of our key reasons to spread the tracking effort over multiple years was to lessen the possibility of any one year being 'different'. With changing weather conditions, development activities (e.g. seismic tests ongoing during transmitter deployment) and varying levels of effort, the project tracked turtles over four years (2016-2019) to 'normalise' the results for the species.

In addition to this, the project also needed to compare activities amongst turtles, and to do this we filtered the data and selected one single point per day and one single point per night for each turtle (recent scientific studies have shown that there can be substantial differences in night time habitat when compared to day time habitat, so we selected the highest quality point for each turtle closest to midday and closest to midnight).

Selecting two points per turtle per day also normalised the activity between turtles. For instance, if one turtle spent more time at one site and sent more signals, this could suggest the area was more important than another area where several turtle combined may have sent fewer signals.

Overall the data sets provided by the turtles were sufficient to reveal habitat connectivity at the broad scale: linkages between Bu Tinah, Ras Al Khaima and Oman; coastal movements, a lack of linkages with Saudi Arabia and short-term (unexplained) looping migrations. The data are limited by the precision of the signal quality received and processed by the Argos satellite system, and generally should be considered to be accurate to within 1000m. This is sufficient to indicate movement patterns at a broad scale, but in cases where finer-scale analyses are required (for instance in Um All Quwaim or Khor Kalba), it may be useful to use GPS-linked tracking devices with positional accuracy of <10m.

An important note related to data relates to the limits to what can be interpreted from signal movements: transmitters send signals to the orbiting satellites but do not contain information on what the turtle is actually doing – this has to be inferred from a view of the entire behaviour pattern for each turtle. However, based on known and understood principles of sea turtle biology, much can be deduced from the tracks. When the turtles remained on the foraging grounds one could reasonably expect them to be feeding, building energy reserves in readiness of the impending nesting migration. These points typically appear as aimless movements all clustered in the vicinity of a central point (the core area within the home range). Following this the turtle behaviour changes into purposeful movements with a (relatively) straight-line displacement. Upon reaching courtship or nesting areas the movement patters revert to the aimless clusters of points. Where no nesting is known to take place (e.g. Musandam and Daymaniyat) these clusters can be assumed to represent courtship areas and where nesting has been confirmed in the past, the clusters can be considered as courtship and internesting habitat. One can infer renesting frequency by the number of two-week intervals turtles spend on the nesting habitats.

However, outside of this it is not possible to clearly define behaviour: why did turtles cross to Iran and not remain along the Omani coast during nesting migrations, when the return paths clearly took them along the coast? What were turtles doing during the looping movements to the north and east of Bu Tinah and why did they do this? Why did one turtle migrate to India on her way to Oman? Why did signals end prematurely for a number of transmitters? The responses to these questions simply cannot be deduced from the satellite telemetry data.

4.4 MIGRATION BEHAVIOUR

Sea turtles have evolved to migrate substantial distances between foraging and nesting grounds. It is likely that the selection of nesting grounds is based on evolutionary choices forced upon turtles with long-term sea level rise and fall. As sea levels rise turtle nesting beaches become unsuitable and turtles venture farther in search of suitable alternatives. But this process rarely works in reverse, with turtles finding beaches closer to home.

Turtles from Oman all migrated substantial distances (500 km to 2000 km) when returning to their foraging grounds, and this is possibly linked to the bathymetry along the coast of the Arabian peninsula, which drops away steeply and does not provide sufficient shallow-water, soft-sediment habitat on which sea grasses can grow. Both the Gulf of Kutch and the Dahlak archipelago offer this sort of habitat, as does much of the Arabian Gulf, explaining the movements of Oman's turtles to these destinations. It is likely that with a larger sample size of post-nesting turtles from Oman the project could identify additional foraging destinations for post-nesting turtles from Oman, and this should be a consideration for national research plans by Oman's Ministry of Environment and Climate Affairs.

All female turtles tracked from Bu Tinah migrated to Ras Al Hadd, with no records of movements to any other destination. This is relevant in the context of nesting population sizes, whereby Oman hosts some 80% of all green turtle nesting in the Arabian region. Recent tracking of post-nesting sea turtles from Saudi Arabia similarly did not display movements to UAE waters, with most turtles headed east towards the Iranian coast. It is possible that with a larger tagging sample size the project may have recorded a migration northwards into Saudi Arabia, but it is likely that the effort required to increase the sample size might be more easily explained via genetic studies. This project collected tissue samples for genetic analysis from all of the green turtles that were processed, but these have yet to be analysed. Notwithstanding some older work on genetics in the Gulf region, there continues to be a need for a large sampling regime among turtles nesting on Saudi Arabian islands against which to which compare the UAE samples. However, once these two tasks are completed it is likely that linkages between these two sites may be more clearly explained.

There were clear overlaps between habitat use of foraging turtles at Ras Al Khaimah and post-nesting turtles from Oman, suggesting that these populations are one and the same – at least that a proportion of Ras Al Khaimah foraging turtles nest in Oman. The project also documented round trip foraging-nesting-foraging migrations for turtles from Bu Tinah to Oman and back, showing how Oman's nesting turtles originate from multiple foraging stocks (also including stocks from as far away as the Red Sea and the Indian coastline).

Male turtle movements overlapped somewhat with the movements of female turtles, with some notable exceptions. Male turtles appear to have stopped at courtship areas that were away from the nesting beaches (notably off Dubai, Musandam and the Daymaniyat islands). While the project did not record any female turtles stopping at these areas this is likely an artifact of sample size and chance. There is no evolutionary reason why a male turtle would migrate to areas that were not part of the population's reproductive strategy, and it is known within sea turtle biology that courtship areas do not necessarily overlap with nesting areas.

The other exception to the migration movements by male turtles was displayed by a turtle that travelled north towards Qatar (possibly with Saudi Arabia as a destination). Without a single record of a northward movement by a turtle until 2019, male turtle 169440 headed towards Qatar after 109 days on the foraging grounds (Figure 26), potentially on his way to the nesting beach islands in Saudi Arabia (Karan and Jana Islands, primarily). While a nesting destination in Kuwait cannot be ruled out, the probability of this given the disparity in nesting stock sizes (tens in Kuwait, 1000s in Saudi Arabia) suggests this would be unlikely. Unfortunately the transmitter stopped sending signals prematurely and following an in-depth look at the signal quality and patter we believe the turtle may have been injured as it neared Ras Laffan Industrial city in Qatar. While Ras Laffan Industrial City has a large and buy seaport, there are also multiple fishing vessels operating in the region along with offshore oil & gas supply and support vessels, any one of which could have contributed to the turtle's condition.

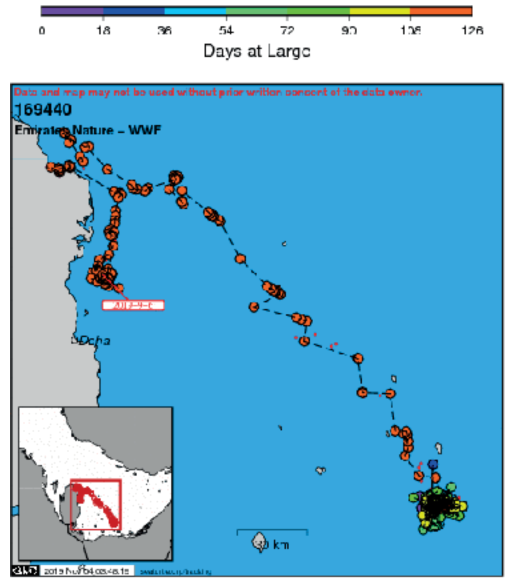


Figure 26: Northwest movements of male green turtle 169440 from Bu Tinah in Abu Dhabi.

In addition to the lone northward movement by turtle 169440 which appeared to be nesting-related, several turtles also undertook some looped swims to the north and east of Bu Tinah that remain unexplained (Figure 26). Some clear examples of these were demonstrated by turtles 160243, 160245, 170121 and 169443. There is the possibility that the migrations were stress responses to the capture and subsequent tagging, but this notion is dispelled by turtles 169443 and 170121 as they remained on the foraging grounds for 117 and 110 days respectfully before moving out on their looping migration.

Turtle 169443 completed the extended swim out to the ~100km north in just one week. Turtle 170121 reached ~200 km from Bu Tinah in 16 days with no apparent stops along the. Turtle 160243 departed immediately and spent 18 days in a loop with no apparent stops until she returned to Abu Dhabi. Similarly, turtle 160245 also departed immediately, taking up residence at a different foraging ground after completing the looping swim. Turtle (169445) undertook looping movements, looping north in August 2019, then east in early September 2019, and finally west in September/October 2019 before returning to Bu Tinah. These movements are uncharacteristic of sea turtles, and once again do not appear to have been a behavioural reaction to the tagging process, as the turtle remained at the Bu Tinah for 108 days before commencing the first loop.

These loops were somewhat similar in shape to migration loops were detected in hawksbills back in 2010-2014, but with a few major differences: 1) the hawksbills in 2010-2014 were 'away' for two to three months while the green turtles in this study were only gone for one to three weeks; 2) the hawksbill turtles moved far further north and east in search of cooler waters, whereas this turtle only moved around 100km; and 3) the hawksbill turtles were seeking out cooler waters, while there were no temperature variations across the locations green turtle ventured during this project (Figure 27).

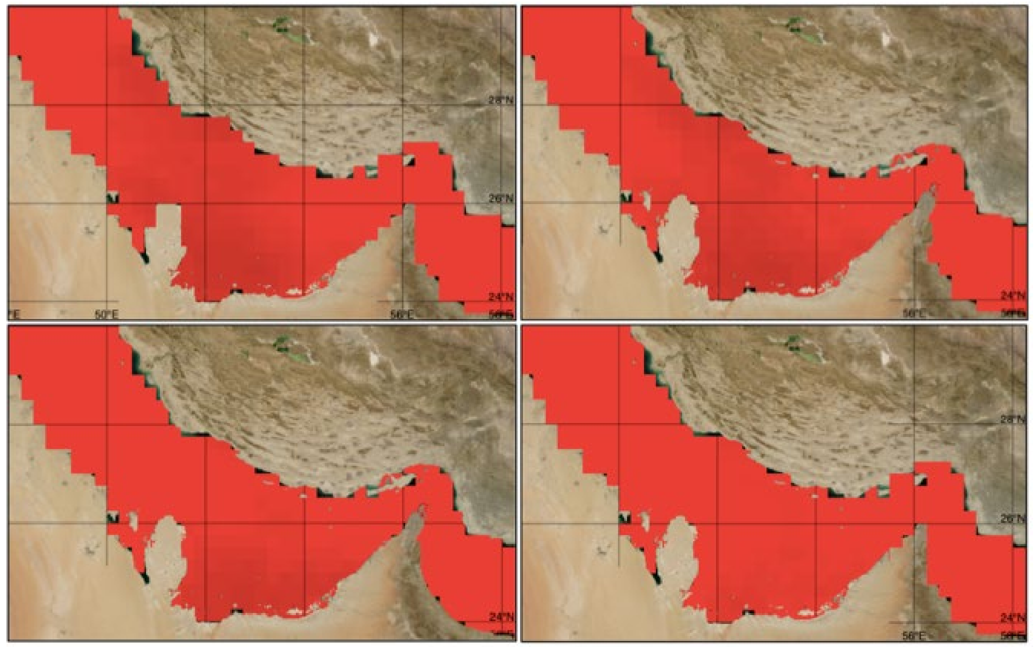


Figure 27: An example of sea surface temperatures in the Gulf on (clockwise from top left) 03, 06, 09 and 12 September 2019 indicating a lack of temperature gradient during the looping migration by turtle 169443.

While it is important to record direction and duration of turtle movements, it is also worthwhile to note how the turtles moved. The project found that turtles preferred to stay close to shore, hugging the coastline (e.g. turtle 163502 travelled from Oman to Eritrea and turtle 160246 moved from Oman to the UAE remaining within 10 km of shore for the entire journey) except in a few isolated cases. For instance, turtle 163503 migrated from Oman to India, and had no choice but to cross deep waters, choosing however to move northward to Pakistan rather then directly eastward to India. In addition to this, turtle (170124) appeared to make a mistake while heading to Oman and reaching India instead, remaining in coastal waters all the way. But rather than return along the same coastal route she was the sole turtle during this project that purposefully crossed the deep Indian Ocean to reach her nesting grounds in Oman.

Conversely, the project recorded several turtles that could have taken a more coastal route but chose not to. In 2018 we recorded six turtles going from Bu Tinah to Oman that swam up the coast of the UAE, reached the Straits off Hormuz and crossed over to Iran. They continued down the coast of Oman and only then did they cross somewhat deeper waters before reaching the Omani coast and continuing, in a coastal manner, towards Ras Al Hadd. On the return journeys they generally remained coastal, so it is unclear why they would not have stayed along the Oman coast in Musandam and down via the UAE and Omani coasts to their destinations.

4.5 NESTING HABITATS

The sole nesting habitat identified during this project was the well-known string of beaches at Ras Al Hadd in Oman. The use of these beaches was documented via multiple re-nesting events by Omani nesting turtles and UAE foraging turtles confirming bidirectional movements of green turtles between the two countries, and across multiple foraging grounds. It was interesting to note that none of the turtles nested in Saudi Arabia, but as suggested above, this has much to do with the proportional distribution of nesters in the region, with Oman (and Yemen) hosting far greater numbers of nesting green turtles than Saudi Arabia.

Of interest also from the movements of turtles from Ras Al Hadd was the finding that these turtles are connected to multiple foraging grounds (Bu Tinah and Ras Al Khaimah and other sites in the UAE, and at least two additional foraging stocks). These movements reinforce the value of the IUCN RMU assessment protocols that take into account nesting and foraging stocks, migration linkages and regional genetic assemblages.

4.6 FORAGING GROUND EXTENT

Sea turtles are mostly protected at their nesting beaches across the region, but less is done about protecting sea turtles at sea, where they spend the vast majority of their time. The extent of the foraging grounds used by turtles in this project are useful data sets that will allow the design of practical and targeted management and conservation action by the relevant government agencies in each Emirate that can further extend the level of protection afforded to sea turtles in the UAE.

The Marawah – Bu Tinah foraging ground is an important habitat for dugongs (Dugong dugon) – indeed supporting the world's second largest aggregation of dugongs, and its designation was largely due to the presence of this species. Dugongs are herbivores, feeding on the same seagrass resources that support the large population of green turtles, and thus it is hardly surprising to find their habitats overlap. The Reserve boundaries actually encompassed approximately 76% of foraging locations received by green turtles in the southwest Arabian Gulf between 2016 and 2019, providing a good level of protection to sea turtles during developmental and foraging life stages. The only suggested expansion to this high level of this protection would be the inclusion of waters surrounding the western end of Abu Al Abyad island, where multiple turtles pointed to important feeding grounds.

The recent designation of Khor Mazhami in Ras Al Khaimah as a protected wetlands area is a welcome addition to the protection of sea turtle habitat. While it is unlikely that many sea turtles use the inner waters of the Khor, the data from this project clearly depicted important foraging grounds in the nearshore waters extending 3-5 km from the Saraya sandbank that could be incorporated into the protected area boundaries, and the project has already made the data sets from this work available to the Environment Protection and Development Authority of Ras Al Khaimah.

4.7 IMPORTANT TURTLE AREAS (ITAS)

One of the key objectives of this project was to refine our knowledge of Important Turtle Habitat (ITA) in the Gulf region, a concept coined back during the hawksbill tracking project to identify those areas at sea where we know less about turtle habitat use than we do on land. Nesting beaches have been well-documented in the Gulf region, but a better understanding of habitat use at sea will allow managers and conservation practitioners to develop targeted conservation action. Figure 28 depicts the location points for all of the turtles tracked inside of the Gulf, and the clusters highlight the favoured foraging grounds. While some of these clusters are made by single turtles sending multiple signals, others indicate areas of higher importance as the data represent signals from multiple turtles. For instance, the red cluster in the vicinity of Saadiyat island just east of Abu Dhabi was made by a single turtle, while the markers in the vicinity of Abu Al Abyad were made by five turtles. Each of the two blue clusters south of Bu Tinah were made by individual turtles, as was the lone black cluster off Dubai (this one was actually identified as a potential courtship area).

Of greatest importance to turtles are the dense clusters surrounding Bu Tinah and Ras Al Khaimah, reinforcing our understanding of the extent of these areas and their importance to green sea turtles in the Arabian Gulf. These two sites are hereby deemed as Important Turtle Areas based on the number of turtles that utilised the habitats over the four years, and the constrained nature of the location data into defined geographical areas.

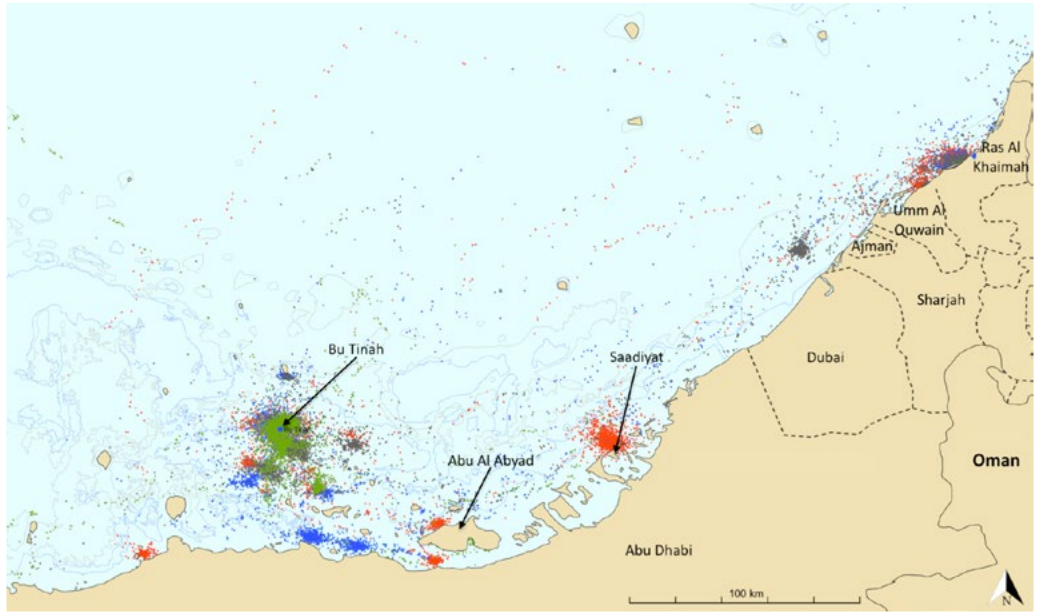


Figure 28: Location points from all turtles tracked in the southwest Arabian Gulf between 2016 and 2019. Movement lines have been removed for clarity. Red markers: 2016 deployments; Blue markers: 2017 deployments; Black Markers: 2019 deployments; Green markers: 2019 deployments. Dashed lines represent the borders between Emirates.

4.8 OVERLAP OF FORAGING GROUNDS WITH MAPPED SEAGRASS HABITAT

Green turtles are herbivorous, and feed primarily on seagrasses once they settle on neritic feeding grounds. Therefore their habitat occupancy off the United Arab Emirates was expected to dovetail substantially with mapped seagrass habitats within the southwestern Arabian Gulf.

But the project found that many of the key areas used by green sea turtles were not mapped seagrass areas – although they very well might contain seagrass (Figure 29). That said, it is important to note that the location data that the project accumulated does not represent only those periods when turtles were feeding, but also areas where they rest, sleep, migrate, and undertake other natural biological functions. That is, the location points do not only point to feeding habitat.

