Combining Citizen Science and Photo Identification to Monitor a Key Green Turtle Feeding Ground in the Southern Egyptian Red Sea

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Citizen science, broadly defined as the involvement of non-specialists in scientific research activities (Socientize 2013), is an increasingly used approach to monitor the status of marine and terrestrial natural resources (e.g., Tulloch *et al.* 2013). This approach offers the enormous advantage of collecting data over large areas and long time periods. Furthermore, it increases public interest and awareness of environmental issues; by taking part in a data collection activity, people become more aware of the threats faced by the study subject and feel empowered to actively engage in leveraging policy making (Dikinson *et al.* 2010).

In recent years, with the development of new technologies, citizen science has often been coupled with photo-identification (or photo-id), a technique that allows the identification of individual animals within a certain species using natural markings (e.g., Markovitz *et al.* 2003). Contrary to other methodologies used to identify single individuals like tagging, photo-id has the advantage of being less intrusive and having less impact on the studied individuals (e.g., Reisser *et al.* 2008). This technique has been successfully employed in ecological and behavioural studies on dolphins (e.g., Currey *et al.* 2008), whale sharks (Brooks *et al.* 2010), manta rays (Kitchen-Wheeler. 2010), basking sharks (Gore *et al.* 2016), sea turtles (Reisser *et al.* 2008; Schofield *et al.* 2008) and cheetahs (Kelly 2001), among others. Photo-id uses photographs of species-specific body patterns, which need to be stable over time and different in each individual within the species. For example, individual dolphins can be distinguished using their dorsal fin (e.g., Currey *et al.* 2008), and whale sharks have a unique spot pattern on their flanks that does not change over time (Holmberg *et al*. 2009; Brooks *et al.* 2010). Previous photo-id studies revealed that for green turtles, *Chelonia mydas*, facial scute patterns could be used to identify individuals over time. Ideally, both left and right profiles are needed for a perfect match, but in some cases one profile is sufficient (Reisser *et al.* 2008; Schofield *et al.* 2008; Jean *et al.* 2010; Chassagneux *et al.* 2013; Carpentier *et al.* 2016). As photo-id for marine turtles requires only minimum equipment (an underwater camera) and minimum training (information about facial patterns to be photographed), it can be easily coupled with collection of other data, including species, size, behaviour, sex, etc. (Williams *et al.* 2015).

Thanks to the presence of a high number of divers and snorkelers in the Egyptian Red Sea, various citizen science initiatives have been carried out or are currently run to collect data on endangered ecosystems or species (e.g., the Red Sea Sharks project <www.redseashark.org>). In 2011, the Hurghada Environmental Protection and Conservation Association (HEPCA) initiated TurtleWatch Egypt, a citizen science-based marine turtle monitoring program, involving dive centres all around the Egyptian Red Sea, from Sharm El-Sheik to Wadi El Gemal National Park. The project aimed to collect information on marine turtles at dive and

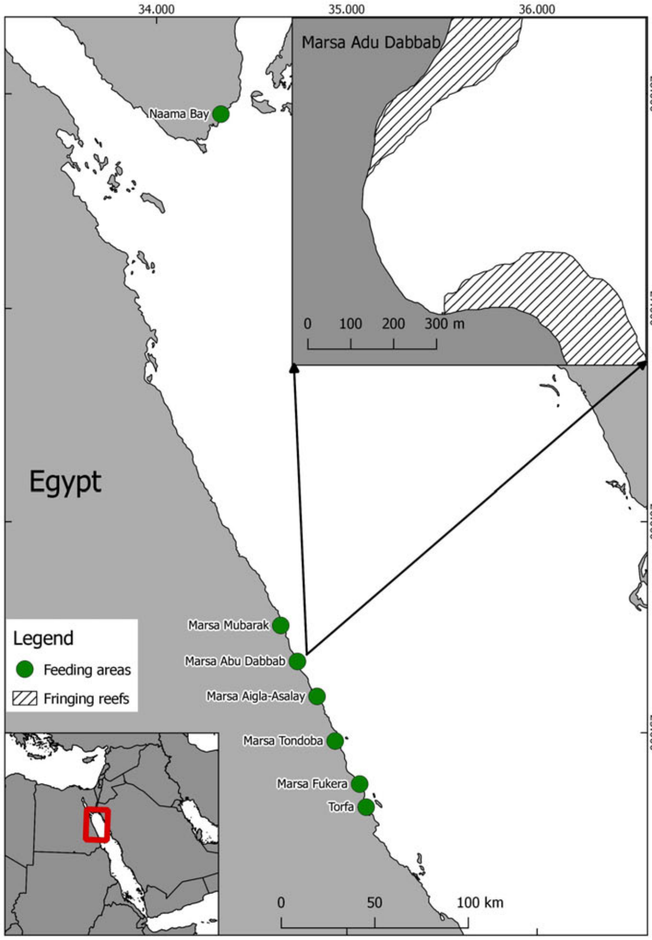

Figure 1. Green turtle feeding grounds identified during systematic and scientific surveys in the Egyptian Red Sea between 2011 and 2013 and close up of the study area, Marsa Abu Dabbab.

snorkeling sites on a regular basis, in order to better understand the abundance, distribution and movements of marine turtles at key feeding sites and to identify potential conflicts with human activities. The project also aimed to raise awareness about threats faced by marine turtles globally and locally (www.hepca.org).

