

TURTLETOSCA: DRONE MONITORING OF THE *CARETTA CARETTA* NESTS IN THE MIGLIARINO SAN ROSSORE MASSACIUCCOLI PARK

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Abstract: The loggerhead turtle (*Caretta caretta*) is the most abundant sea turtle species in the Mediterranean Sea. In 2023, 454 nests were identified along Italian beaches, these results represent the absolute Italian nesting record. It was also an exceptional year (2023) for Tuscany, in the central of Italy, where 24 nests were found. This area of central Italy seems to be no longer an exceptional site, so it is necessary to organize monitoring activities in order to cover most of the Tuscan beaches where *Caretta caretta* could nest. Between the mouths of two rivers, the Serchio and the Arno, lies a natural park, owned by the Tuscany Region, called the Migliarino San Rossore Massaciuccoli Natural Park (MSRM Park), a protected area with 34 km of protected coastline. With the aim of identifying, protecting and managing *Caretta caretta* turtle nests in this area, a monitoring program has been initiated using UAVs (Unmanned Aerial Vehicles), or drones, inside MSRM Park. In the first working season, which ran from June to August 2023, one carcass and some possible *Caretta caretta* tracks were identified, but no nest at the moment.

Keywords: Loggerhead Turtle, Unmanned Aerial Vehicle, Scientific Monitoring, Citizen Science

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Introduction

The ranges of many species are shifting poleward as a result of global warming because environmental temperature is one of the major determinants of geographic distribution in animals. Being ectothermic, sea turtles are particularly sensitive to variation in environmental temperature, and they are expected to shift their range according to the movement of their climatic niche as an adaptive response to climate warming. The loggerhead turtle (*Caretta caretta*) is a priority species included in App. II/IV of the Habitats Directive whose conservation requires to activate a strict protection regime across the species' entire natural range, both within and outside Natura 2000 sites (Habitats Directive) and the identification of core areas (e.g. nesting beaches, foraging grounds, migratory corridors) that must be designed as Site of Community Importance and managed in accordance with the ecological requirements of the species. Located at the northern edge of the species range, the Mediterranean Sea has been colonized by individuals from the Atlantic population in at least two independent events in the late Pleistocene and the Holocene originating the current nesting populations in the central and eastern Mediterranean. The species has therefore survived past climatic changes by shifting its nesting range in accordance with the migration of its thermal niche. Yet the loggerheads' capacity to adapt to present and future climate changes is uncertain because of the accelerated rates of climate warming, cumulative impacts of human activities and restricted availability of alternative habitats caused by coastal urbanization. The successful colonization of new climatically suitable areas, in fact, does not only rely on the availability of environmental conditions favourable for embryonic development, but it is tightly linked to the exposure to threats on the nesting beaches deriving mostly from coastal development.

Nowadays the loggerhead turtle is the most abundant sea turtle species in the Mediterranean Sea. Italy hosts regular nesting events along the Ionic coasts of the southern Calabria and in the Pelagian Islands (Linosa and Lampedusa) [3], as well as along the southern Tyrrhenian Sea (Campania). In 2023, 454 nests were identified along Italian beaches, these results representing the absolute Italian nesting record. It was also an exceptional year (2023) for Tuscany, in the central of Italy, where 24 nests were found. In this region, the first nest identified dates back to 2013. Until 2018, only seven nests of the *Caretta caretta* species were documented in Tuscany. However, this area of central Italy seems to be no longer an exceptional site, so it is necessary to organize monitoring activities in order to cover most of the Tuscan beaches where *Caretta caretta* could nest.

In the Mediterranean area *Caretta caretta* is subject to a mix of anthropic pressures. Coastal development is associated with the permanent alteration of coastal habitats due to the presence of hotel resorts, tourism-related constructions such as restaurants, bars, houses and other businesses typically built along the beach. Light Pollution is one distinctive and particularly damaging form of habitat alteration caused by coastal development, defined as the introduction of artificially produced detrimental light into the environment. Hatchlings emerging from their nests at night depend upon subtle brightness cues to lead them safely to

the sea. Bright artificial light sources attract hatchlings and lead them away from the ocean where the small turtles succumb to attacks by predators, exhaustion, desiccation, or strikes by vehicles on nearby roads and parking lots. Shore-based lights can also misdirect adult turtles, returning to the sea after nesting, in a similar way, wandering on the beach for hours. Recreational activities and beach management practices associated with coastal urbanization are also important threats. Driving on the beach and the use of heavy machinery for beach cleaning purposes are common practices and are responsible for alterations in sand characteristics, the destruction of turtle clutches and the deletion of tracks before sea turtle observers can record them.