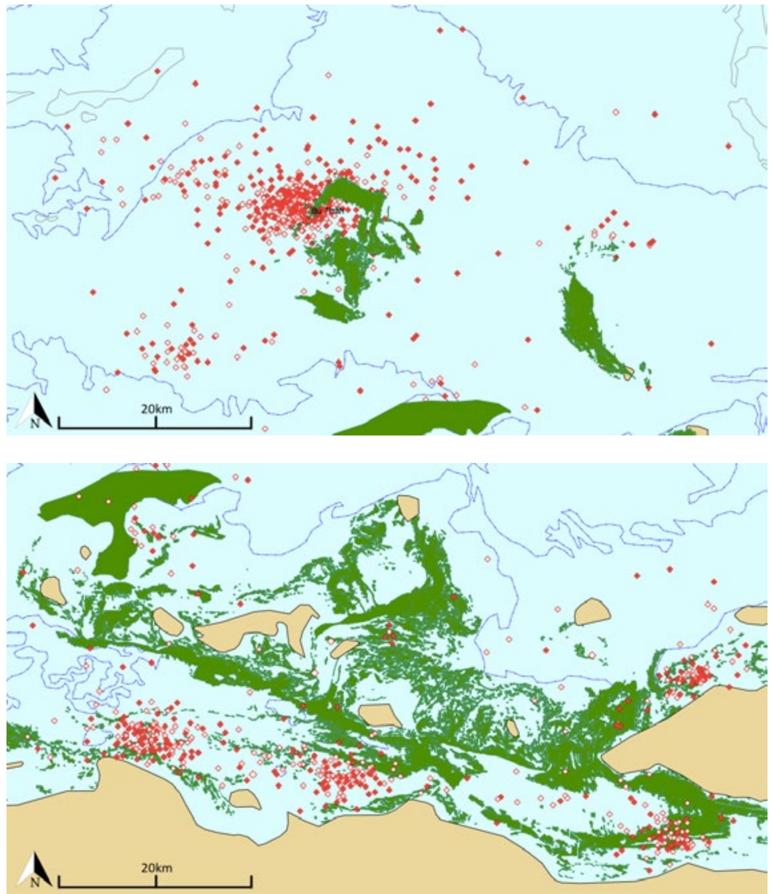
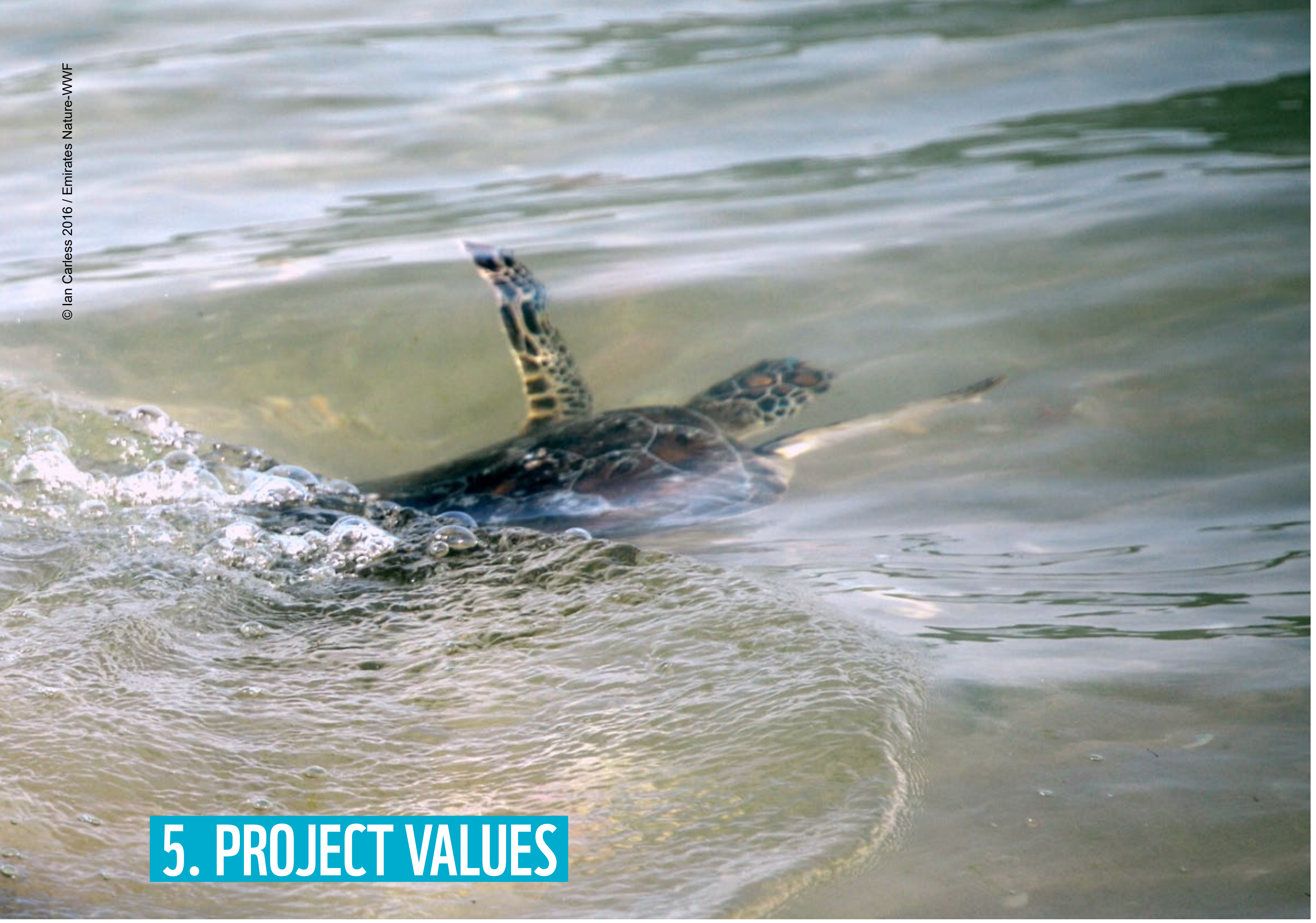


Figure 29: Relationship between location markers and seagrass habitats for green turtles tracked during the Green Turtle Project. Top panel: clear use of seagrass habitats by turtles at Bu Tinah; Bottom panel: lack of overlap between location markers and seagrass habitats between Abu Al Abyad and Al Mirfa.

Thus, while some of the seagrass habitat maps and turtle distribution do not overlap entirely or conclusively, it is likely that some of the area within the turtle distribution contains seagrasses that have yet to be mapped, and also likely seagrasses this need not cover the entire distribution maps of green sea turtles in the Gulf. Lastly, it is important to also note that not all seagrass areas need necessarily support sea turtle populations.



5. PROJECT VALUES

5.1 POTENTIAL CONSERVATION / MANAGEMENT AREAS

Several key habitats that are currently not under any form of protection or management have been revealed through this study. The Gulf of Kutch in India and the Dahlak archipelago in Eritrea, along with the northeast coast off Masirah in Oman are worthy of additional study, given the project only recorded one movement to each of these sites. It is likely that additional studies at these sites, or additional tracking from Ras Al Hadd would reinforce the value of these two locations (and potentially identify additional locations) as green turtle foraging habitat. In order to better understand regional linkages outside of the Arabian Gulf, studies such as these are highly recommended. Similarly, an expansion of tagging effort to other areas in the UAE might also point to additional key foraging areas.

In spite of these limitations, in addition to the Marawah Marine Biosphere Reserve in Abu Dhabi and the Khor Mazhani protected area in Ras Al Khaimah, within the UAE there are several additional noteworthy foraging habitats that fall outside current marine protected areas:

1. Waters outside of the recently declared Khor Mahzani wetlands reserve in Ras Al Khaimah. Green sea turtle foraging habitat extends offshore and southwest of the proposed reserve boundaries (Figure 30) and should be considered in the delineation of the final protected area.
2. The region south west of Al Marjan Island and northeast of Al Rafaah in Umm al Quwaim. Foraging green turtles from Ras Al Khaimah also use foraging grounds further west of the Khor Mahzani area which are worthy of consideration for management of fishing and boating activities (Figure 31). Multiple turtles occupied this habitat during the course of the project, and while the area is smaller than that off the Saraya sanbank it represents an important sea turtle foraging habitat.
3. The waters off Saadiyat island east of Abu Dhabi (Figure 32) were also documented as green turtle feeding areas, however the location cluster was created by the movements of only one turtle, rather than multiple turtles. It would be of great use to conduct additional studies in this region to determine if the habitat is used by a larger number of green turtles.
4. The waters surrounding the western extent of Abu Al Abyad Island in Abu Dhabi. Several turtles displayed an affinity for foraging grounds north and south of Abu Al Abyad Island (Figure 33) and warrant consideration of an expansion of the Marawah Marine Biosphere Reserve. While not as concentrated as points off Rask Al Khaimah and Saadiyat the fact that multiple turtles used these foraging grounds points to their importance.

It is likely also that tagging programmes in the far western extent of Abu Dhabi and other regions within the UAE might also reveal additional important turtle areas for the UAE. This project limited deployment of transmitters to two well-known foraging grounds, and none of those turtles ventured out to the west to seek foraging grounds. It is likely that additional foraging areas exist in this region that have yet to be identified. Lastly, it is likely that – notwithstanding the small proportions of turtles that link Saudi Arabian nesting sites and UAE foraging grounds - additional tagging of post-nesting turtles from Saudi Arabia may identify foraging grounds for green turtles in the UAE that were not identified during this project.

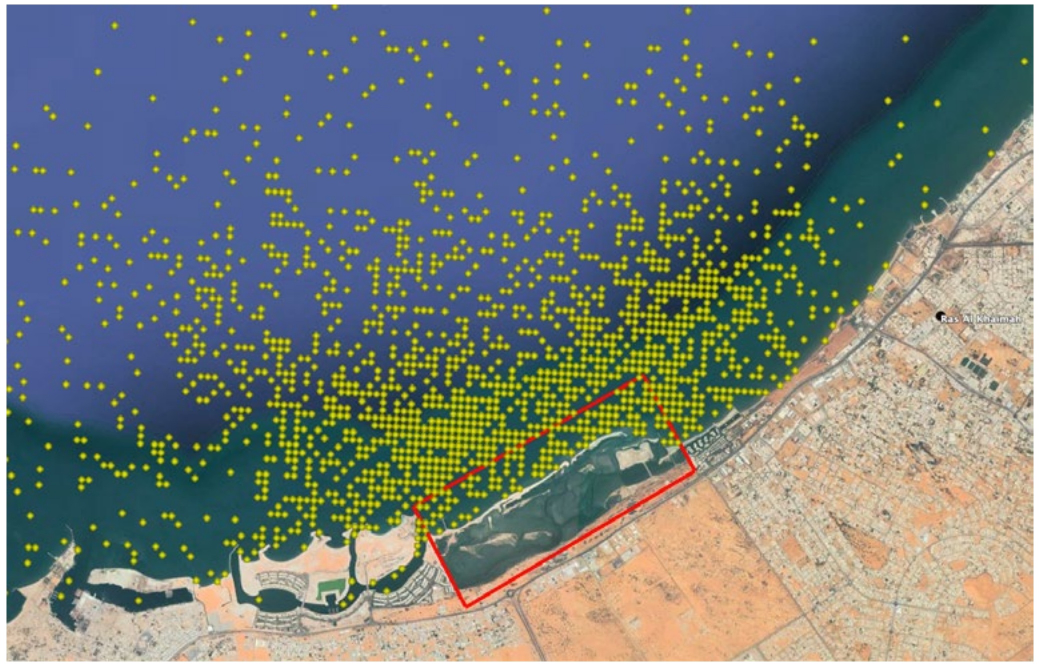


Figure 30. Filtered location points off the coast of Ras Al Khaimah in relation to the proposed Khor Mahzani reserve (while at present the exact boundaries remain unknown, the area highlighted in red encompassed the general area in question)

Figure 31. Filtered location points for Ras Al Khaimah foraging turtles indicating use of the waters west of Al Marjan island.

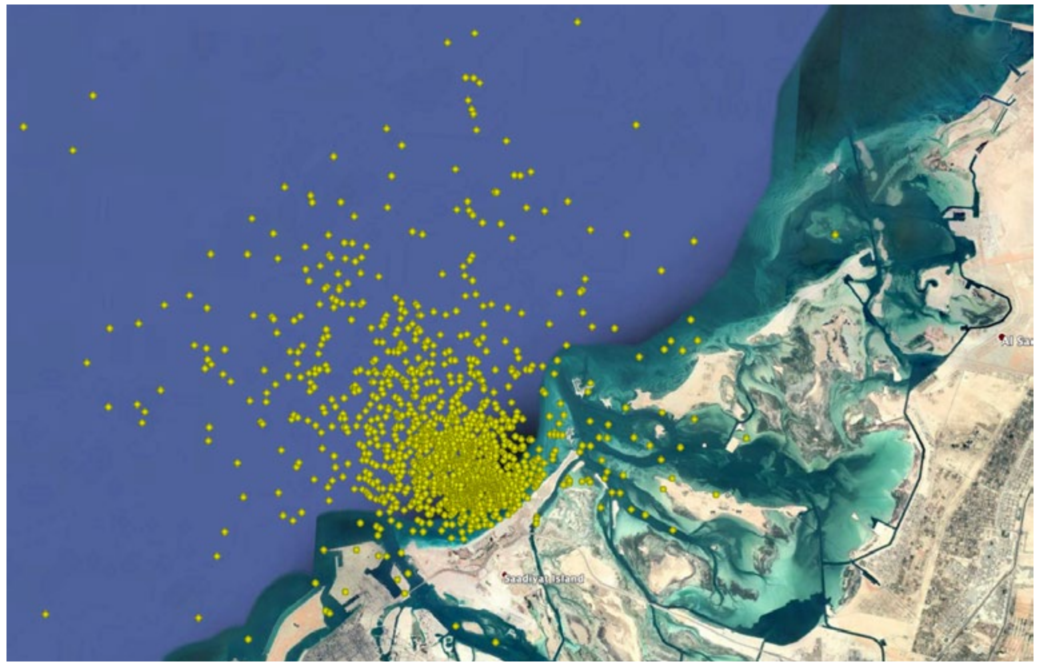


Figure 32. Filtered location points off the coast of Abu Dhabi indicating substantial use of the waters off Saadiyat Island.

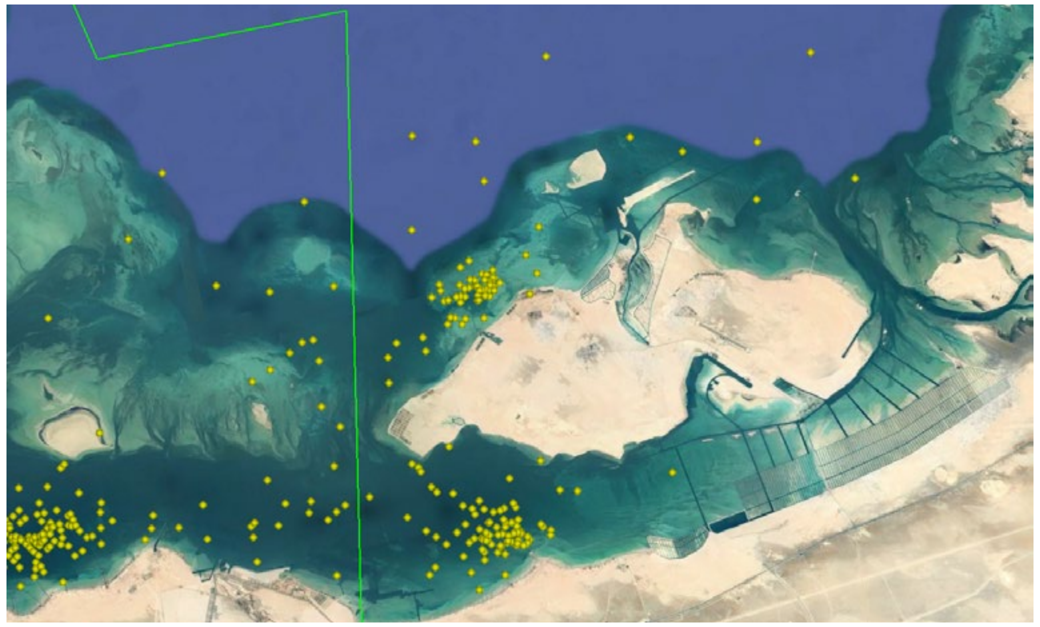


Figure 33. Filtered location points by five turtles off the coast Abu Dhabi highlighting use of waters around Abu Al Abyad Island. Green line marks the eastern boundary of the Marawah Marine Biosphere Reserve.

5.2 DATA USES & CONTRIBUTIONS

The knowledge and science garnered by this project contribute to advancements in conservation and assist in the development of pragmatic management interventions. The outcomes of this work impact the following spheres of management and governance:

1. CONTRIBUTION TO THE UAE SEA TURTLE NATIONAL PLAN OF ACTION (NPOA)

In 2019 the United Arab Emirates released its first National Plan of Action for the Conservation of Sea Turtles. Launched by the Ministry of Climate Change and Environment, the three-year NPOA for the Conservation of Marine Turtles in the UAE aims to expedite local laws to protect turtles and stymie the direct and indirect causes of their deaths. These causes include abandoned fishing nets, plastic debris and other pollution as well as the destruction of turtle habitats through coastal developments, desalination and climate change. Increased research, monitoring and information exchange is also outlined in the scheme. The data generated by this project (and its precursor, the Hawksbill project of 2010-2014) were large contributions of knowledge on which many of the actions in the NPOA were based.

2. UPDATE TO THE UAE ENDANGERED SPECIES LIST

Also in 2018 and 2019 the UAE conducted its internal Red List assessment for marine and terrestrial species, amongst which sea turtles were assessed. The data generated by the green and hawksbill turtle projects were key data sets used in determining range and connectivity, allowing accurate assessments of habitat use and connectivity than had been understood from limited tag return information and limited tracking in the past.

3. IMPROVED AWARENESS AT A NATIONAL AND INTERNATIONAL LEVEL

Sea turtles extremely charismatic species. Sea turtles have the ability to evoke a wide range of empathetic and mesmerizing emotions amongst the general public, and with greater the press coverage, there is greater general public participation and contributions to turtle conservation. Since the inception of the Gulf Green Turtle Project there have been a minimum of 70 press coverage events comprising over 200 pages of media coverage by major newspapers or television news channels, in electronic print media and television alone. At today's advertising rates, this coverage is worth some USD 750,000 in-kind support of sea turtle conservation. While we acknowledge that the press coverage was not generated solely via the Gulf Green Turtle Project, we believe that the project contributes substantially to the interest amongst both the press and the wider general public.

4. COLLABORATION AMONGST MULTIPLE LOCAL AGENCIES AND STAKEHOLDERS

The Green Turtle Project has brought together multiple national agencies with a common goal: the conservation of sea turtles in the UAE. These agencies include the Ministry of Climate Change and Environment, the Environment Agency Abu Dhabi, the Environment Protection and Development Authority of Ras Al Khaimah, and the Environment and Protected Areas Authority of Sharjah. Internationally the project has also collaborated with Oman's Ministry of Environment and Climate Affairs, the Environment Society of Oman, Five Oceans LLC and the Marine Research Foundation. At a global level, the project has contributed to initiatives under the UN Convention on Migratory Species and the UN the Convention on Biological Diversity. The collaboration and heightened dialogue amongst this wide and multi-faceted list of key players will lead to improved conservation of sea turtles in UAE waters for years to come.

5. IMPROVED UNDERSTANDING OF BIOLOGY AND ECOLOGY OF GREEN SEA TURTLES IN THE GULF REGION

Sea turtles continue to be enigmatic, and this project has unraveled some of the mysteries with regard to Gulf green turtles. We now have a much better understanding of where they nest, what habitats they use to forage, possible courtship areas, and where these areas overlap with human expansion and industrial development. We know more about nesting frequency, about nesting beach fidelity, and about genetic connectivity than we ever did in the past. The data generated by this project will be published in peer-reviewed publications to share with the wider scientific and conservation community, and will be legacy documents in our quest for knowledge on sea turtle biology and ecology in the Gulf region.

6. CONCLUSIONS

After four years of work Emirates Nature – WWF, the Marine Research Foundation and the project partners have amassed the most robust data on migrations and linkages between feeding grounds and nesting grounds for sea turtles ever assimilated for the Gulf region. At a wider geographical scale, the project has some of the most robust data sets linking feeding and foraging sites in the entire Indian Ocean.

By tracking 51 green sea turtles between 2016 and 2019 the project has gathered a wide range of information related to biology and ecology of green turtles in the Gulf region. These new findings support National and regional conservation and management activities, and the data provide added information related to the extent of foraging areas in Abu Dhabi and Ras Al Khaimah waters. They also indicate that Gulf turtles also migrate towards India and Eritrea, provide some insights into mating behaviour, and highlight clear linkages between the UAE and Oman.

The education and awareness components of this work, alongside the substantial partnerships and communication channels that have been established or enhanced through this tracking project, bode well for the future of sea turtles in the UAE. Press releases between 2016 and 2019 in the UAE portray the current focus on sea turtles: “Critically-endangered Hawksbill turtles to start annual nesting in Abu Dhabi”; “Endangered turtles released off Bu Tinah Island”; “Green Turtle juveniles under long-term observation”; “UAE sea turtles at risk of disappearing”; “Sheikh Mohammad releases giant turtle into the Arabian Gulf”; “25 turtles released into the sea after being nursed back to health”; “UAE ecotourists help save Hawksbill turtles”; “Turtles swim towards a new life, thanks to UAE marine specialists”; “Dubai princess rescues 80-year-old turtle”; “Turtle›s plastic-filled stomach highlights ocean crisis”; “Ras Al Khaimah bans plastic bags in sea to protect marine life”; “Sea turtles are down but not out”. Their Excellences the Royal family, major corporations and the public at large have been involved in turtle releases and awareness activities.

The project has drawn together partners from multiple backgrounds and interests, and has awakened interest amongst the media and the general public. It has influenced national policy, and ignited a passion for sea turtles throughout the UAE. This work contributes to setting National policy in the UAE, and at the same time forms the backbone to a number of international conservation initiatives, spearheaded by the UN Convention on Biological Diversity, the UN Convention on Migratory Species, and the International Union for the Conservation of Nature and Natural Resources (IUCN). The results of this work features in decisions made at the Convention on International Trade in Endangered Species (CITES), and at regional fora looking to promulgate protected areas. The recent release of a comprehensive National Plan of Action suggests the authorities are committed to identifying priorities and tackling conservation challenges as resources become available. Key results from this project include the following:

i. Foraging female green turtles from Bu Tinah migrate and nest in Oman, providing direct linkages between the large rookery at Ras al Hadd and these foraging sites;

ii. No female turtles from the Bu Tinah foraging grounds moved northwards towards Saudi Arabia or towards any other nesting destination;

iii. Male green turtles migrate out of the Gulf and breed in Oman, with a potential courtship area identified off the Daymaniyat islands;

iv. A courtship area may also exist off the coast of Dubai and around the Musandam peninsula, following movements by several male turtles to these locations;

v. Male turtles on UAE foraging grounds are significantly smaller than female turtles, by an average of ~6 cm;

vi. While nesting appears to be predominantly at Ras al Hadd, turtles utilise a long stretch of coastline spanning the tip of the Arabian peninsula down to Masirah island as internesting habitat;

vii. Internesting habitat is mostly coastal and shallow, but in a few isolated cases turtles ranged up to 300km offshore, in waters which are over 2000m deep, likely to evade attention by male turtles in the vicinity of the nesting beaches;

viii. A small proportion of nesting turtles from Oman may migrate towards India to feed;

ix. A small proportion of nesting turtles from Oman may migrate towards Eritrea to feed;

x. Foraging green sea turtles and seagrass habitats are substantially protected in the UAE, with nearly 76% of assemblages of turtles found within the Marawah Marine Biosphere Reserve and Marine Protected Area;

xi. A robust delineation of the core foraging areas has been processed for Ras Al Khaimah, which can help the Environmental Protection and Development Authority in developing measured protection to these habitats;

xii. Additional foraging areas identified by this project include the waters north and south of Abu Al Abyad Island and waters off the coast of Saadiyat Island (both in Abu Dhabi), and waters west of Al Marjan Island in Ras Al Khaimah;

xiii. The vast majority of migrations take place in nearshore waters, with the turtles remaining in shallow coastal habitats;

xiv. Deep sea crossings occur infrequently and appear to be movements where no other option was available (e.g. across the Gulf of Oman)

xv. The data collected by this project has great value to science and conservation, and our findings contribute to the growing body of literature on the biology and ecology of marine turtles of the Arabian Gulf, and can be used to enhance national and regional management strategies such as reviews of the UAE’s National Biodiversity Strategic Action Plan (NBSAP), the delineation of Ecologically or Biologically Significant Marine Areas (EBSAs), and/or incorporation into the Network of Sites of Importance for Marine Turtles established by the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA Marine Turtle MoU).