Five species of marine turtles inhabit the Egyptian Red Sea: the green turtle, the hawksbill turtle (*Eretmochelys imbricata*), the leatherback turtle (*Dermochelys coriacea*), the loggerhead turtle (*Caretta caretta*) and the olive-ridley turtle (*Lepidochelys olivacea*). Only green and hawksbill turtles are commonly observed and are known to feed and nest in the area (Frazier and Salas 1984; Hanafy 2012; Mancini *et al.* 2015a). Previous studies showed that green turtles aggregate at feeding grounds in shallow, coastal bays where seagrass meadows are abundant (Mancini *et al.* 2015a; Elsadek 2016). At least six important feeding sites were identified in the Southern Egyptian Red Sea: five in the Marsa Alam area, and one in the Northern Red Sea, near the tourist resorts of Sharm El-Sheik (Mancini *et al.* 2015b; Elsadek 2016; Mancini *et al. in press*; Fig. 1).

These studies showed that green turtles are present year-round at feeding locations and stay over long periods (Mancini *et al.* 2015b; Elsadek 2016). Systematic surveys conducted by researchers at 12 index sites in the Southern Red Sea provided an estimated population of 280 green turtles, with a majority of adult and sub-adult individuals (54%) and a higher presence of females (75% of the adult population) (Elsadek 2016). However, size-based selective habitat use was also found, with some areas used predominantly by juveniles (e.g., Marsa Fukera; Elsadek 2016). Additionally, preliminary analysis of data collected through TurtleWatch Egypt provided important information that in most cases confirmed scientific findings and also confirmed the presence of loggerhead and olive ridley turtles in the Northern Red Sea (Mancini and Elsadek *in press*).

TurtleWatch Egypt was stopped in 2014 as a consequence of the tourism crisis, due to a lack of volunteers in the field. In Summer 2015, with tourism slowly coming back to Egypt, a marine biologist located in Marsa Abu Dabbab, one of the major green turtles feeding grounds in the Southern Egyptian Red Sea, reinitiated a citizen science monitoring program based on the TurtleWatch Egypt protocol in order to monitor green turtles that were specifically using this bay. The project aimed at 1) having a better understanding of green turtle abundance, population structure, site fidelity, behaviour and seasonality, 2) increasing awareness about endangered green turtles among local communities and foreign visitors, and 3) testing the utility of photo-id techniques to characterize a green turtle population in a feeding ground. This paper presents the results of the monitoring program carried out in Marsa Abu Dabbab in 2015-2016, with a focus on data collected from January to December 2016, when the new protocol was validated after some tests in the field.

Methods: *Study area*—Marsa Abu Dabbab is a shallow bay located 35 km north of the town of Marsa Alam, in the Southern Egyptian Red Sea (N 25.316175; E 34.767308; Fig. 1). It stretches for about 600 m from the northern to the southern side and for about 400 m from the shore to the open sea. The bay is characterized by two coral reefs extending along the northern and southern part of the coast and by a seagrass area growing all over the basin of the bay, from the depth of 1 m by the shore down to a depth of 40 m at the point of the open sea. About a third of the seabed lies in shallow waters (1-6 m). The waters inside the bay are relatively quiet year-round as the northern coast acts as a shield against the prevailing winds and currents. The water temperature can vary between 21°C during winter (January-February) and 31°C during summer (July-August). Underwater visibility conditions are generally very good (20-50 m visibility), but they can vary substantially according to weather conditions. Due to the abundant seagrass meadows, the bay is used by green turtles and occasionally by dugongs (*Dugong dugon*). Moreover, green turtles nest sporadically on the beach.

Due to its easy access and rich marine wildlife, Marsa Abu Dabbab has become a famous tourist destination over the last 15 years. It is visited every day by tourists coming from the three resorts situated on the beach itself and from many others. Diving and snorkeling with dugongs and green turtles are the main attraction in the bay.

Marine turtle monitoring and photo-ID—A marine turtle monitoring program was re-initiated in Summer 2015, however the data collection protocol was tested and modified in the first months, therefore here we present the results related to the data collected from January to December 2016, with higher effort during the summer months, due to the high tourist season. Regular surveys were conducted by snorkeling or by scuba diving and generally lasted 40 minutes and involved a marine biologist or a trained guide and tourists. All regular surveys took place during the daytime between 9 am and 5 pm, following a standardized transect. During snorkeling surveys, attention was focused on the shallow part of the bay (0 to 12 m), while scuba dive surveys allowed exploration of the deeper area in the middle of the bay (up to 30 m in depth).