Beach furniture, recreational equipment and other large objects left at night on the beach reduce the habitat available for nesting and prevent females from accessing suitable nesting sites. People on the beach during the night may disrupt nesting activity as females may abandon their nesting attempts or incubating nests may be destroyed through trampling or by umbrellas thrust into the sand. Moreover, recreational activities may result in an increase of nest predation risk from animals that are attracted to the beach due to the greater food availability.

Monitoring of nesting tracks is an essential first step for the management of the species and for correct use of the coastal strip. The involvement of volunteers is also important, encouraging the creation of citizen science projects in the environmental and ecological sciences. This work was born from a close collaboration between local authorities (the Municipality of Pisa and the Migliarino San Rossore and Massaciuccoli Natural Park), research institutions (CNR and the University of Pisa) and volunteer citizens. The activities also refer to the LIFE TURTLENEST project of which Legambiente NGO is the leader. Through a multi-disciplinary approach, the project will improve the conservation status of *Caretta caretta* aided by: i) the establishment of an international network; ii) the use of shared best-practice procedures specifically revised to mitigate the threats on emerging nesting sites; iii) the capacity building of trained field operators; iv) the identification of new index sites for monitoring; v) the strengthening of the Natura 2000 network. In conclusion, the goals of this project were: 1) to obtain the first information, through videos and images, of the presence of nesting traces of the *Caretta caretta* in the coastal stretch of the MSRM Park and 2) to increase the monitoring effort along the coastal strip of Tuscany, in an area not yet studied up to now.

Materials and Methods

Area sampling

Between the mouths of two rivers, the Serchio and the Arno, lies a natural park, called the Migliarino San Rossore Massaciuccoli Natural Park (MSRM Park), a protected area with 34 km of protected coastline.

The MSRM Park lies between 43° 51' 36" – 43° 35' 25" N and 10° 14' 26" – 10° 21' 11" E. It was established in 1979 in order to safeguard around 23 150 ha of dunes, mesophilous and xerophilous forests, wetlands and agro-forestry

landscape, along approximately 30 km of coast. In 2004, UNESCO designated the park as a Biosphere Reserve. Although only constituting a fraction of the surface area of the park (about 394 ha, 1.7 % of the total area), the recent dune bands represent an area of extraordinary richness in terms of unique habitats and endemic plants. At the same time, however, there is strong anthropogenic pressure, linked to seaside tourism and the presence of urban settlements, and on some stretches significant erosion (GNRAC, 2006) [1]. In order to characterize the climate, temperature and precipitation data were used from a weather station located at the eastern edge of the park (San Piero a Grado, Pisa). Annual average rainfall for the ten-year period from 1997 to 2007 was 773 mm, with the highest rainfall recorded in the autumn, and an annual average temperature of 14.4 °C, with maximum values close to 30 °C. The area exhibits a period of summer drought and water shortages from June to September. The area has a Mediterranean macrobioclimate, with an upper meso-Mediterranean thermotype and a lower sub-humid ombrotype. The coastline of the park can be divided into three different sectors in relation to coastal dynamics and anthropization: i) the northern sector (N), about 8 km long is subject to protective restrictions but freely accessible to the public and with a low level of urbanization. The coastline is prograding (approximately 140 m since 1954). ii) The central sector (C), about 11 km long is subject to protective restrictions and closed to the public. The coastline is undergoing rapid erosion (approximately 180 m since 1954). iii) The southern sector (S), about 11 km long, is open to the public with partial protective restrictions [1].

Monitoring

During the nesting season (May–August), Legambiente and CNR staff and volunteers monitor sea turtle nesting tracks during morning patrols along the San Rossore beach in Pisa (Figure 1).