7. ACKNOWLEDGEMENTS

We are grateful to H.E. Razan Khalifa Al Mubarak, Managing Director of the Environment Agency Abu Dhabi and Treasurer of the Board at Emirates Nature-WWF and the Board of Directors for their continued support for this project, particularly through the challenging tag-retention period in the first years of the project.

Seed funding for this work was provided by Emirates Nature-WWF office in the United Arab Emirates and subsequent funding was provided by the numerous sponsors, listed here in alphabetical order: Al Khaja Group, American School of Dubai, Apple Inc., Beach Rotana Abu Dhabi, Environment Agency – Abu Dhabi, Emirates NBD, Farnek, Gems Founders School, Gems the Kindergarten Starters, Lush Fresh Handmade Cosmetics LLC, National Bank of Fujairah PJSC, Park Hyatt Abu Dhabi Hotel and Villas, Times Hotel, The Lime Tree Café & Kitchen, and Yas Mall. We are indebted to the support of our efforts under this project via turtle adoptions and support for the Emirates Nature-WWF marine programme.

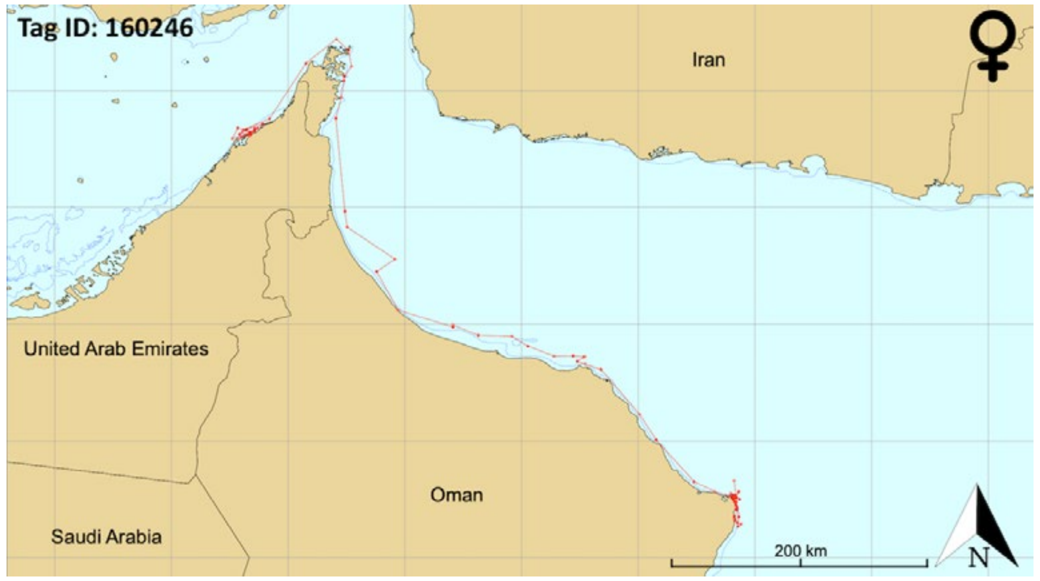
This work would not have been possible without the close cooperation with strategic partner agencies and organisations in each country: In Oman the Ministry of Environment and Climate Affairs, Five Oceans LLC, and the Environment Society of Oman; in the UAE the Environment Agency-Abu Dhabi, the Environment and Protected Areas Authority of Sharjah, the Environment Protection and Development Authority of Ras Al Khaimah, and the Ministry of Climate Change and Environment.

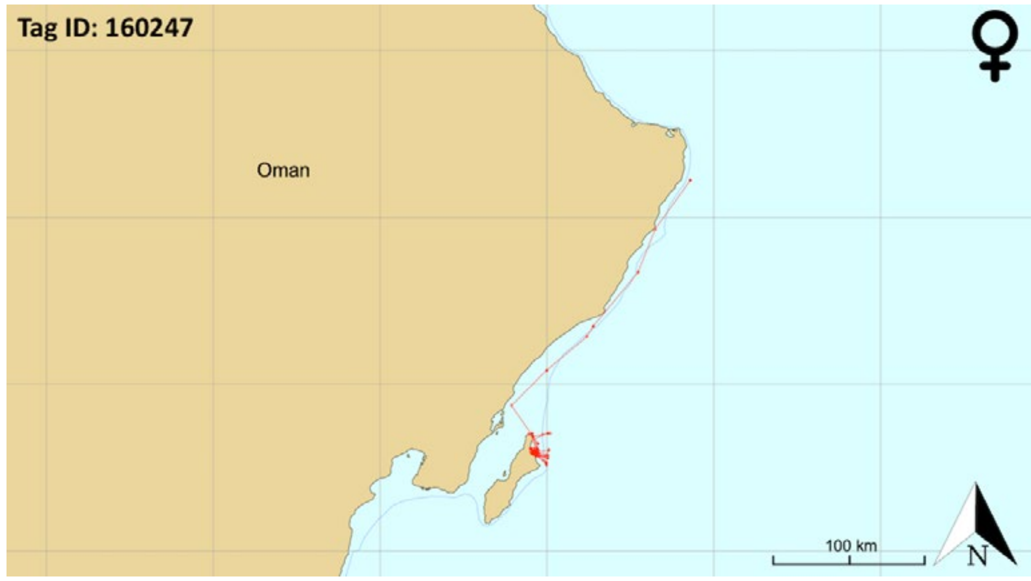
For their support during the fieldwork we are extremely grateful to the technical staff of the Environment Agency-Abu Dhabi and rangers at Bu Tinah island; to the staff and volunteers of the Environment Protection and Development Authority at Ras Al Khaimah; and to the staff and volunteers of the Ministry of Environment and Climate Affairs in Oman, the Environment Society of Oman and Five Oceans LLC for assisting with efforts at the Ras Al Hadd Turtle Reserve. We are also extremely thankful for the tag data interpretation provided by Kevin Lay at Wildlife Computers.

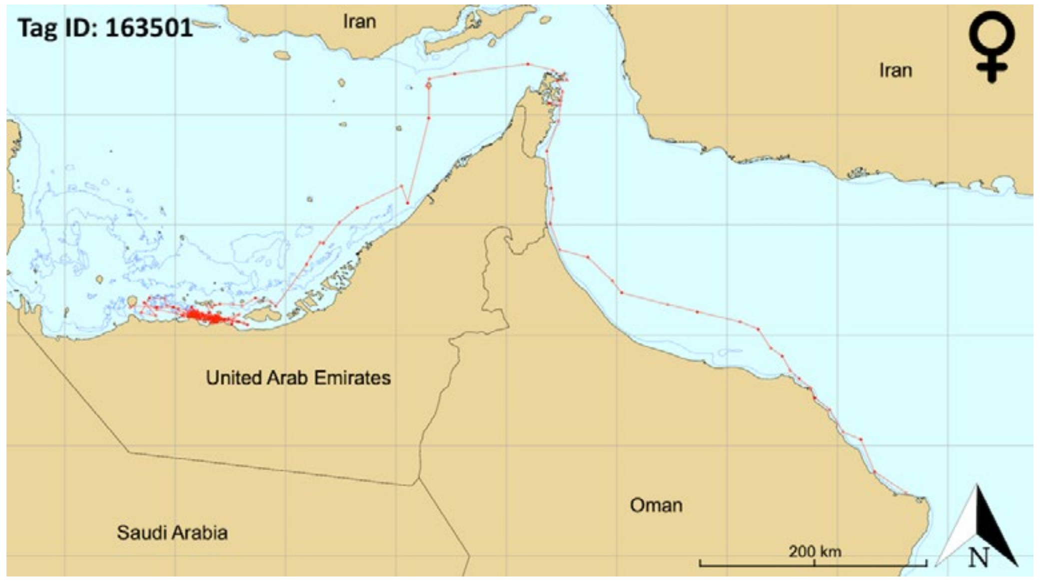
ANNEX A. INDIVIDUAL MIGRATION TRACKS

Notes:

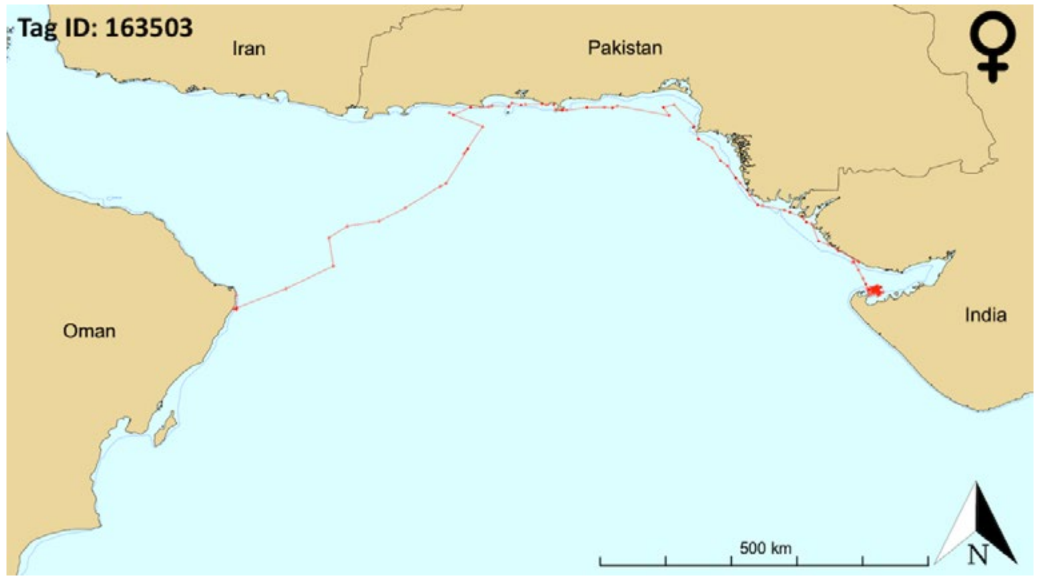
1. Tracks are colour coded by deployment year: red – 2016; blue – 2017; dark grey – 2018; green – 2019.
2. Maps are generally grouped by location, rather than by deployment year.
3. Grids represent one degree of latitude and longitude
4. Closed markers are best filtered day points; open markers are best filtered night points.
5. The first six maps represent deployments from Ras Al Hadd in Oman, the balance represent deployments from the United Arab Emirates.


Tag ID: 160246
Iran
United Arab Emirates
Oman
Saudi Arabia
200 km
N

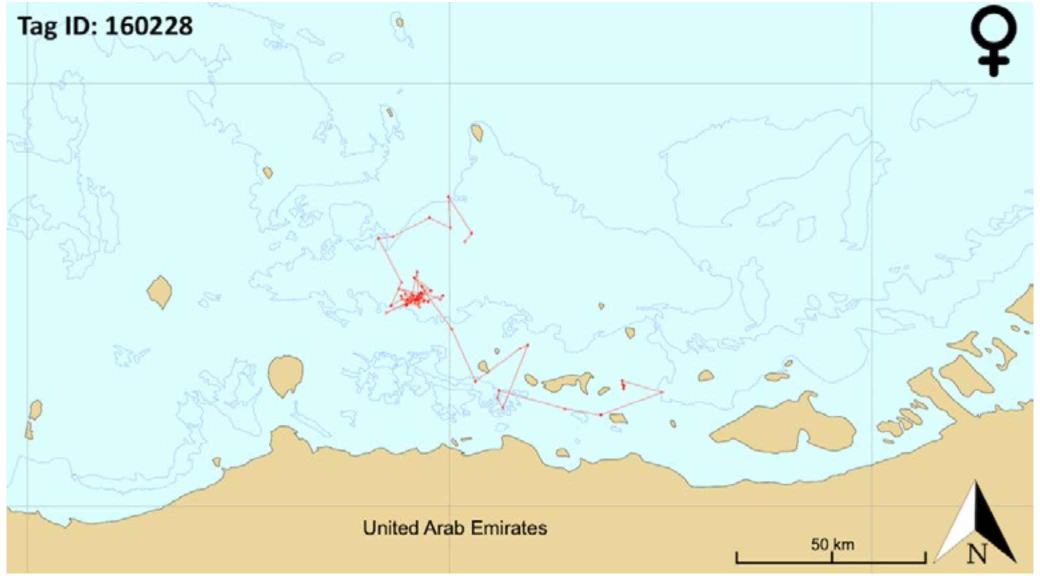

Tag ID: 160247
Oman
100 km
N

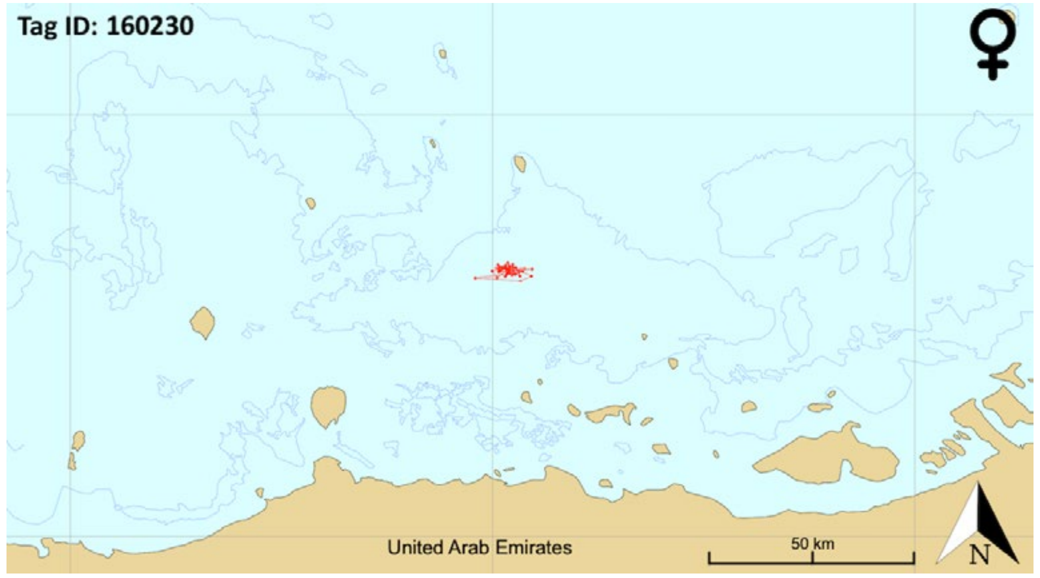

Tag ID: 163501
Iran
Iran
United Arab Emirates
Oman
Saudi Arabia
200 km
N

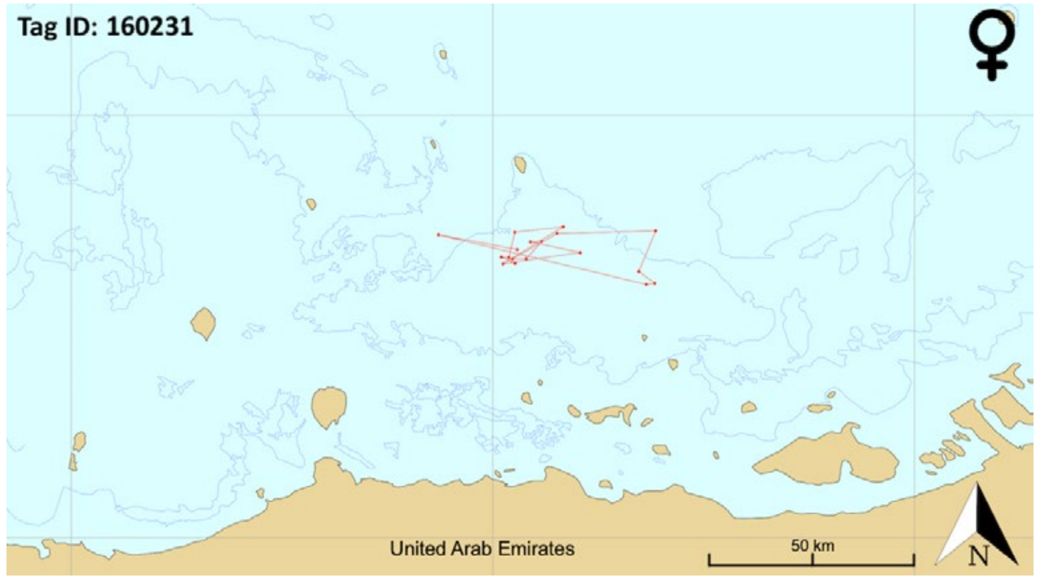

Tag ID: 163502
Saudi Arabia
Oman
Eritrea
Yemen
Somalia
500 km
N

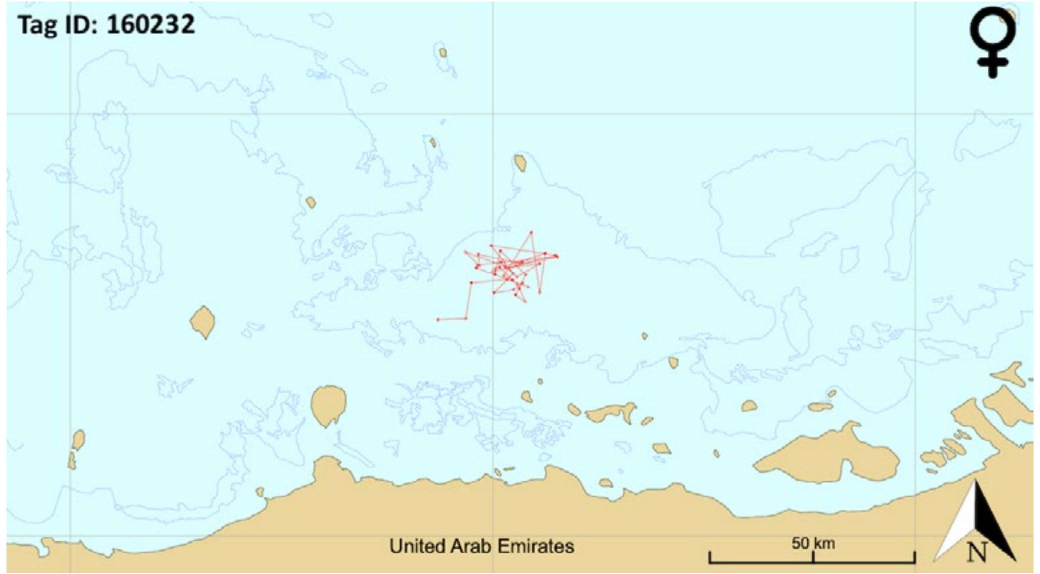

Tag ID: 163503
Iran
Pakistan
Oman
India
500 km
N

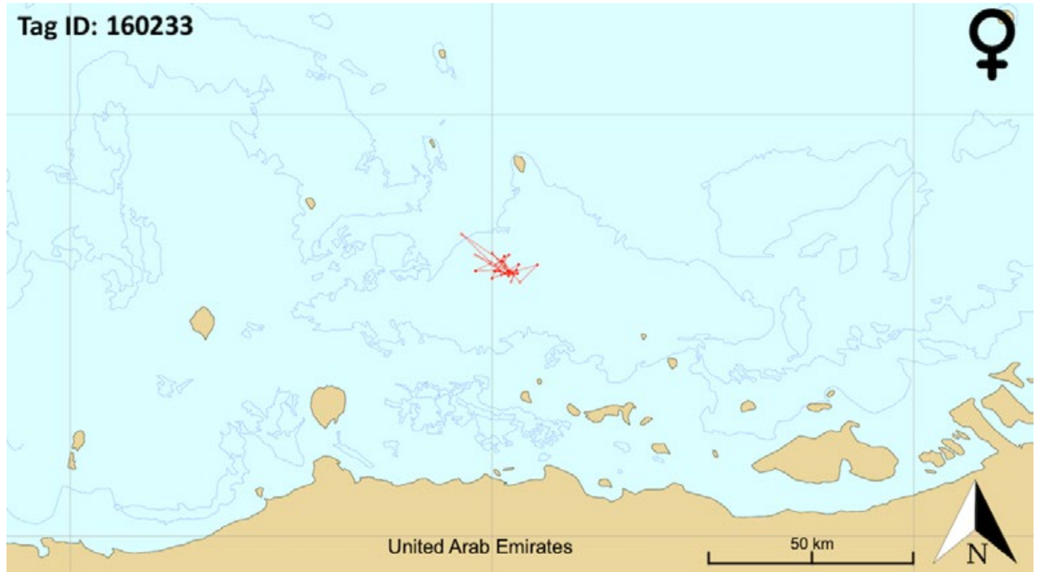

Tag ID: 163504
Oman
100 km
N

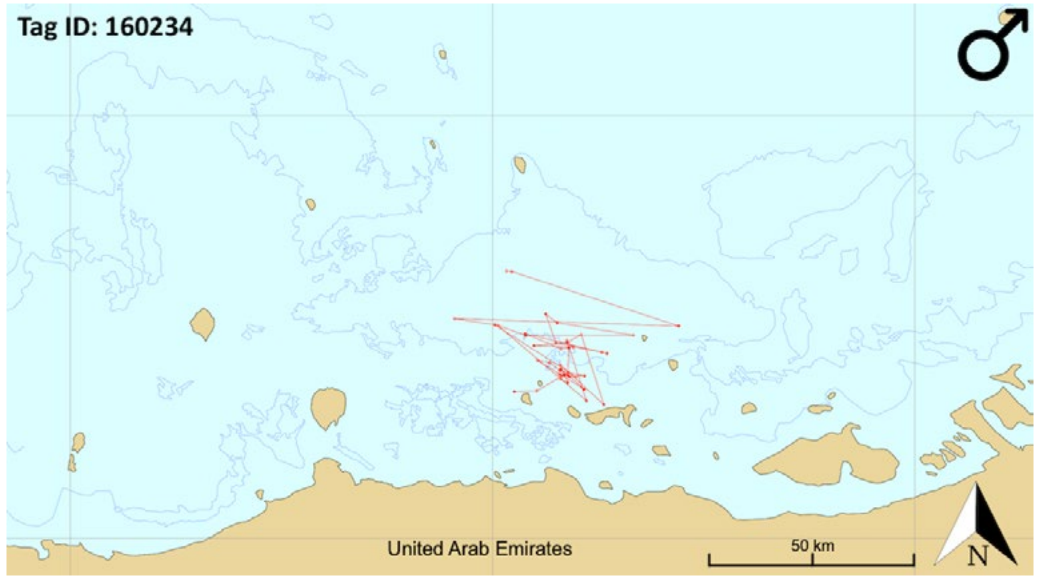

Tag ID: 160228
United Arab Emirates
50 km
N

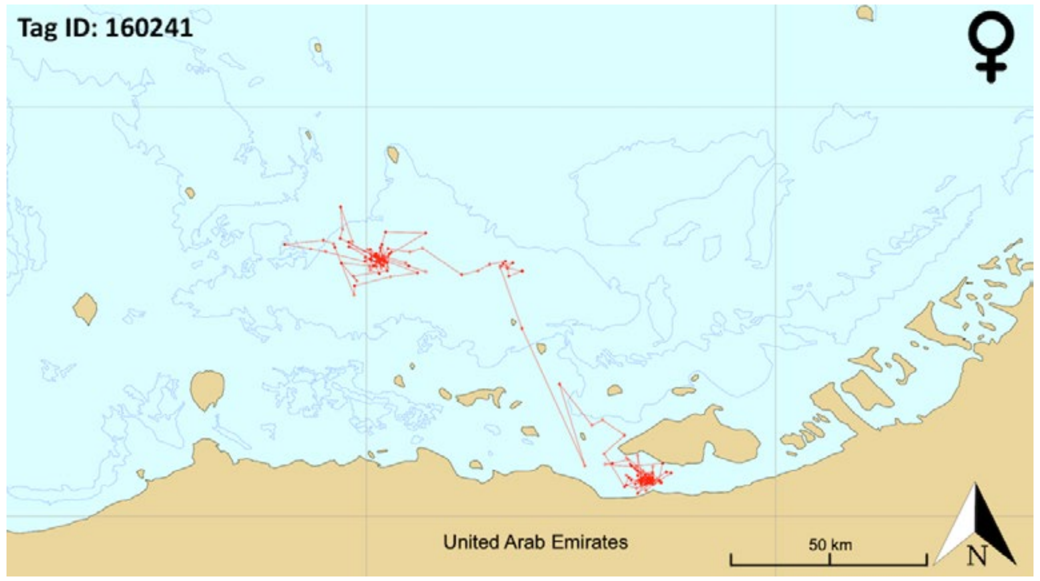

Tag ID: 160230
United Arab Emirates
50 km
N

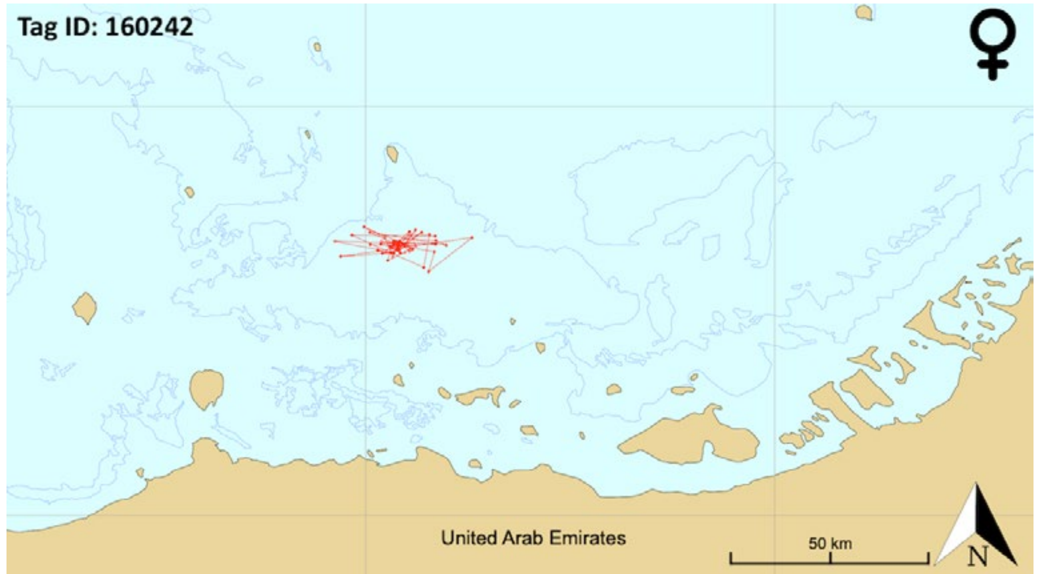

Tag ID: 160231
United Arab Emirates
50 km
N

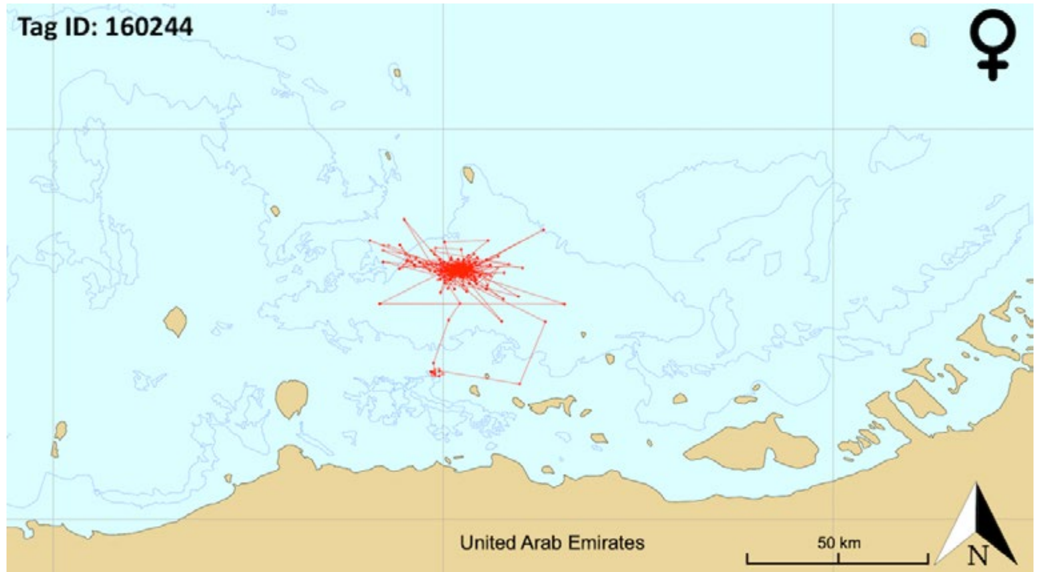

Tag ID: 160232
United Arab Emirates
50 km
N

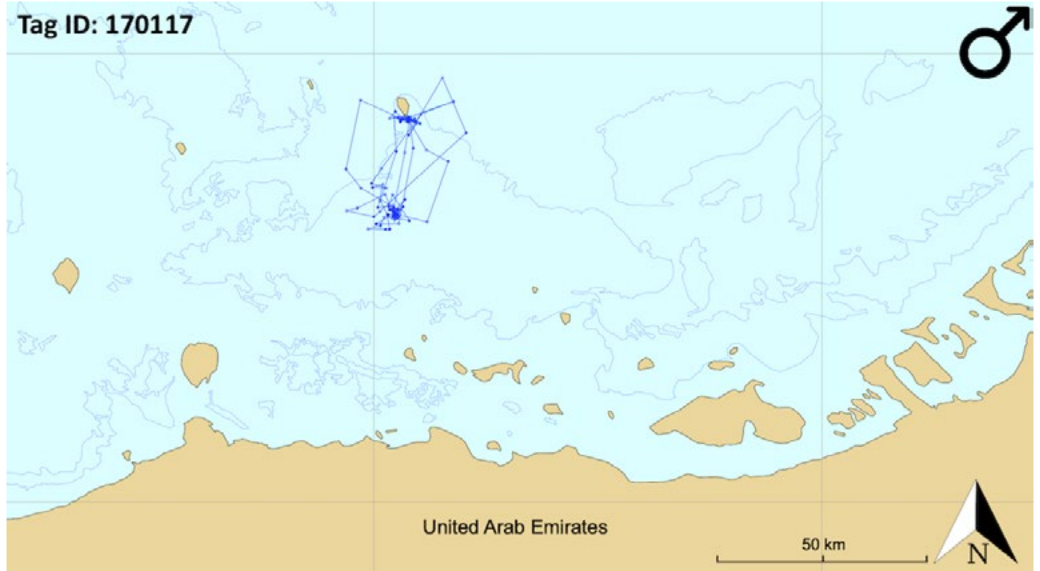

Tag ID: 160233
United Arab Emirates
50 km
N

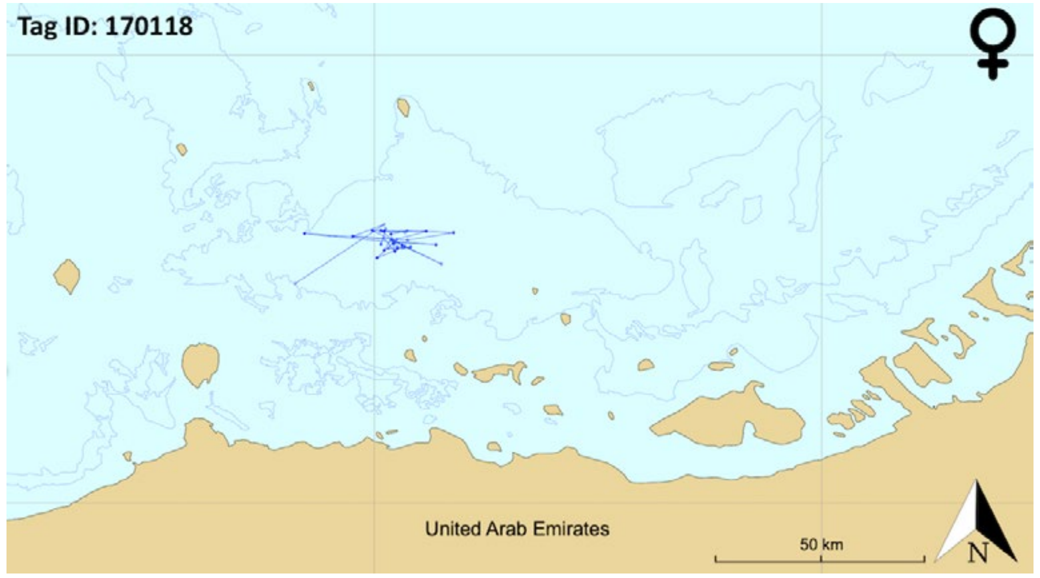

Tag ID: 160234
United Arab Emirates
50 km
N

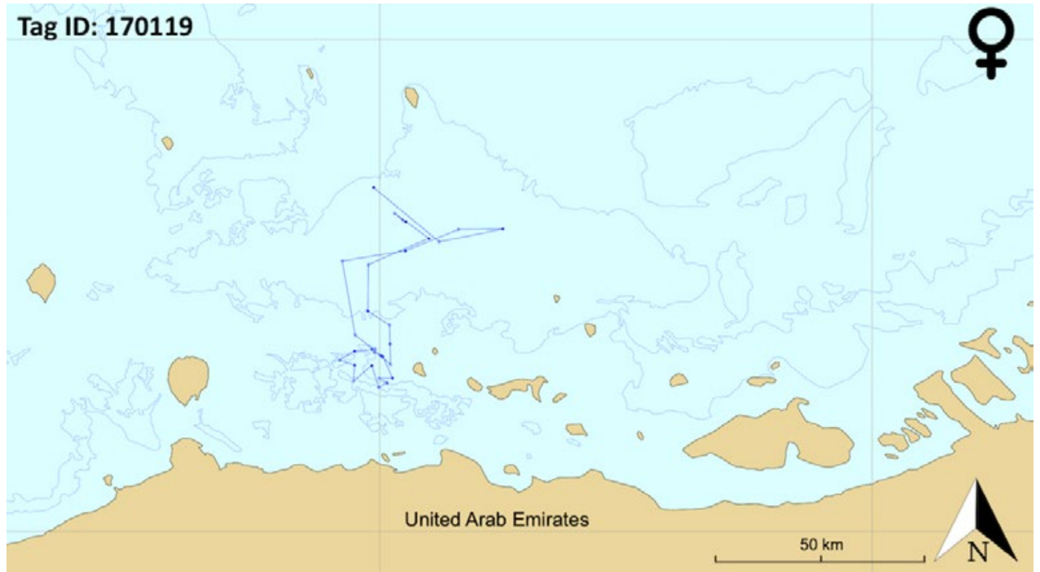

Tag ID: 160241
United Arab Emirates
50 km
N

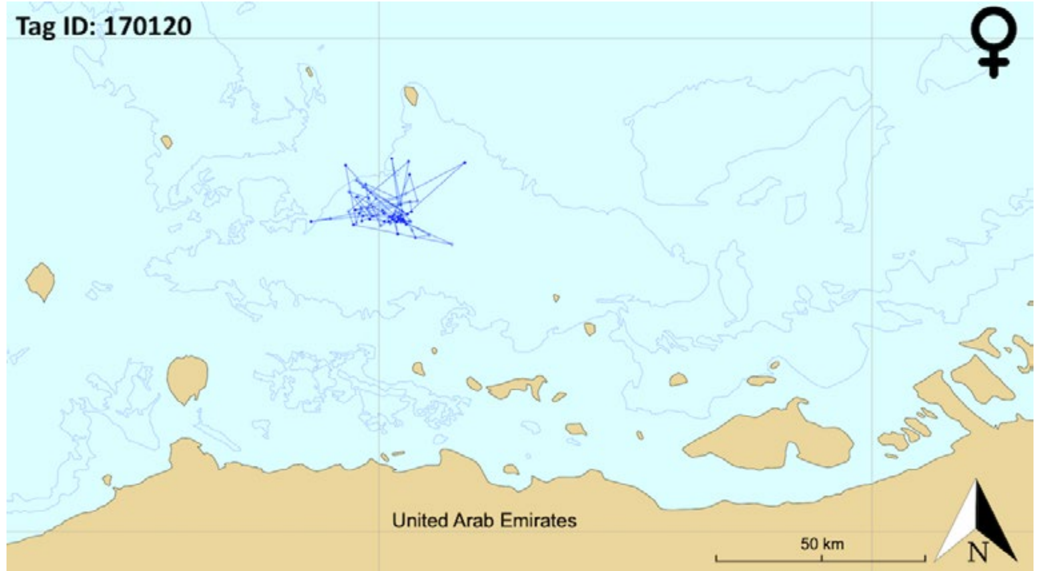

Tag ID: 160242
United Arab Emirates
50 km
N

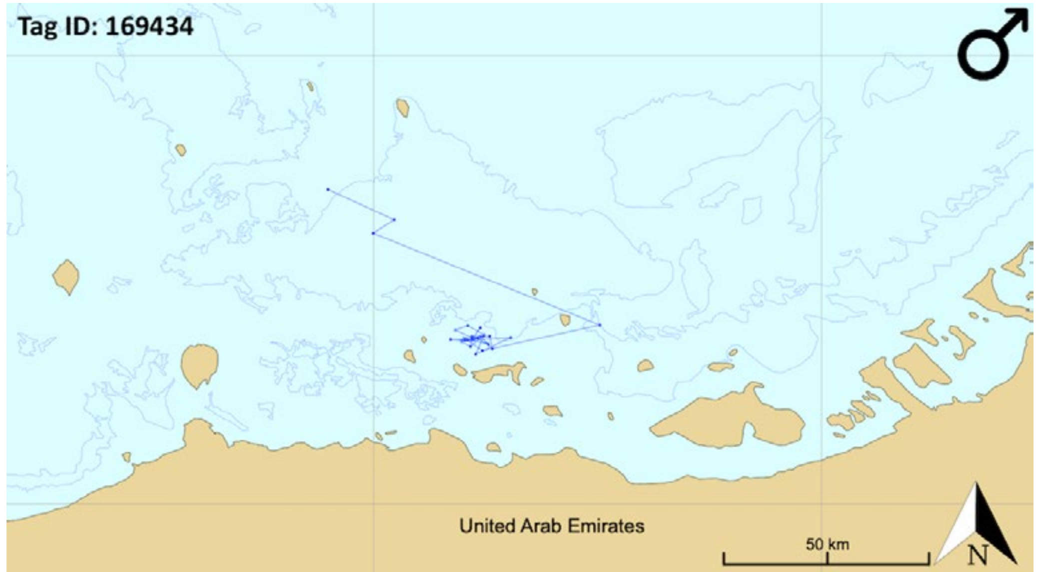

Tag ID: 160244
United Arab Emirates
50 km
N

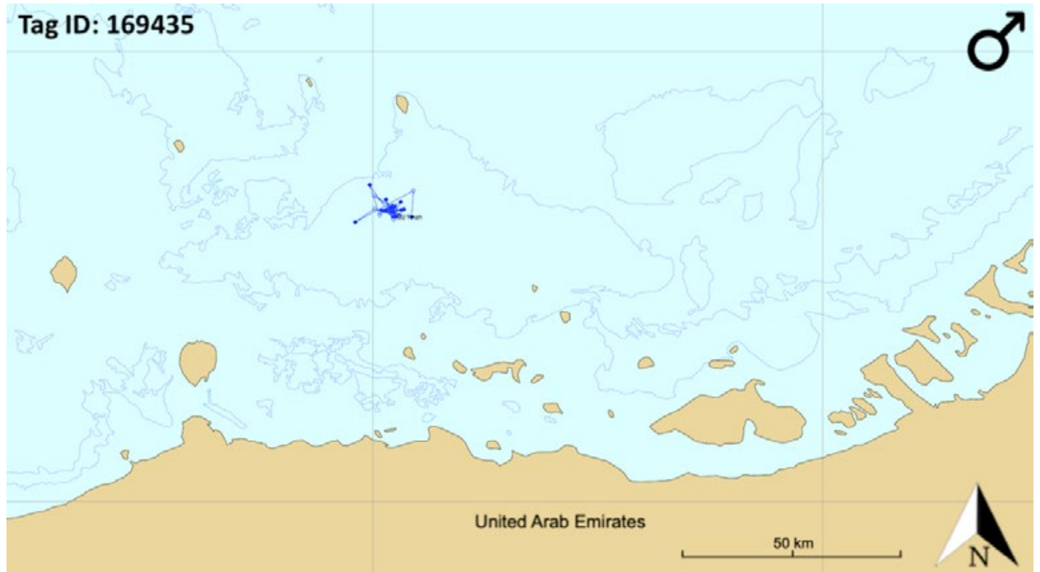

Tag ID: 170117
United Arab Emirates
50 km
N

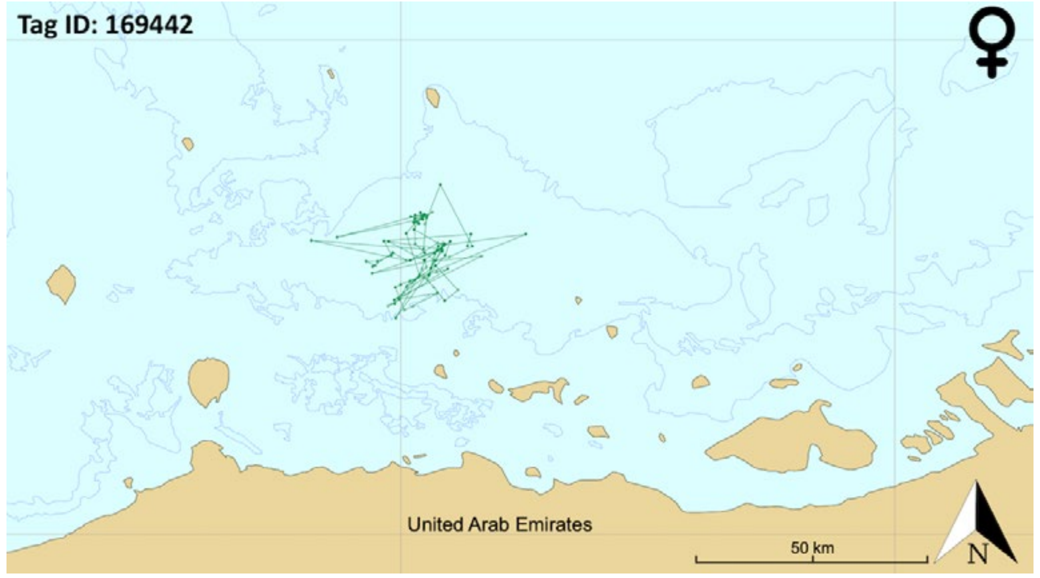

Tag ID: 170118
United Arab Emirates
50 km
N

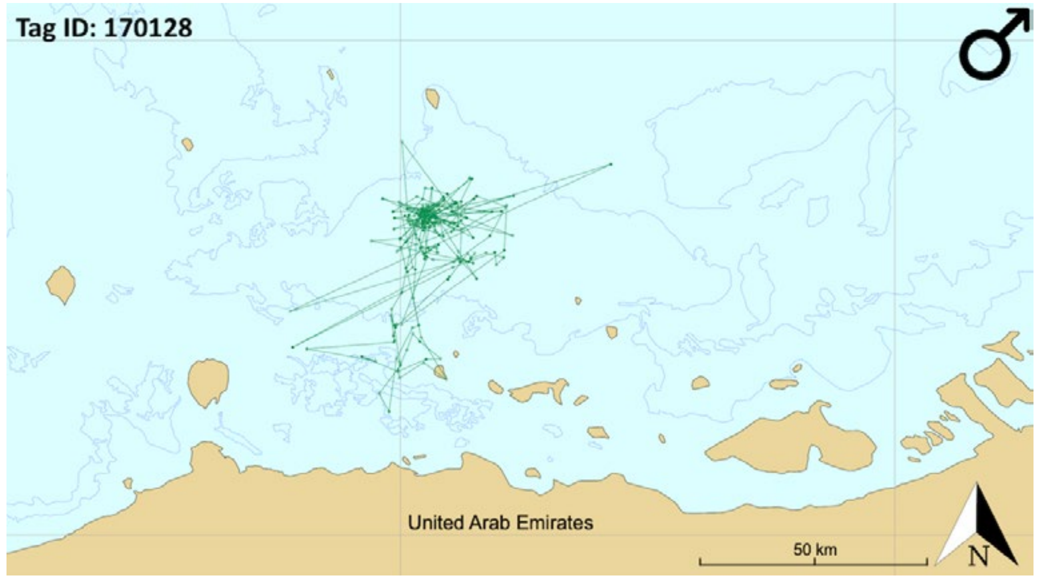

Tag ID: 170119
United Arab Emirates
50 km
N

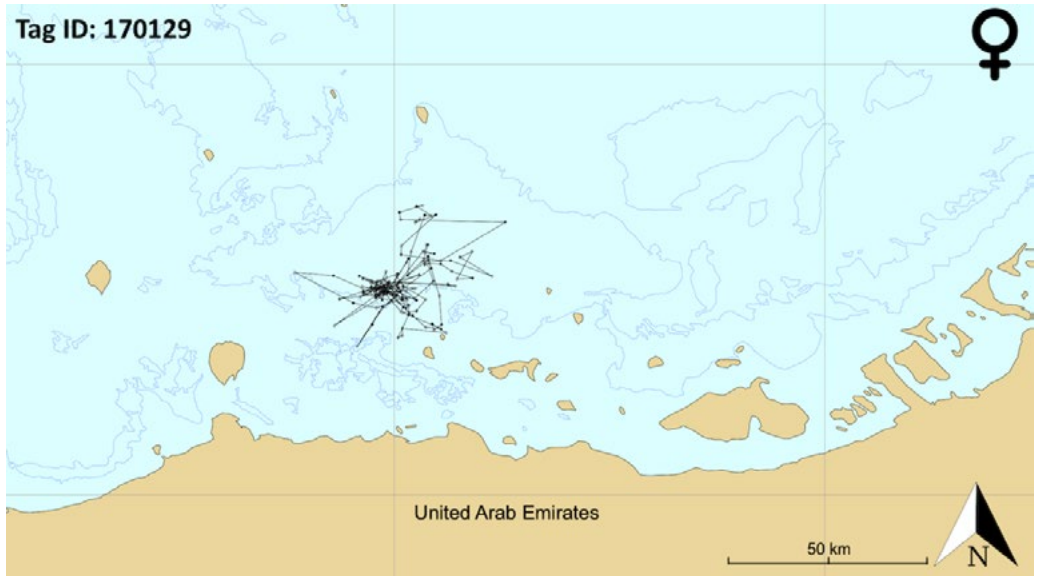

Tag ID: 170120
♀
United Arab Emirates
50 km
N

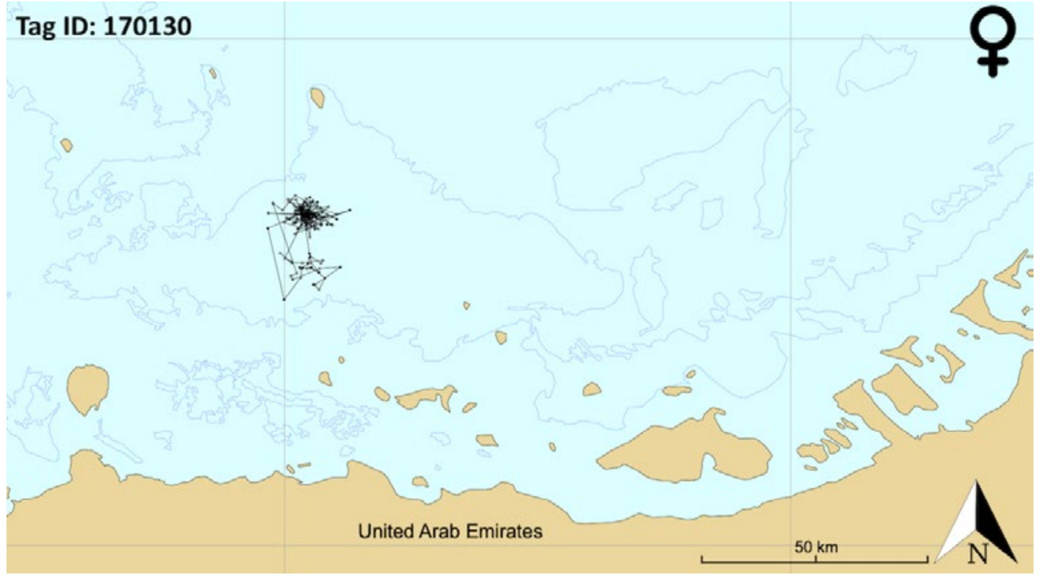

Tag ID: 169434
♂
United Arab Emirates
50 km
N

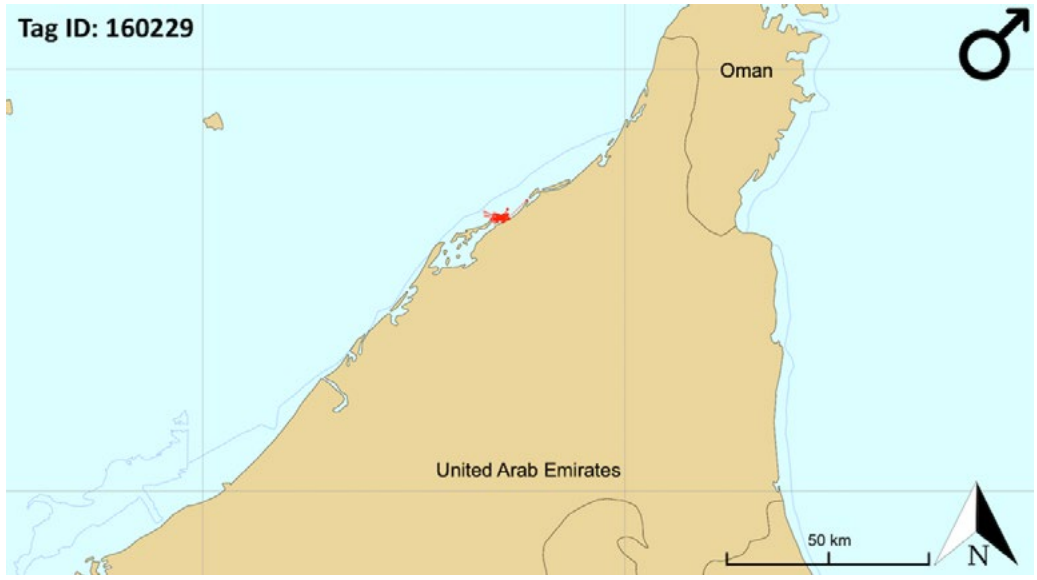

Tag ID: 169435
♂
United Arab Emirates
50 km
N

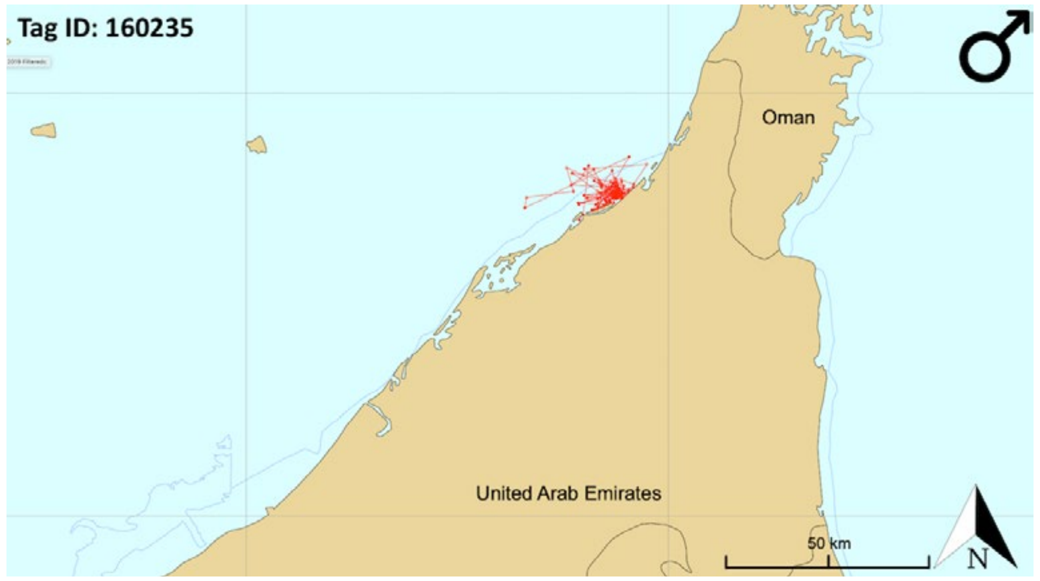

Tag ID: 169442
♀
United Arab Emirates
50 km
N

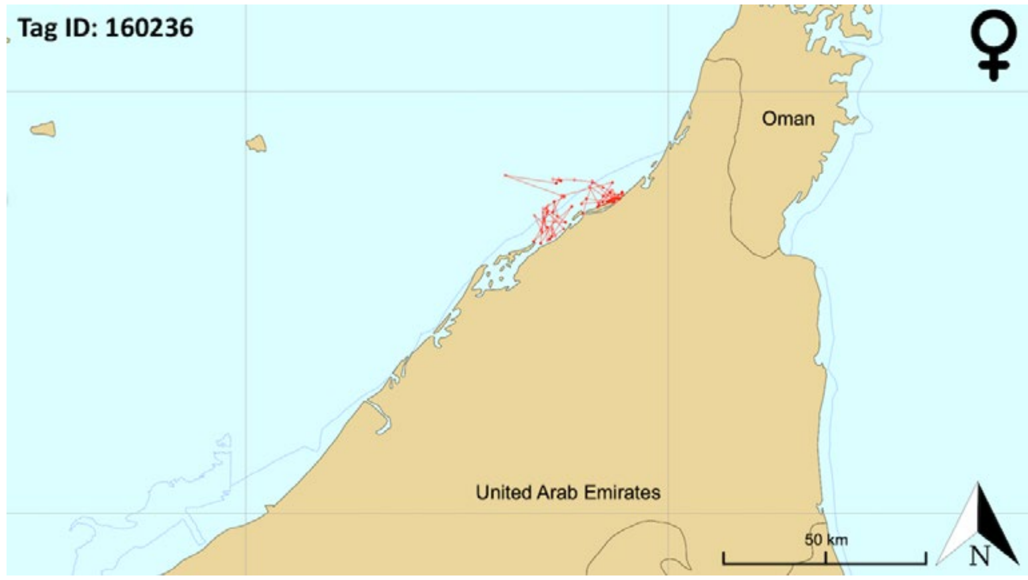

Tag ID: 170128
♂
United Arab Emirates
50 km
N

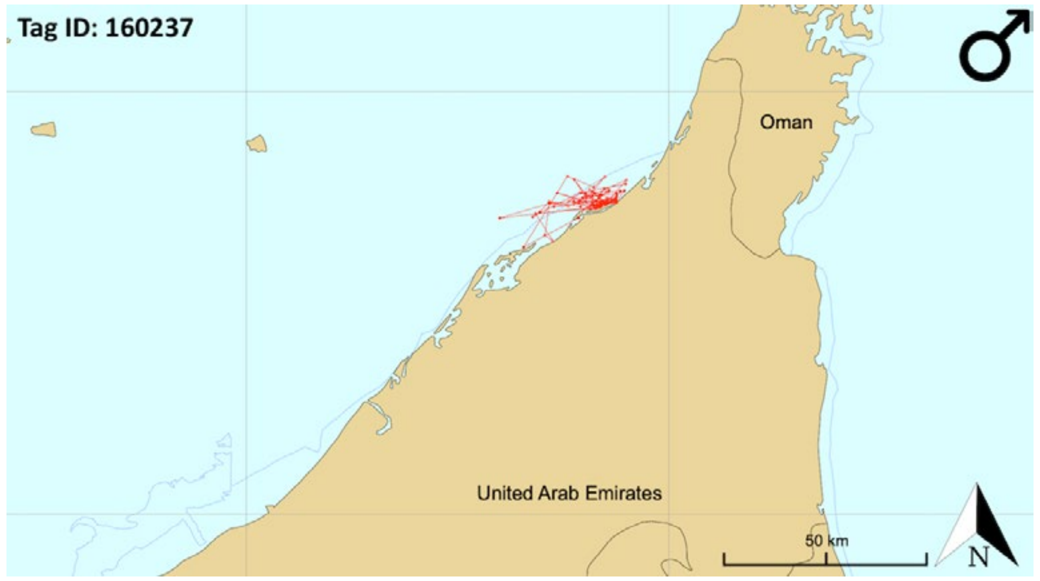

Tag ID: 170129
♀
United Arab Emirates
50 km
N

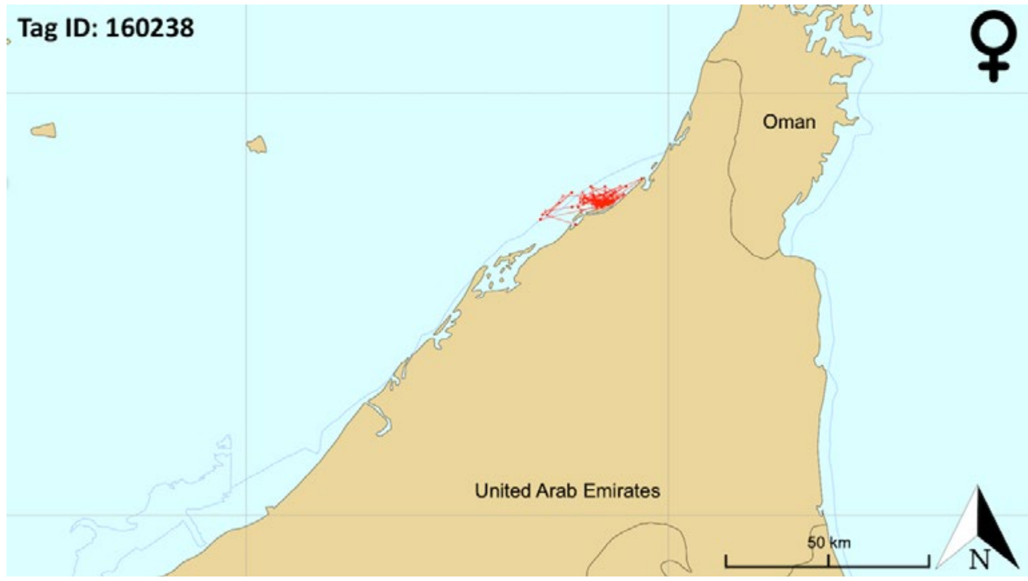

Tag ID: 170130
United Arab Emirates
50 km
N

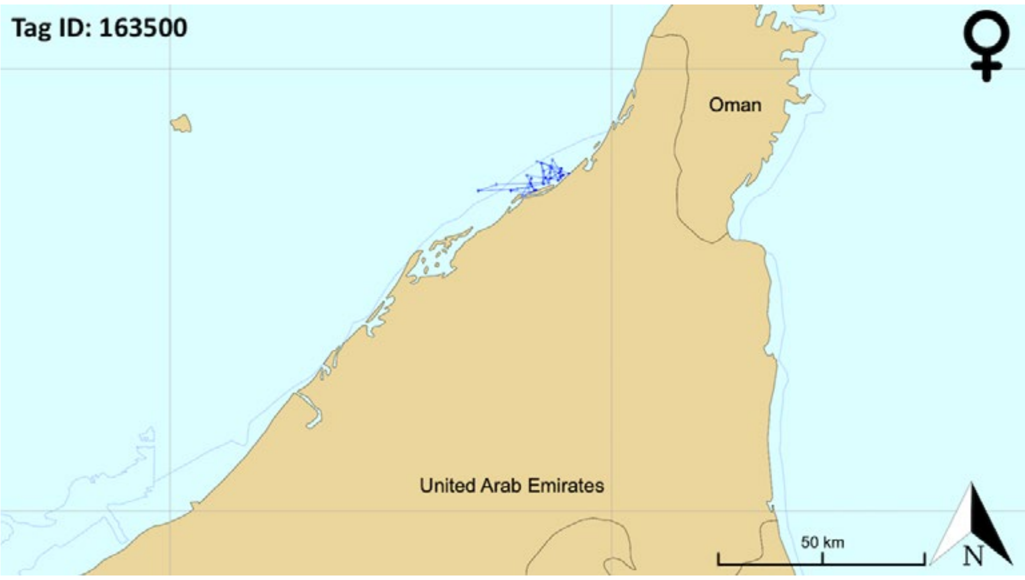

Tag ID: 160229