With the aim of identifying, protecting and managing *Caretta caretta* turtle nests in this area, a monitoring program has been initiated using UAVs (Unmanned Aerial Vehicles), or drones, inside MSRM Park, within the coastal stretch of protected area with access allowed, by the managing body, for research purposes only. Drones have made it possible to observe tens of kilometers of beach in the early hours of the morning. The work protocol applied envisaged the use of a Phantom 4 PRO v2 quadcopter-type UAV, which had already been used previously, in the same area, for environmental surveys of several types [2], [4], [5]. Inside this specific application, the drone performed an automatic flight over the coast profile up to a height of 30 m. Two operators performed the monitoring: the first performed the real-time observation on the UAV ground station monitor, the second performed the recorded observation on a high-resolution monitor from the UAV's SD memory, changed when replacing the battery. This allowed us a double reading and greater guarantee against errors of interpretation. The temporal frequency of the survey was twice a week, with the involvement of only two operators acting from two different access points.

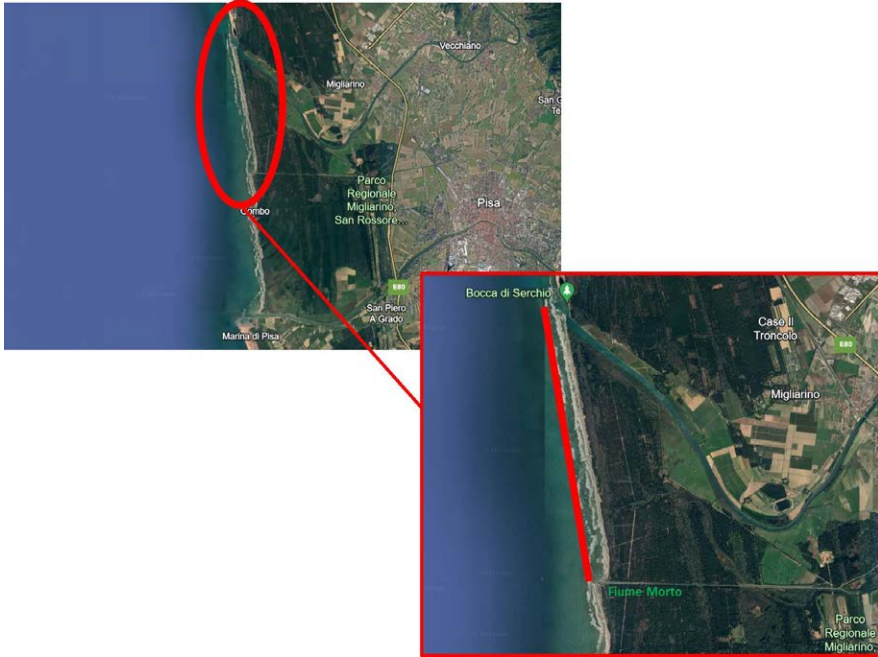


Figure 1 – The sampling area from Fiume Morto (south) to Bocca di Serchio (north).

Results

As part of this activity, 7.42 km were analyzed with a total flight time, excluding battery changes and movements, of 64 minutes at a height of 30 m. During the flight the camera aimed nadirally recorded the video in 4K format (4096×2160) with H264 CODEC. In the first working season, which ran from June to August 2023, one carcass and some possible *Caretta caretta* tracks were identified, but no nest recorded at the moment. The activities were carried out and disseminated, thanks to a citizen science project with the Legambiente NGO, which involved around 40 volunteers.

The first flights, 30 meters above the ground, made it possible to study the entire monitored beach in detail, identifying those possible sections obstructed by the presence of wood or by an excessive quantity of accumulated beach litter.

We point out two images taken by the drone which represent an area with human footprints (Figure 2), in an area where it is possible to access only with authorization of MSRMPark and a second figure, where a "U" shaped structure can be seen (Figure 3). In this case an inspection had to be carried out to better investigate the footprint. These were two furrows left by the movement of some trunks.



Figure 2 – Human footprints on the sand.



Figure 3 – “U” shaped on the sand.

Another image instead led to the discovery of a sea turtle carcass (Figure 4). The image at thirty meters above sea level was already very clear, however an inspection was subsequently carried out to observe the state of decomposition of the animal (Figure 5).



Figure 4 – *Caretta caretta* carcass from above.



Figure 5 – *Caretta caretta* carcass inspection.

The last image shows a possible nesting attempt of the marine reptile in search of a suitable place for nesting (Figure 6). After that, more in-depth research, carried out by expert technicians, ruled out that the track in Figure 6 had been left by a female of Loggerhead sea turtle.