Oman
United Arab Emirates
50 km
N

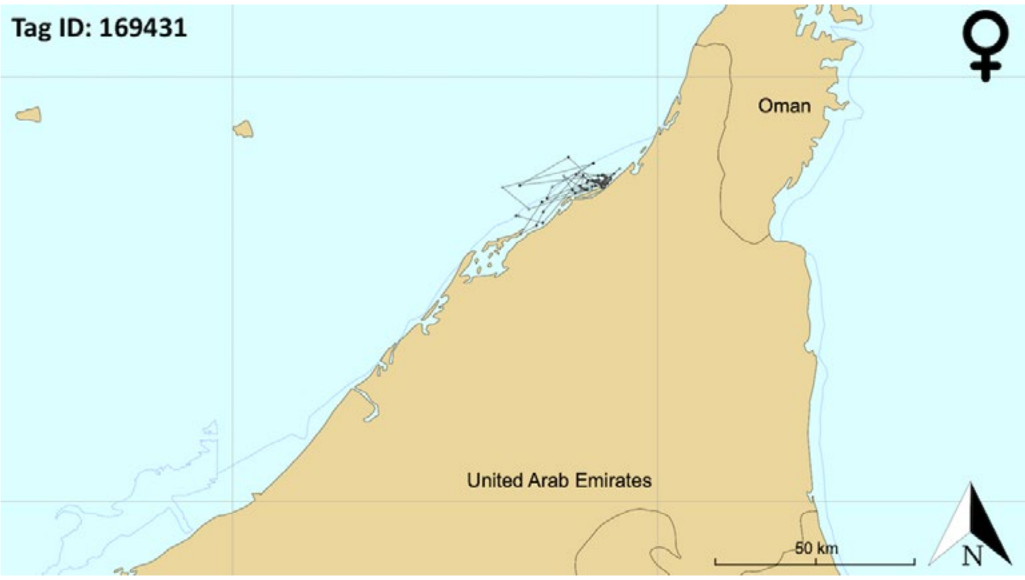

Tag ID: 160235
Oman
United Arab Emirates
50 km
N

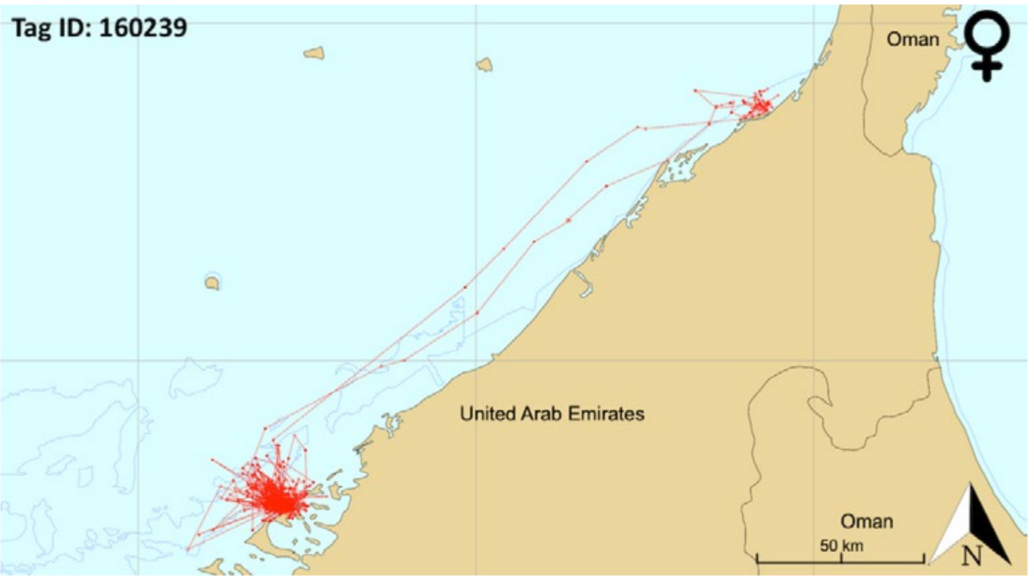

Tag ID: 160236
Oman
United Arab Emirates
50 km
N

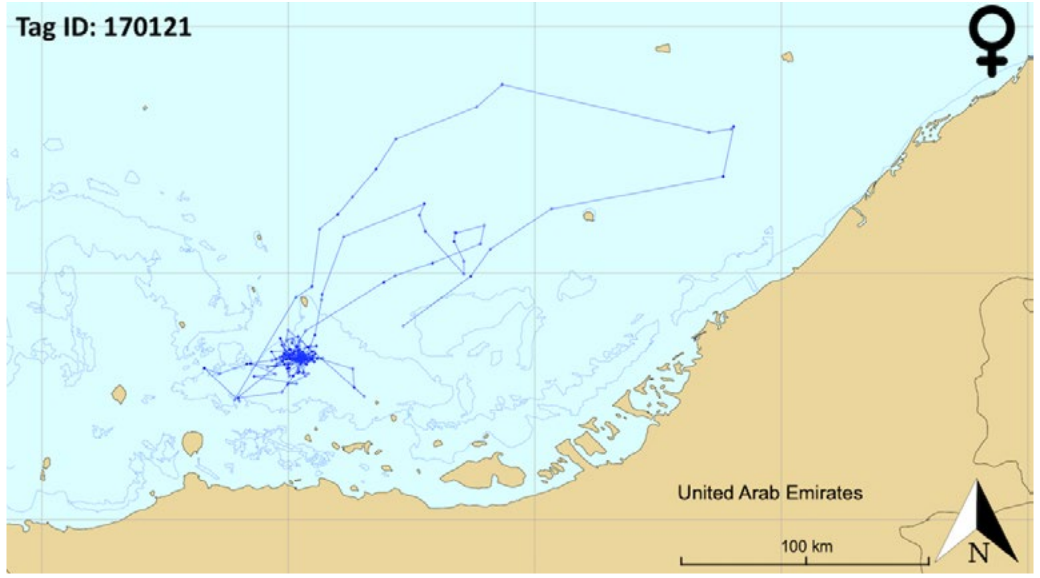

Tag ID: 160237
Oman
United Arab Emirates
50 km
N

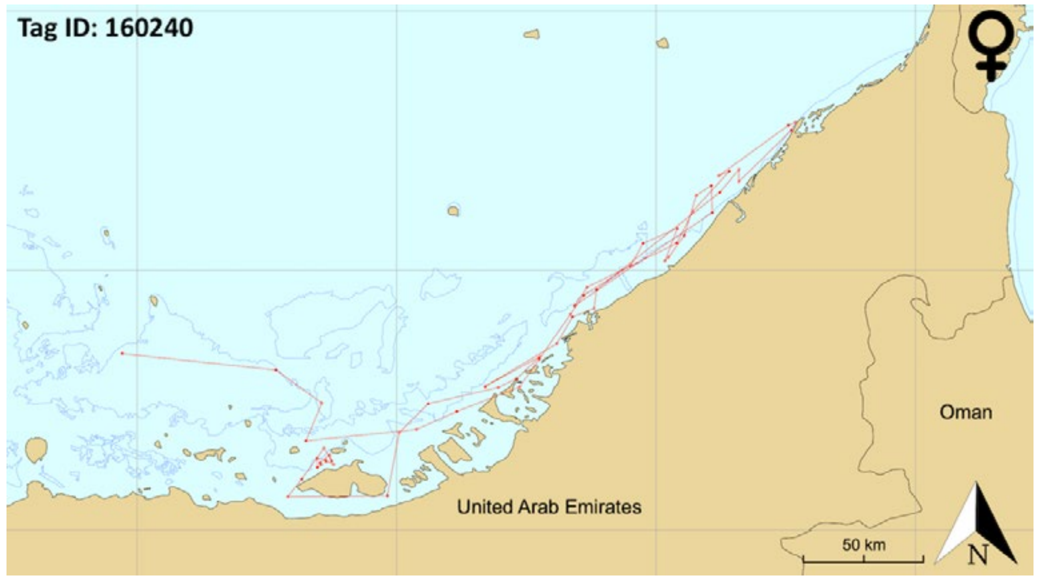

Tag ID: 160238
Oman
United Arab Emirates
50 km
N

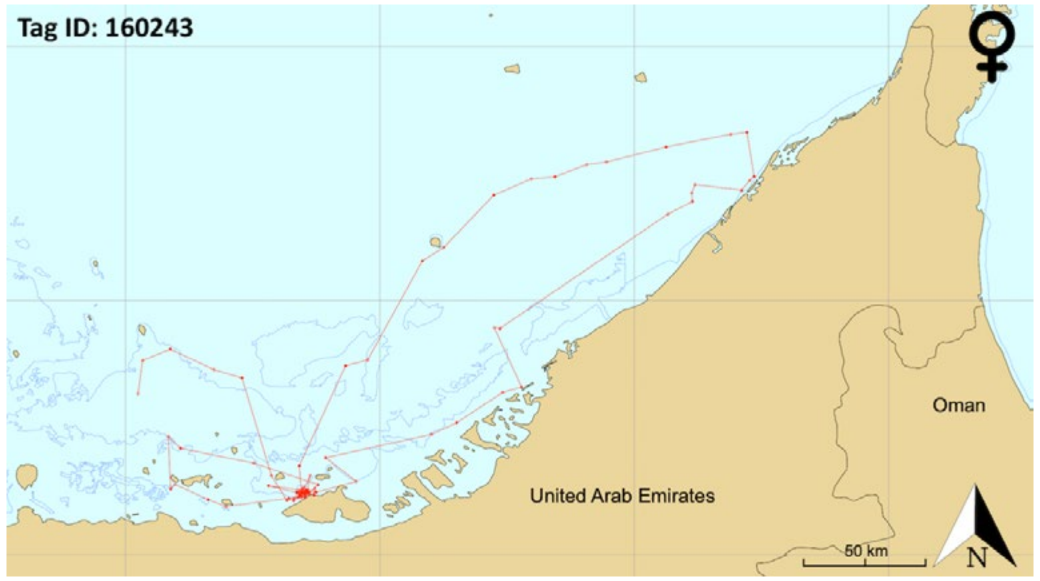

Tag ID: 163500
♀
Oman
United Arab Emirates
50 km
N

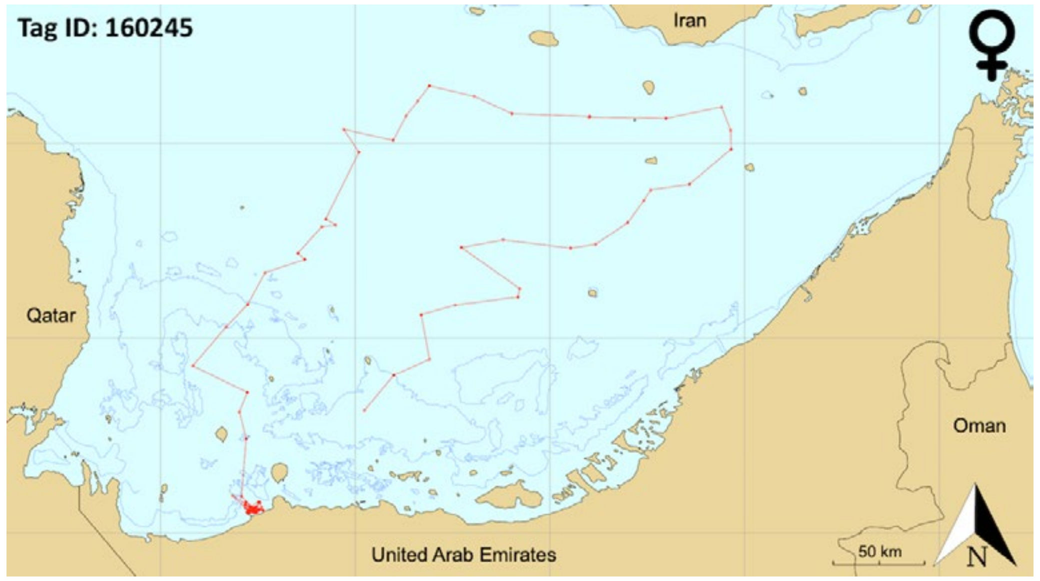

Tag ID: 169431
♀
Oman
United Arab Emirates
50 km
N

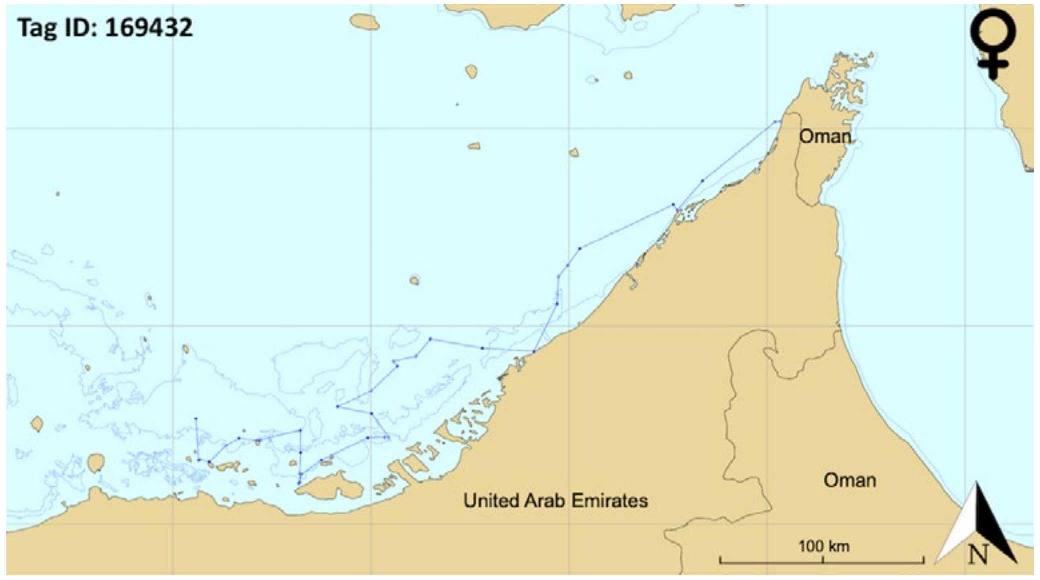

Tag ID: 160239
Oman
♀
United Arab Emirates
Oman
50 km
N

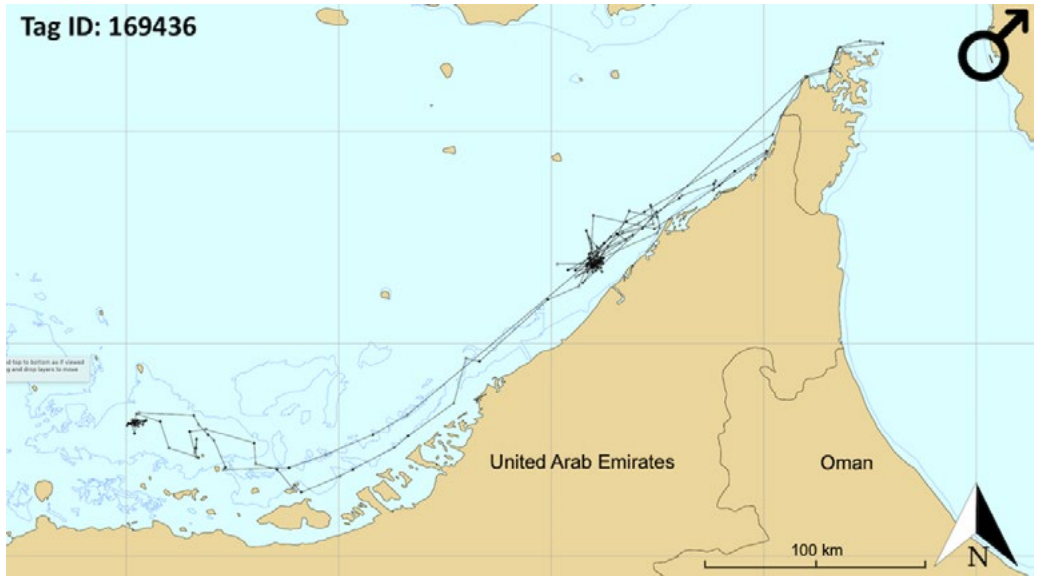

Tag ID: 170121
♀
United Arab Emirates
100 km
N

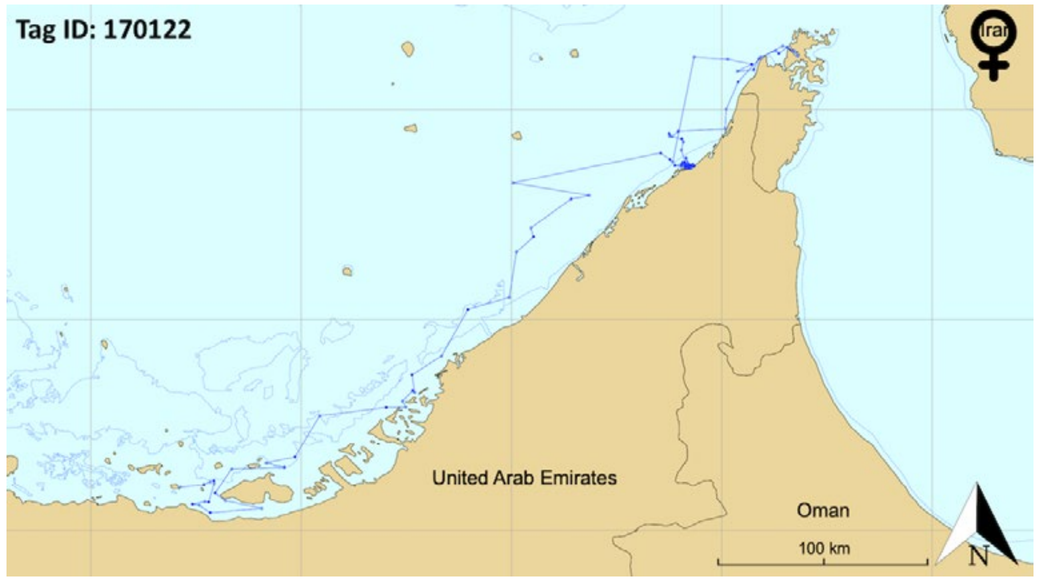

Tag ID: 160240
♀
Oman
United Arab Emirates
50 km
N

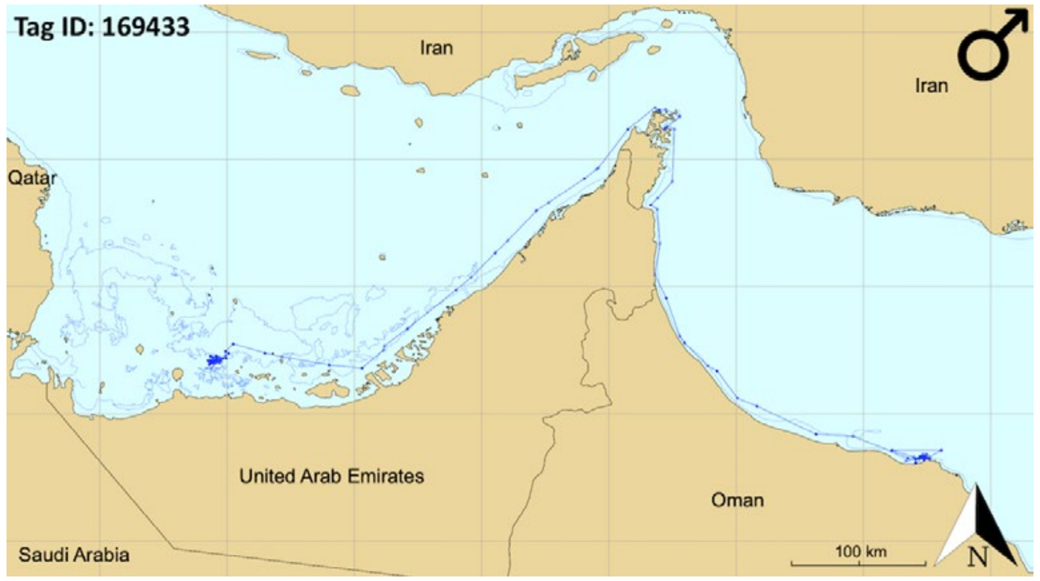

Tag ID: 160243
♀
Oman
United Arab Emirates
50 km
N

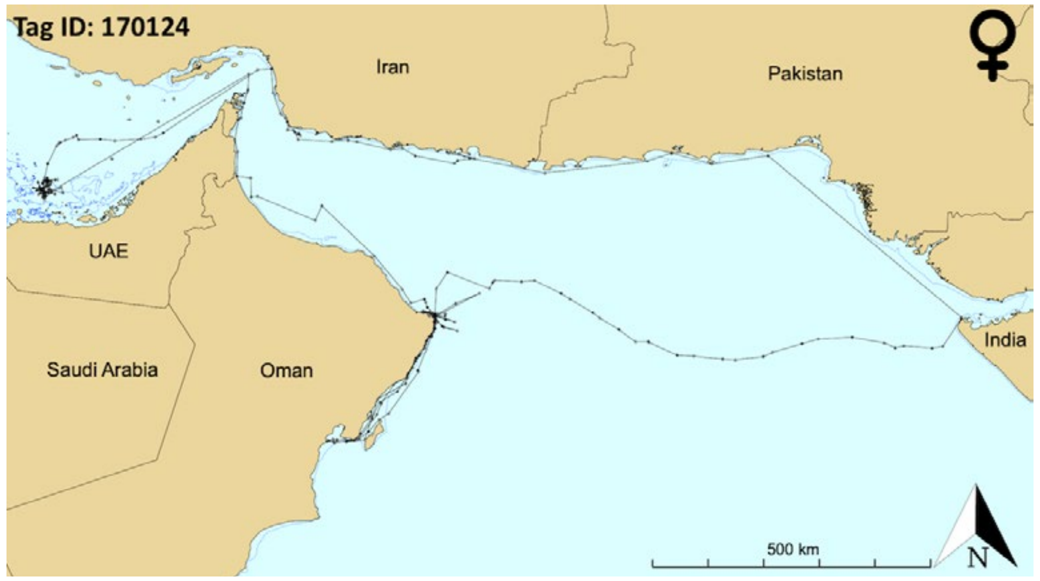

Tag ID: 160245
Iran
Qatar
Oman
United Arab Emirates
50 km
N

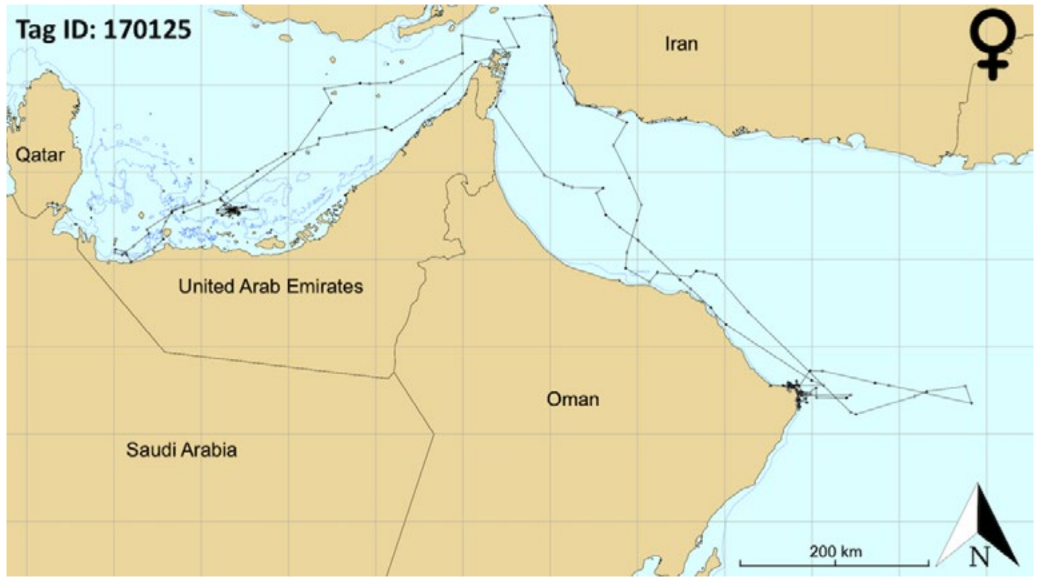

Tag ID: 169432
Oman
United Arab Emirates
Oman
100 km
N

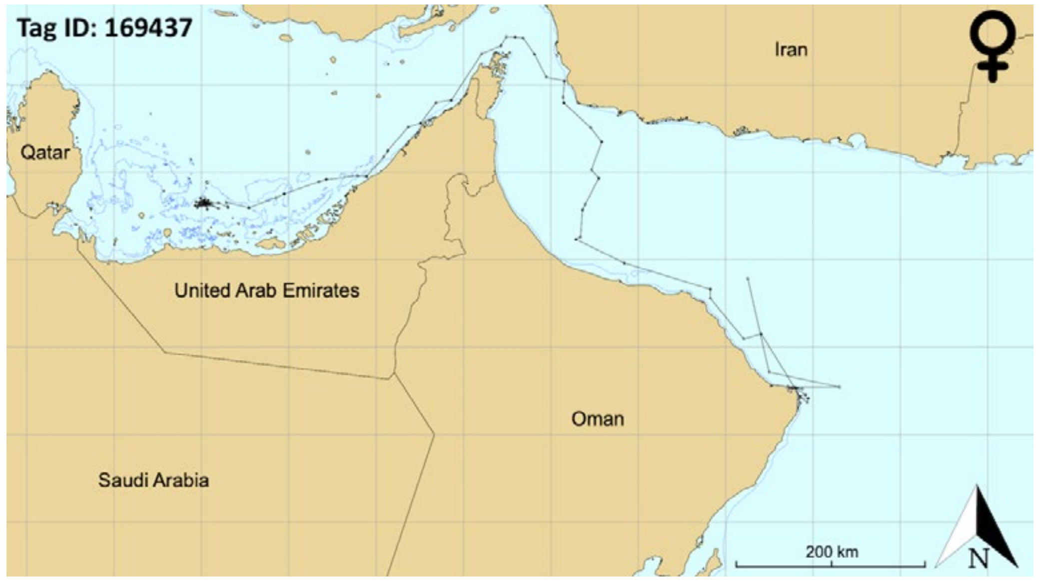

Tag ID: 169436
United Arab Emirates
Oman
100 km
N

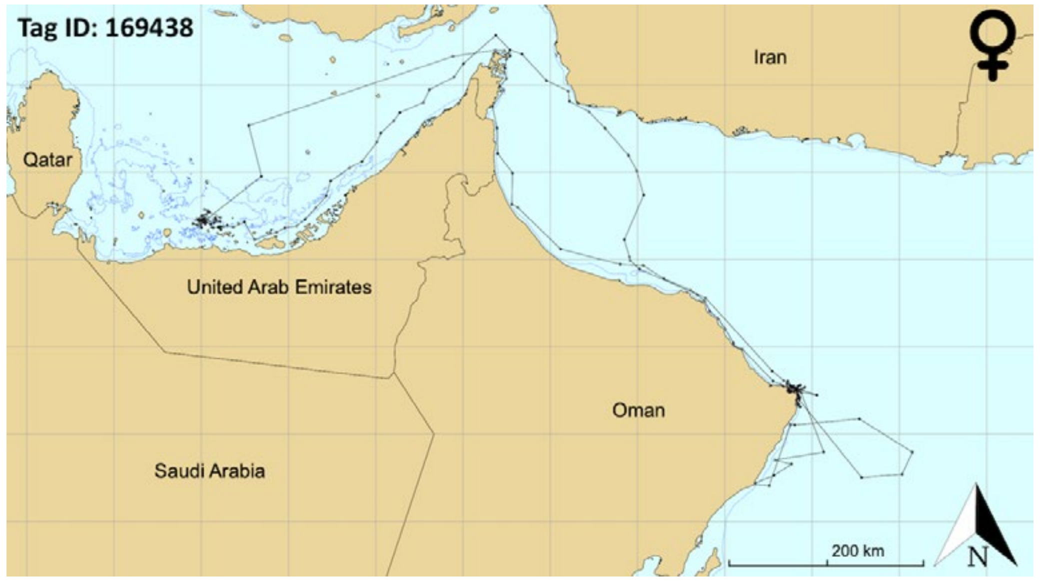

Tag ID: 170122
Iran
United Arab Emirates
Oman
100 km
N

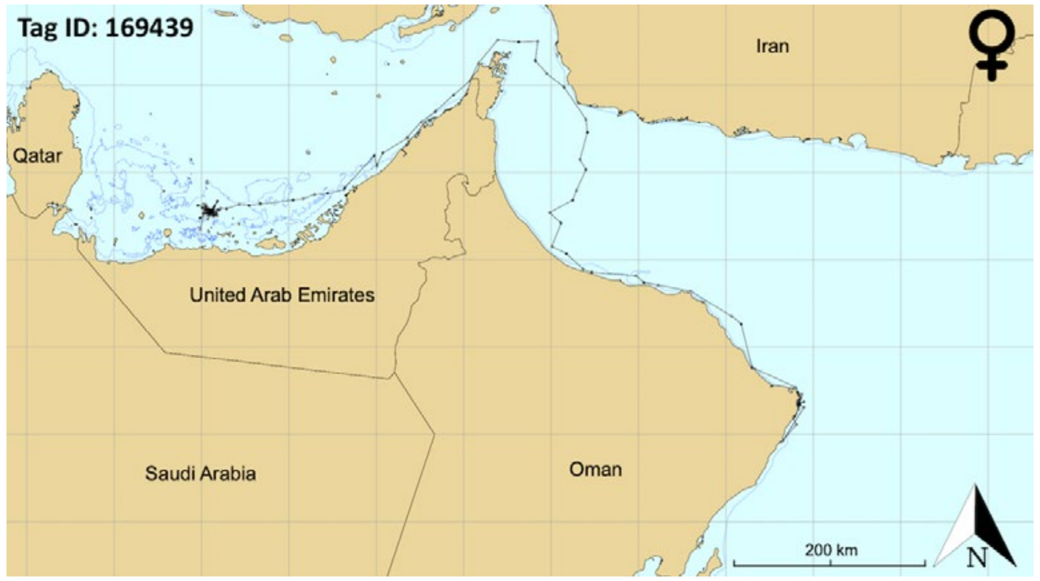

Tag ID: 169433
Iran
Iran
Qatar
United Arab Emirates
Oman
Saudi Arabia
100 km
N


Tag ID: 170124
Iran
Pakistan
UAE
India
Saudi Arabia
Oman
500 km
N

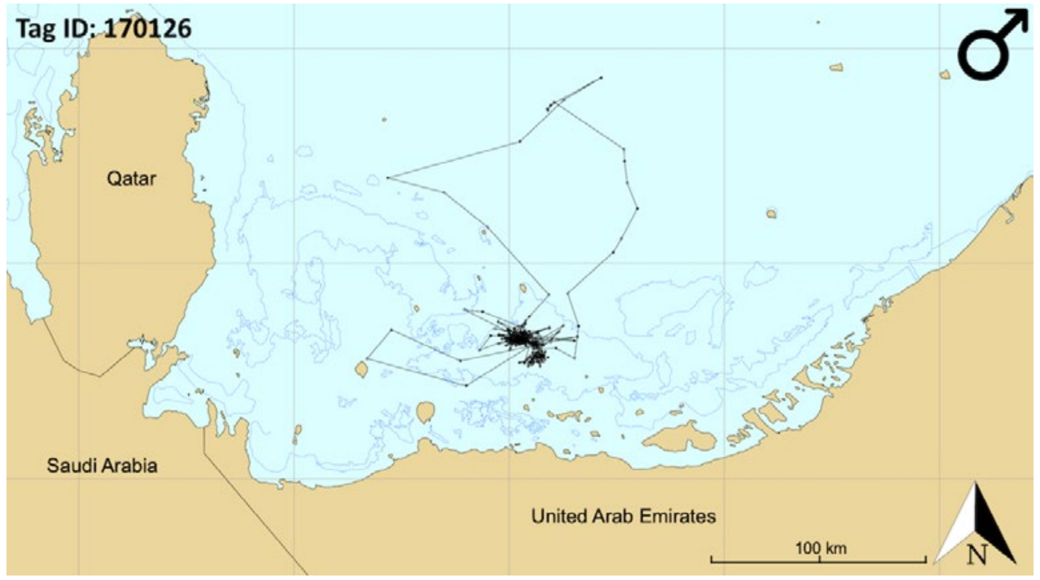

Tag ID: 170125
Iran
Qatar
United Arab Emirates
Oman
Saudi Arabia
200 km
N

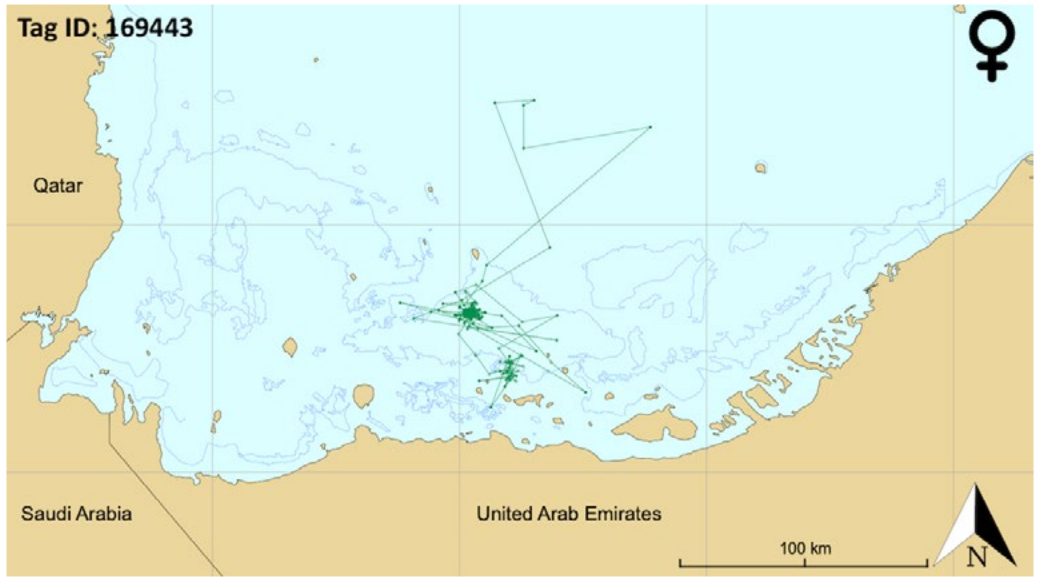

Tag ID: 169437
Iran
Qatar
United Arab Emirates
Oman
Saudi Arabia
200 km
N

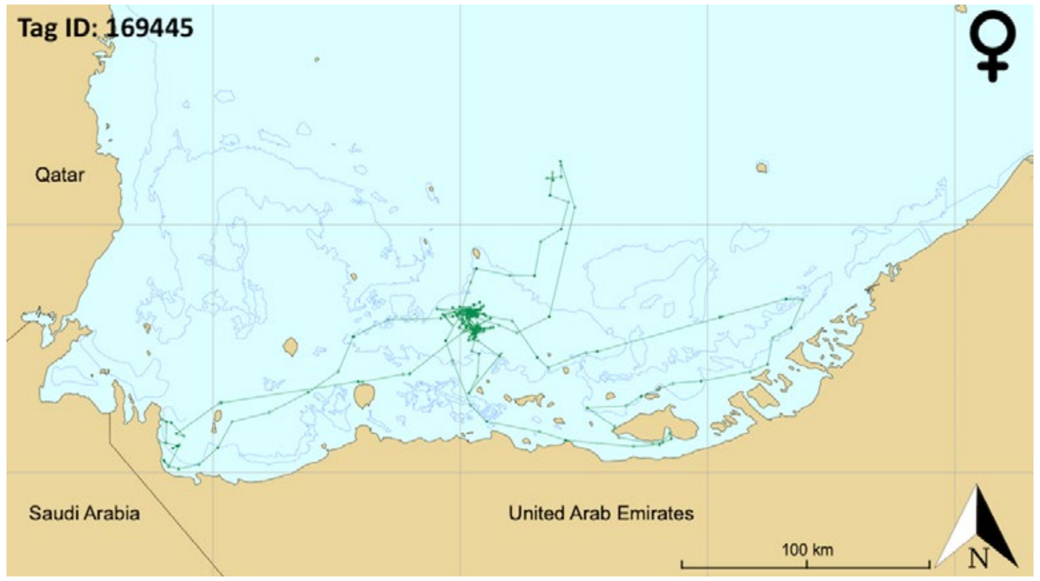

Tag ID: 169438
Iran
Qatar
United Arab Emirates
Oman
Saudi Arabia
200 km
N

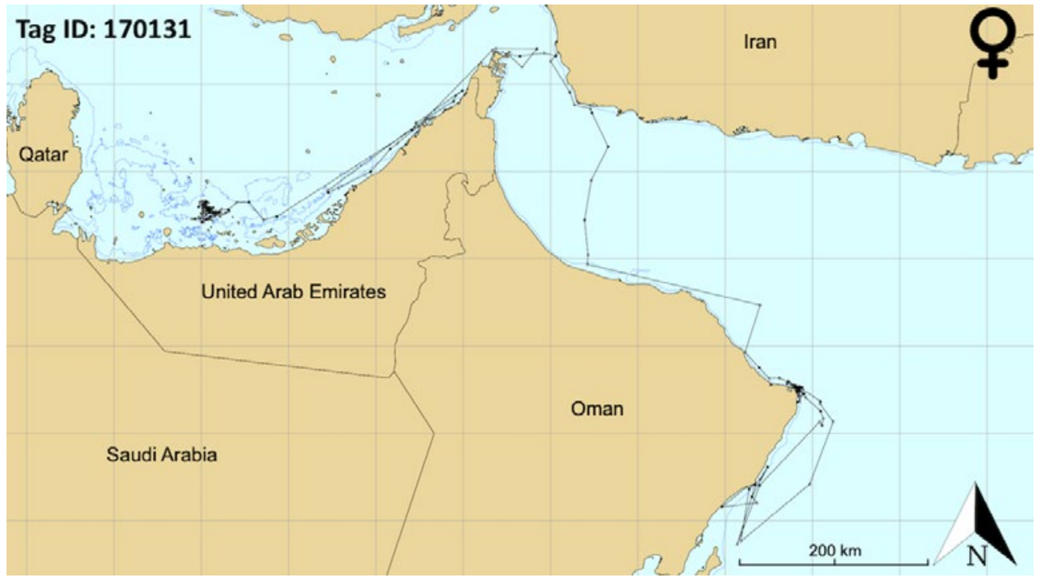

Tag ID: 169439
Iran
Qatar
United Arab Emirates
Saudi Arabia
Oman
200 km
N


Tag ID: 169440
Qatar
Saudi Arabia
United Arab Emirates
50 km
N


Tag ID: 170126
Qatar
Saudi Arabia
United Arab Emirates
100 km
N







المناقشة

بعد أربع سنوات من العمل، قامت جمعية الإمارات للطبيعة بالتعاون مع الصندوق العالمي للطبيعة ومؤسسة البحوث البحرية وشركاء المشروع بتجميع البيانات الأكثر وضوحاً وقوة حول الهجرات والترابط بين مناطق التغذية وأماكن تعشيش السلاحف البحرية التي تم تحديدها في منطقة الخليج. وذلك من خلال تتبع 51 سلحفاة بحرية خضراء بين عامي 2016 و 2019، حيث جمع المشروع مجموعة واسعة من المعلومات المتعلقة بالوظائف الحيوية للسلاحف الخضراء وبيئتها في منطقة الخليج. إذ تدعم هذه النتائج الجديدة أنشطة الإدارة والمحافظة على السلاحف الوطنية والإقليمية، كما توفر معلومات إضافية متعلقة بامتداد مناطق التغذية في مياه أبوظبي ورأس الخيمة.

في الغالب تتم حماية السلاحف البحرية على الشواطئ التي تعشش عليها في جميع أنحاء المنطقة، وفي المقابل لا توجد جهود كافية لحماية السلاحف البحرية في البحر، حيث تقضي السلاحف الغالبية العظمى من وقتهم. يعد تحديد نطاق مناطق التغذية التي تستخدمها السلاحف الخضراء عبر هذا المشروع بمثابة مجموعات بيانات مفيدة من شأنها أن تتيح تصميم إجراءات إدارة ومحافظة عملية وفعالة من قبل الجهات الحكومية المعنية في كل إمارة والتي يمكن أن تزيد من مستوى الحماية الممنوحة إلى السلاحف البحرية في الدولة.

كشفت هذه الدراسة عن العديد من الموائل الرئيسة غير المحمية أو المدارة (خليج كوتش في الهند وأرخبيل دلاك في إريتريا، وأيضًا الساحل الشمالي الشرقي قبالة مصيرة في عُمان)، ومن المحتمل إجراء دراسات إضافية في هذه المواقع، أو المزيد من التعقب من المواقع الأخرى الأمر الذي من شأنه أن يعزز قيمة هذه المواقع (ويحتمل أن يحدد مواقع إضافية) كموائل تغذية للسلاحف الخضراء.

بالإضافة إلى محمية مروح للمحيط الحيوي البحري في أبوظبي ومحمية خور مزاحمي في رأس الخيمة، فقد حدد المشروع أيضًا موائل تغذية إضافية تقع خارج المناطق البحرية المحمية الحالية؛ مثل مياه تقع خارج محمية خور مزاحمي للأراضي الرطبة التي أعلنت عنها مؤخرًا رأس الخيمة؛ كذلك المنطقة جنوب غرب جزيرة المرجان وشمال شرق الرفاعة في أم القيوين؛ أيضاً المياه قبالة جزيرة السعديات شرق أبو ظبي؛ وأيضاً المياه المحيطة بالجزء الغربي من جزيرة أبو الأبيض في أبو ظبي. قد تضمن هذه المواقع بعضاً من مستويات من الحماية و / أو الإدارة.

لقد جمع المشروع بين شركاء ينتمون لخلفيات متعددة ومصالح مختلفة، كما أثّر في السياسة الوطنية، وأشعل شغفًا بالسلاحف البحرية في جميع أنحاء دولة الإمارات. وقد ساهم هذا العمل في السياسة الوطنية في دولة الإمارات العربية المتحدة، وشكل في الوقت نفسه العمود الفقري لعدد من مبادرات الحفظ الدولية، التي تقودها اتفاقية الأمم المتحدة بشأن التنوع البيولوجي، وكذلك اتفاقية الأمم المتحدة بشأن الأنواع المهاجرة، والاتحاد الدولي لحفظ الطبيعة والموارد الطبيعية. حيث تظهر نتائج هذا العمل في القرارات المتخذة في اتفاقية التجارة الدولية بالأنواع المعرضة للانقراض، وفي المنتديات الإقليمية التي تسعى لتوسيع نطاق المناطق المحمية.