Figure 6 – False nesting attempt.

Discussion

This activity was the starting point for a new project of scientific monitoring of the coast of a protected natural area. Furthermore, it was also a citizen science project, with the organization of training activities aimed at new volunteers.

In general, one of the possible reasons for the absence of nesting within the protected area of the park could be the presence of considerable quantities of material, much of it anthropogenic, accumulated on these beaches, due to the presence of the nearby river outlet of the Arno and the lack of frequent beach cleaning operations. This considerable amount of material could act as a deterrent for spawning, although further investigation will be necessary to confirm this hypothesis. In any case, the protocol developed, based on the aerial survey, has proven to be extremely efficient, allowing for frequent surveys even in areas with difficult direct access to the sites to be examined, limiting anthropogenic impact in protected and fragile environments, and greatly reducing the number of personnel required for this type of investigation.

The discovery of the carcass from above made possible the subsequent intervention in the field and the activation of the procedure for the recovery of the animal.

It should be highlighted that nesting attempts must always be verified, to understand if they are real and, possibly, investigating why the nesting was not successful.

This result showed the effectiveness of the tool in searching for any carcasses of marine animals, suggesting that the identification of these in protected natural areas, remote or difficult to access areas could be facilitated by the use of these tools. The tool can be so useful in a coastal protected natural area to study other critical issues of the territory, such as coastal erosion or even the invasion of alien species.

For the future, the presence of possible traces is a first step towards identifying the nest, the next phase must be that of recognition in the field.

Conclusions

It is extremely important for the conservation and protection of the species to understand if nesting sites considered occasional could become regular nesting areas over time.

Shots from above make it possible to identify the tracks of the turtles that come out of the sea in search of the possible right point in which to dig their nest in the sand. In addition the images from UAVs can provide valuable information about the environment, including changes in land cover, vegetation health, and even wildlife behavior.

In conclusion it should be stressed that protecting the species also means dealing with environmental, social and economic questions. Climate change and global warming impact biodiversity and ecosystems and, consequently, our territories and our lifestyle. Taking care of the protection of the Loggerhead sea turtle also means safeguarding the economies of our territory. *Caretta caretta* contribute indeed to local economies through ecotourism, particularly in areas where turtle watching is a popular activity. They also play a vital role in marine ecosystems, affecting the population dynamics of jellyfish and other species.

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Author Contributions

YG conception and design of the study, methodology and training of citizen scientists, investigation, formal analysis, writing - original draft, review, and editing. SM and MP methodology, investigation, formal analysis, writing - original draft, review, and editing. CM and MZ methodology and training of citizen scientists, investigation, formal analysis, writing - original draft, review, and editing. AD training of citizen scientists, investigation, writing – review and editing. FL writing – review and editing.

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

- [1] Bertacchi A. (2017) - *Dune habitats of the Migliarino – San Rossore – Massaciuccoli Regional Park (Tuscany – Italy)*, Journal of Maps, 13(2), 322–331. DOI: 10.1080/17445647.2017.1302365
- [2] Luppichini M., Bini M., Paterni M., Berton A., Merlino S. (2020) - *A New Beach Topography-Based Method for Shoreline Identification*, Water 2020, 12, 3110. DOI: 10.3390/w12113110

- [3] Mingozi T., Masciari G., Paolillo G., Pisani B., Russo M., Massolo A. (2008) - *Discovery of a regular nesting area of loggerhead turtle *Caretta caretta* in southern Italy: a new perspective for national conservation*, Biodiversity and Conservation in Europe, 277-299. DOI: 10.1007/s10531-006-9098-6
- [4] Merlino S., Paterni M., Berton A., Massetti L. (2020). *Unmanned aerial vehicles for debris survey in coastal areas: Long-term monitoring programme to study spatial and temporal accumulation of the dynamics of beached marine litter*, Remote Sensing, 12(8), 1260. DOI: 10.3390/rs12081260
- [5] Merlino S., Paterni M., Locritani M., Andriolo U., Goncalves G., Massetti L. – (2021) - *Citizen Science for Marine Litter Detection and Classification on Unmanned Aerial Vehicle Images*, Water 2021, 13, 3349. DOI: 10.3390/w13233349