وقد تم بالفعل إدراج البيانات التي تم جمعها بواسطة هذا المشروع في خطة العمل الوطنية لدولة الإمارات العربية المتحدة للحفاظ على السلاحف البحرية وموائلها، كما تم استخدامها لتحديث حالة أنواع السلاحف في قائمة الأنواع المهددة بالانقراض في دولة الإمارات العربية المتحدة. وقد ساعد المشروع أيضًا في رفع مستوى الوعي على الصعيدين الوطني والدولي وأدى أيضًا إلى تعزيز التعاون بين العديد من الهيئات المحلية وأصحاب المصلحة. وقد ساهم المشروع في تحسين إدراكنا لبيولوجية السلاحف البحرية الخضراء وبيئتها، وكذلك كشف بعض الأسرار المتعلقة ببيولوجية السلاحف الخضراء في المنطقة العربية. لدينا الآن معرفة أفضل عن أماكن تعشيشهم، الموائل التي يستخدمونها في التغذية، والأماكن المحتملة للمغازلة والتزاوج، ومناطق تداخل هذه المناطق مع توسع الأنشطة البشرية والتنمية الصناعية. نحن نعرف المزيد عن تكرار التعشيش، وعن التعشيش على الشاطئ، وعن الجينات ونحن على استعداد أفضل لأن نكون أكثر فعالية في الحفاظ على السلاحف البحرية.

يمكن لنتائج هذا المشروع أن تقدم المعلومات الضرورية لوكالات الإدارة وممارسات المحافظة على السلاحف في منطقة تضم أحد الموائل البحرية الأكثر تحديًا للمناخ على كوكب الأرض، والتي تخضع أيضًا للتوسع الحضري الهائل وضغوط الشحن والصناعات المحلية، والتي تدعم أعداداً كبيرة من مناطق التعشيش والتغذية أو السلاحف البحرية المهددة بالانقراض. وبفضل هذه المعلومات، ستكون وكالات الإدارة أكثر قدرة على وضع إجراءات حفظ فعالة لضمان حماية السلاحف البحرية.

النتائج

لقد تراوحت مدة الإشارات المرسلة بين 14 إلى 647 يومًا، وقد كان المشروع قادرًا على استخدام 27754 نقطة بيانات تم ترشيحها من إجمالي 35402 نقطة تم استلامها، على مدار ما يقارب 6939 يوم تتبع بين عامي 2016 و 2019. في عمان كانت جميع السلاحف بالغة، واستهدف المشروع السلاحف الكبيرة في مواقع التغذية حيث كان الهدف هو تتبع البالغين في حالة الإستعداد للتكاثر، وبالتالي فإن الفئة العمرية للسلاحف التي صادفها المشروع منحازة نحو فئات الحجم الأكبر. بما فيهم السلاحف الست في منطقة التعشيش بعمان، حيث جمع المشروع عينات من 131 سلحفاة بالغة أنثى و 47 سلحفاة من الذكور البالغين، منهم 11 ذكراً (23% من الذكور البالغين) و 36 أنثى (27% من الإناث البالغات) في حالة استعداد للتكاثر. وقد تم تتبع هذه السلاحف من خلال أجهزة إرسال الأقمار الصناعية.

توفر بيانات الهجرة بعضًا من أهم نتائج هذا العمل. إذ أنها تكشف عن وجود روابط بين مواقع التعشيش ومناطق التغذية والمسارات العامة التي تسلكها السلاحف واستخدام موائل التغذية المهمة. حيث تحركت جميع السلاحف من سلطنة عمان نحو مناطق التغذية بعد العديد من حالات التعشيش الإضافية. لم ينتقل عدد من السلاحف من بوطينة ورأس الخيمة بعيدًا عن نقاط الإنطلاق، وذلك بسبب فقد الإشارات قبل قيام السلحفاة بأي عملية هجرة (إما بسبب فشل الإرسال أو ببساطة لإن السلاحف لم تتحرك). كانت هناك تحركات لمسافات طويلة (> 1000 كم) قامت بها سلحفتان من سلطنة عمان، ومسافة طويلة (2500 كم) واحدة مكتملة من منطقة التغذية إلى التعشيش ثم مرةٍ أخرى إلى منطقة التغذية قامت بها سلحفاة من بو طينة، ولكن بشكل عام أكملت التحركات مئات من الكيلو مترات بدلاً من آلاف الكيلو مترات.

لقد تضمنت الحركتان الطويلتان اللتان قامت بهما السلاحف من سلطنة عمان سلحفاة واحدة تحركت شرقًا إلى خليج كوتش في الهند والثانية تحركت جنوب غرب على طول ساحل اليمن، وقد دخلت البحر الأحمر، واستقرت في أرخبيل دلاك قبالة إريتريا. يُعرف كلا الموقعين بأنهما مواقع تغذية للسلاحف البحرية الخضراء. وقد كانت دولة الإمارات العربية المتحدة الوجهة الثالثة للبحث عن الطعام، حيث انتقلت سلحفتان إلى الخليج العربي، واستقرت إحداهما قبالة الساحل الغربي لإمارة أبوظبي والثانية استقرت على مناطق التغذية المعروفة قبالة رأس الخيمة. وتؤكد هذه التحركات على الترابط بين مناطق التعشيش في سلطنة عُمان ومناطق التغذية في الإمارات والتي يجب مراعاتها أثناء وضع خطط الإدارة والحفاظ على السلاحف. تنقلت إحدى السلاحف من رأس الخيمة إلى الجنوب الغربي باتجاه أبوظبي ثم عادت إلى رأس الخيمة، ونظراً لأن هذه السلاحف في حالة استعداد للتكاثر، فإن هذا السلوك يشير إلى أن السلاحف البالغة يمكنها استخدام أكثر من منطقة تغذية.

كما سجل المشروع أربع تحركات من بو طينة إلى الشمال الشرقي حتى الخليج وعادت إلى بو طينة مرة أخرى، وعلى الرغم من أن أيا من السلاحف لم تتوقف عند أي نقطة – مما يشير إلى عدم وجود سلوك التغذية أو المغازلة أو البحث عن الطعام. إلا أنه وحتى الوقت الحالي، لم يتضح لنا سبب سلوك السلاحف بهذه الطريقة.

هاجرت إحدى السلاحف الذكور من بو طينة إلى منطقة قريبة من جزر الديمانيات في سلطنة عمان وقد أمضت وقتًا طويلاً هناك، مما يشير إلى أن هذه المنطقة قد تكون بمثابة منطقة مغازلة للسلاحف التي تعشش لاحقًا على الشواطئ الرئيسة. ونظراً إلى أن جزر الديمانيات تستضيف مناطق تعشيش متفرقة للسلاحف الخضراء، وهناك احتمال ضئيل بأن يكون هذا الذكر واحداً من السلاحف التي تم تنشئتها في الديمانيات. توجهت سلحفاة ذكر إضافية من بوطينة شمالاً إلى مضيق هرمز قبل أن تفقد إشاراتها، ومن المحتمل أن تكون هذه السلحفاة قد توجهت أيضًا إلى سلطنة عُمان أو إلى منطقة مغازلة قبالة مسندم. إذ قام المشروع أيضًا بتسجيل تحركات سلحفاة ذكر أخرى أمضت وقتًا طويلًا قبالة ساحل دبي. ونظراً لأنه كان في حالة استعداد للتكاثر، فمن الممكن أن تكون هذه أيضاً منطقة مغازلة.

ومن بين أبرز النتائج التي تم التوصل إليها، هو قيام ست سلاحف من بوطينة بهجرة مكثفة للعيش في رأس الحد بسلطنة عمان، تم إرسال ثلاث منهم لإشارات حتى عادت إلى بوطينة بعد حوالي خمسة إلى ستة أشهر. هذه هي بعض المسارات الأولى من نوعها بين الأوساط العلمية، تم التقاطها عن عمد وتفقد حالتها لمعرفة استعدادها للتكاثر وتتبعها بهدف توثيق سلوكها خلال رحلة الذهاب والإياب. كانت مسارات الهجرة مستقيمة نسبياً في حالتين، حيث كانت السلاحف تسير على ساحل دولة الإمارات، وتتجه إلى الساحل الإيراني عند تقاطع مضيق هرمز، وتتحرك جنوبًا على طول الساحل الإيراني قبل عبور خليج عمان متجهة جنوبًا حتى الساحل العماني لتصل إلى مناطق التعشيش في محيط رأس الحد. بينما نجد أن السلحفاة الثالثة اتخذت طريقاً غير مستقيم، حيث تحولت شرقًا وتم تتبعها على طول شواطئ إيران وباكستان وجنوبًا إلى خليج كوتش في الهند. ثم إتجهت غربًا وسبحت في خط مستقيم نحو موقع تعشيش في عُمان، وعبرت المياه التي يتجاوز عمقها 5000 متر، قبل أن تصل في النهاية إلى رأس الحد. عند الانتهاء من التعشيش، اتبعت السلاحف الساحل العماني في الخليج العربي وسبحت مباشرة إلى بو طينة لاستكمال مسارات هجرة التعشيش ذهابًا وإيابًا.

العديد من سلاحف بوطينة لا تغادر مناطق تغذيتها، حيث جمع المشروع بيانات من السلاحف التي تم إطلاقها في بوطينة قبل أن تغادرها في هجرات التعشيش. بين عامي 2016 و 2019 بقيت31 سلحفاة بالقرب من بو طينة لفترات تتراوح من 0 إلى 647 يومًا، وتم اكتساب ما مجموعه 5156 موقع خلال هذا الوقت. تشير هذه البيانات إلى أن السلاحف التي تم وسمها وإطلاقها في بوطينة استخدمت محمية مروح للمحيط الحيوي وكذلك الموائل خارج هذه المنطقة، خاصة في المياه التي يبلغ عمقها أقل من 10 أمتار على طول الرمال الغربية من الجوانب الشمالية لأبي الأبيض، قبالة جزيرة السعديات، وجنوب جزيرة بوطينة.

كانت مجموعة فرعية من 3901 موقع تحديثات من داخل محمية مروح للمحيط الحيوي، ممثلة ما يقرب من 76% من جميع المواقع للسلاحف الخضراء التي تم إطلاقها في بو طينة، وتغطية جيدة لمناطق الأعشاب البحرية المهمة داخل محمية مروح للمحيط الحيوي البحري.

وبالمثل، جمع المشروع بيانات حول تغذية السلاحف البحرية الخضراء في رأس الخيمة، وسوف تساعد هذه البيانات في تحديد المناطق المهمة للسلاحف في هذا الموقع. تم استلام ما مجموعه 3408 نقطة موقع من جميع السلاحف في المنطقة المجاورة لرأس الخيمة وجزيرة سرايا وفي موقع بين جزيرة المرجان في رأس الخيمةٍ والرفاعة في أم القيوين. و قد تساعدٍ بيانات التغذية على اليابسة في تعزيز مناطق الأعشاب البحرية المعينة حالياً، حيث أمضت السلاحف وقتاً كبيراً في المناطق التي لم يتم بعد تعيين الأعشاب البحرية فيها.

لقد تم تتبع سلحفاة وحيدة ذكر في عام 2019 (متجهة إلى الشمال الغربي نحو قطر بعد أن بقيت في أماكن التغذية لعدة أشهر، و قد كان هذا هو التسجيل الوحيد لسلحفاة متجهة إلى الشمال الغربي، ربما كان ذلك في محاولة للوصول إلى جزر التعشيش في المملكة العربية السعودية. حيث وصلت إلى الشواطئ الشمالية لقطر قبل أن تتجه جنوبًا، ويعتقد أن السلحفاة كانت عاجزة نوعًا ما بناءً على جودة الإشارات في الأسبوع الأخير من الإرسال.

لم تقم أي من السلاحف التي تم تعقبها من رأس الخيمة بالهجرة التعشيشية، ولكن يرجع جزء من السبب إلى العثور على عدد قليل من السلاحف في حالة استعداد للتكاثر في هذا الموقع. لم يتم تعقب أي سلاحف إلى أي وجهة تعشيش أخرى في المنطقة. حيث يرتبط تفضيل سلطنة عمان كوجهة تعشيش ارتباطا وثيقًا بعدد الأعشاش: إذ تستضيف سلطنة عمان حوالي 5000 عُشاً سنويًا وتستضيف المملكة العربية السعودية حوالي 1000 عشّ سنويًا. كما سجلت الإمارات حالة تعشيش واحدة فقط في التاريخ الحديث، وتسجل الكويت من أربعة إلى عشرة أعشاش سنويًا، أما إيران فتسجل أعداد مماثلة أو أكثر قليلاً. ونظراً إلى ذلك، نجد أن هناك احتمال بنسبة 80% تقريبًا أن تأتي السلحفاة الخضراء من الأعشاش العمانية، واحتمال بنسبة 20% أن تأتي من الأعشاش السعودية، وفرصة ضئيلة للغاية أن تأتي من الإمارات أو إيران أو الكويت.

بخلاف ذلك نجد أنه تم العثور على حالة إتمام واحدة لرحلة كاملة في الخليج، حيث عبرت سلحفاة من عمان إلى باكستان في طريقها إلى الهند (حيث تجاوز عمق المياه 3000 متر)، في حين بقيت جميع السلاحف التي تم تعقبها في عام 2016 في المياه الضحلة (بعمق أقل من 20 مترًا) مما يشير إلى تفضيل السلاحف للمياه الساحلية الضحلة بدلاً من الممرات المحيطية العميقة.

الملخص التنفيذي

المقدمة

إن مشروع الحفاظ على السلاحف الخضراء هو مشروع تنفذه جمعية الإمارات للطبيعة بالتعاون مع الصندوق العالمي للطبيعة بالشراكة مع الهيئات الحكومية، المنظمات غير الحكومية والقطاع الخاص في دولة الإمارات العربية المتحدة، وسلطنة عمان. ومن بين الشركاء في هذا المشروع وزارة التغير المناخي والبيئة، ووكالة البيئة في أبوظبي، وهيئة حماية البيئة والتنمية في رأس الخيمة ، وهيئة البيئة والمناطق المحمية في الشارقة. بينما في عمان؛ يتعاون المشروع مع وزارة البيئة والشؤون المناخية وجمعية البيئة العمانية وشركة المحيطات الخمس ذ.م.م. بينما قدمت مؤسسة البحوث البحرية المشورة العلمية والخبرة البحثية للمشروع.

تلعب السلاحف البحرية أدوارًا بيئية محورية في النظم البيئية البحرية. كونها من الأنواع الرئيسة في الموائل البحرية، كما تعد مؤشراً على الصحة النسبية لمختلف النظم البيئية البحرية. ولها أهمية كبيرة في مجال السياحة والأبحاث. ولكنها تواجه العديد من التهديدات على مدار فترات زمنية طويلة بسبب طول عمرها وتأخرها في البلوغ. تأتي التهديدات للسلاحف البحرية من مصادر عديدة ومتنوعة، قد تكون تهديدات بيولوجية روتينية مثل (الافتراس، أو المرض، أو فقدان الموائل) وتهديدات طبيعية غير متوقعة مثل (العواصف، وعوامل التعرية، وما إلى ذلك) وأنشطة البشر بما في ذلك فقدان الموائل، والإلتقاط العرضي في مصايد الأسماك، وجمع البيض، التلوث، الإضاءة، الشباك المهملة، وتغير المناخ.

بعد الانخفاض العالمي طويل الأمد في أعداد السلاحف، تم تصنيف السلاحف الخضراء عالمياً على أنها مهددة بالانقراض من قِبل الاتحاد الدولي للحفاظ على الطبيعة. وعلى المستوى الإقليمي، صنفت في شمال المحيط الهندي على أنها معرضَة للخطر. بينما على المستوى الوطني، صنفتها القائمة الحمراء للسلاحف الخضراء على أنها معرض للخطر أيضًا، استنادًا إلى أقل من 10000 سلحفاة بالغة، يتوقع أن يستمر التراجع في أعداد السلاحف البالغة، وأن يواجهوا أربع تهديدات أساسية: تناول الفضلات البحرية، الإصطدام بالقوارب، الوقوع في الشباك، وفقدان الموائل.

على الرغم من توافر معلومات جوهرية عن أماكن تعشيش السلاحف الخضراء، إلا أنه لا تزال الكثير من البيانات المتعلقة بموائلها في منطقة الخليج غير متوفرة، الأمر الذي يحول دون وضع خطط فعالة لإدارة تلك المناطق والمحافظة عليها، بالإضافة إلى وجود معلومات غير كافية عن ترابط تلك المناطق على الصعيدين الوطني والإقليمي فيما يتعلق بالمعلومات البيولوجية للسلاحف البحرية ودورات حياتها – وبالتالي تقل فرص الحفاظ عليها. لقد تم تصميم مشروع السلاحف الخضراء لتقديم المعلومات اللازمة لوضع خطط الإدارة وإستراتيجيات المحافظة على السلاحف، حيث توفر بيانات التتبع التي ترسلها أجهزة إرسال الأقمار الصناعية المثبتة على السلاحف البحرية الخضراء معلومات عن مواقع التعشيش ومناطق التغذية ومسارات الهجرة. تساعد هذه المعلومات في تسليط الضوء على الروابط الإقليمية بين البلدان التي تقيم فيها السلاحف وتعشش فيها، وتساعد في تحديد المناطق الإضافية الهامة للسلاحف الخضراء في الخليج العربي.

الأساليب

في الفترة بين عامي 2016 و 2019، قام المشروع بتتبع 51 سلحفاة بحرية خضراء باستخدام أجهزة إرسال الأقمار الصناعية لتحديد الروابط بين مناطق التغذية ومواقع التعشيش، بالإضافة إلى مسارات الهجرة والتكيف السلوكي. حيث نشر المشروع 45 جهاز إرسال في جزيرة بو طينة، على بعد 80 كم تقريبًا من ساحل أبو ظبي، وقبالة شاطئ سرايا الرملي جنوب رأس الخيمة، وكلاهما في دولة الإمارات العربية المتحدة. كما تم نشر ستة أجهزة إرسال إضافية في سلطنة عُمان في عام 2016.

في سلطنة عمان، قام المشروع بتتبع السلاحف بعد التعشيش من شواطئ التعشيش إلى أماكن التغذية. بينما في دولة الإمارات العربية المتحدة، تم تعقب السلاحف في الاتجاه المعاكس، أي من مناطق التغذية إلى مواقع التعشيش الخاصة بها. في أبو ظبي، تمكن الفريق من إصطياد السلاحف في مناطق المياه الضحلة باستخدام أسلوب روديو. بينما في رأس الخيمة، عمل المشروع مع الصيادين الذين يستخدمون شباك السين الساحلية لصيد الأسماك، من أجل جمع السلاحف عندما يتم جلب الشباك إلى الشاطئ. وذلك من أجل اختيار السلاحف البالغة المستعدة للتكاثر في هذين الموقعين، ثم يتم إجراء عملية تنظير البطن لتحديد الجنس وكذلك الفئة العمرية للسلاحف، وللتأكد ما إذا كانت في حالة استعداد للتكاثر. إذ أنه بمجرد تحديد الجنس والحالة الإنجابية، واختيار السلاحف لتتبعها، يتم لصق أجهزة إرسال الأقمار الصناعية عليها باستخدام مواد لاصقة مخصصة.

لقد تمت معالجة البيانات بواسطة نظام أرجوس، وتم تحميلها بشكل منتظم طوال فترة البحث. حيث تمت تصفية جميع البيانات لاستبعاد المواقع على اليابسة، ثم تمت تصفيتها أيضًا للحصول على دقة عالية الجودة للموقع بسرعة 10 ≥ كم / ساعة بين التحديثات. ولاستبعاد التحيز السلوكي بين السلاحف المهاجرة، فقد تم اختيار تحديثين لكل سلحفاة يوميًا: الأول هو الأعلى دقة قرب منتصف النهار، بينما الثاني هو الأعلى جودة قرب منتصف الليل. حيث تم تقسيم تحديثات الموقع إلى ثلاث فئات وذلك وفقًا لنشاط السلاحف: بالنسبة للسلاحف التي تم إطلاقها في سلطنة عمان، تم تصنيف جميع التحديثات قبل نقطة المغادرة من موقع التعشيش على أنها تعشيش داخلي (فترة ما بعد الإطلاق حتى المغادرة من موقع التعشيش). بينما بالنسبة إلى السلاحف في دولة الإمارات العربية المتحدة، فقد تم إعتبار جميع مواقع ما قبل المغادرة هي موائل تغذية. ثم تم تصنيف تحديثات الموقع المتلاحقة حتى تم البدء في التغذية (في حالة السلاحف العمانية) أو التعشيش (في حالة السلاحف في الإمارات) على أنها تحديثات هجرة (السفر المباشر الهادف من موقع التعشيش مع الحد الأدنى من الانحراف عن المسار المستقيم). ثم بعد ذلك، تم الاستدلال على نشاط التغذية أو التعشيش وذلك من خلال خفض معدلات السفر والانحراف عن اتجاه الهجرة المقصود إلى أماكن أخرى لمسافات قصيرة مع تغييرات عشوائية في الوجهة.

لقد إستخدم المشروع عملية تحليل كيرنيل للكثافة وذلك ضمن نظام معلومات جغرافية لتحديد امتداد مناطق التغذية الرئيسة التي تستخدمها السلاحف، أو المناطق الهامة لهم.

نُشر في ديسمبر 2019 بواسطة جمعية الإمارات للطبيعة بالتعاون مع الصندوق العالمي للطبيعة، أبو ظبي، الإمارات العربية المتحدة

لمزيد من المعلومات برجاء زيارة: www.emiratesnaturewwf.ae

الإيميل: emiratesnature@enwwf.ae

بيلشر إن جيه، سي جيه رودريجز– زارات، م انتونوبولو. 2019. مشروع الحفاظ على السلاحف الخضراء 2016-2019: التقرير العلمي النهائي. جمعية الإمارات للطبيعة بالتعاون مع الصندوق العالمي للطبيعة. أبو ظبي، الإمارات العربية المتحدة.78 صفحة.

عن جمعية الإمارات للطبيعة بالتعاون مع الصندوق العالمي للطبيعة

جمعية الإمارات للطبيعة جمعية بيئية غير حكومية، تأسست عام 2001 تحت رعاية سمو الشيخ حمدان بن زايد آل نهيان، ممثل الحاكم في منطقة الظفرة ورئيس مجلس إدارة هيئة البيئة أبو ظبي.

خلال ما يقرب من عقدين من الزمن، كانت جمعية الإمارات للطبيعة بالتعاون مع الصندوق العالمي للطبيعة شريكًا بارزًا وفعالًا في الحفاظ على البيئة في المنطقة. نظرًا لكونها جزءًا من شبكة الصندوق العالمي للطبيعة العالمية، التي تفخر بتراث عمره 50 عامًا ، نفذت الجمعية العديد من مشاريع المحافظة على الطبيعة والتعليم في المنطقة منذ عام 2001. تعمل الجمعية على المستوى الإتحادي في الدولة ولها مكاتب في أبو ظبي ، دبي والفجيرة ويديرها مجلس إدارة إماراتي.

عن مؤسسة البحوث البحرية

مؤسسة البحوث البحرية هي مؤسسة أبحاث غير ربحية مقرها في كوتا كينابالو، ماليزيا، وتم تأسيسها بموجب قانون الأمناء الماليزيين لعام 1951. أنشئت لتعزيز فهم النظم البيئية البحرية والنباتات والحيوانات المختلفة المرتبطة بها في جنوب شرق آسيا وغيرها من مناطق الهند والمحيط الهادي. تقوم المؤسسة بتنفيذ عدد من المشاريع المتعلقة بتقييم التنوع البيولوجي وحفظه وتسعى إلى توفير حلول موجهة للإدارة للإدارات الحكومية والعاملين في مجال المحافظة على الطبيعة.

إخلاء المسؤولية

لا يعني تعيين الكيانات الجغرافية وعرض المواد في هذا التقرير التعبير عن أي رأي من أي نوع من جانب جمعية الإمارات للطبيعة بالتعاون مع الصندوق العالمي للطبيعة فيما يتعلق بالوضع القانوني لأي بلد أو إقليم أو منطقة أو سلطاتها أو فيما يتعلق بتعيين حدودها.

شركاء المشروع

جمعية الإمارات للطبيعة
WWF
تم نشر هذا التقرير بالاشتراك مع MRF
MARINE RESEARCH FOUNDATION MRF SABAH, MALAYSIA

مشروع الحفاظ على السلاحف الخضراء

التقرير العلمي النهائي المنطقة العربية