Each time a turtle was found, the observers collected the following data:

1) Photographs of right and left facial sides, when possible, from a distance of about 1 m
2) Approximate straight carapace length (SCL)
3) Sex
4) Activity at first sight
5) Approximate location in the bay
6) Time
7) Depth
8) Water temperature
9) Surface activities (i.e., presence of speedboats)
10) Water conditions
11) Presence of other divers or snorkelers

The approximate SCL was used to estimate the reproductive stage of observed turtles. Green turtles with a SCL < 70 cm were considered juveniles; turtles with a SCL between 70 and 90 cm were considered sub-adults, and turtles with a SCL > 90 cm were considered adults (Hirth 1997).

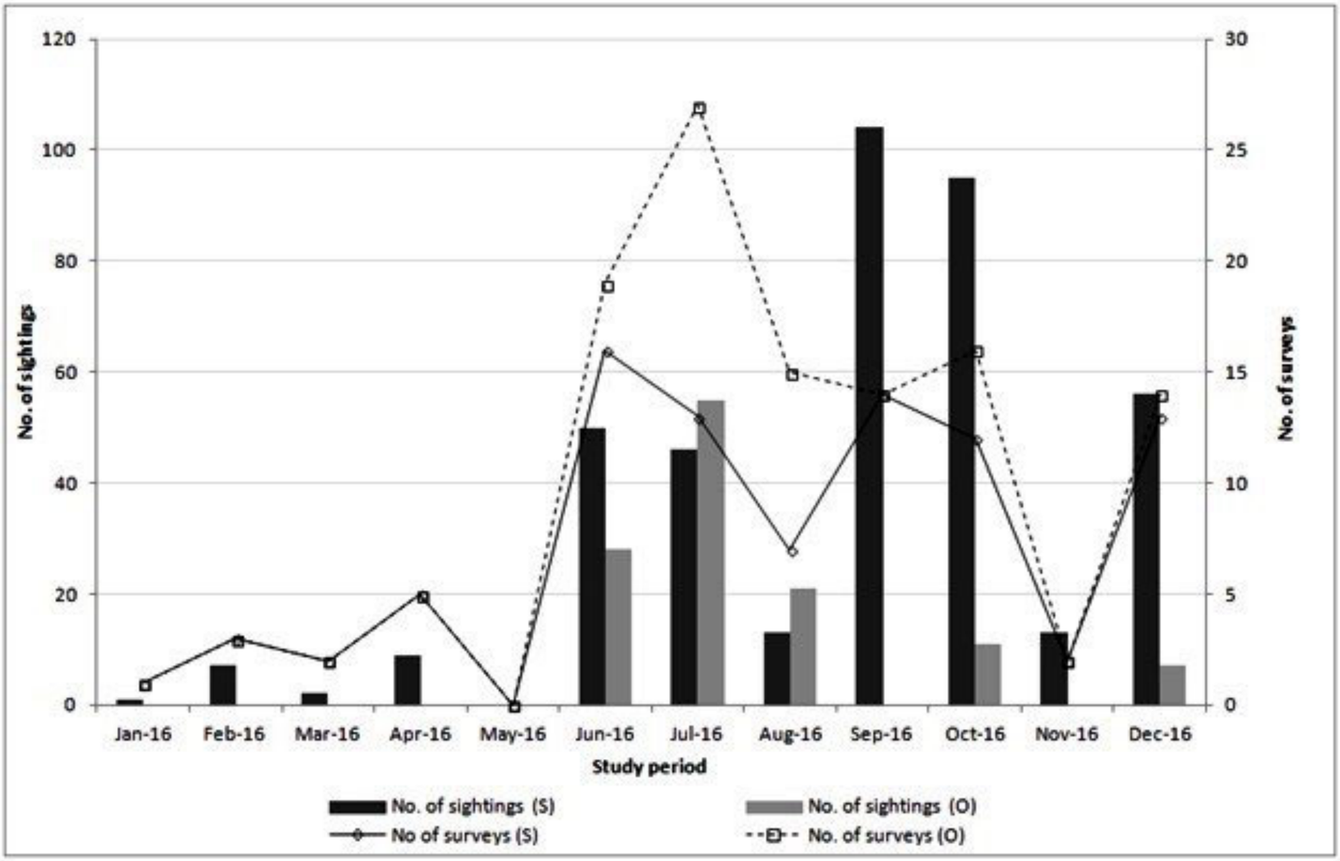

Figure 2. Number of green turtle sightings per survey during regular (S) and opportunistic (O) monitoring that took place in Marsa Abu Dabbab from January to December 2016.

In addition to the regular monitoring, opportunistic data were collected by enthusiastic divers who after receiving a briefing and participating in the regular turtle surveys, decided to collect information during their solo (i.e., without a marine biologist or trained guide) snorkeling or diving trips. In this case, only the total number of sightings, the date of the survey and the photos were collected. Opportunistic data were grouped in a separate dataset and analysed separately, due to some overlap in dates and times with the regular monitoring effort. In this study, we report only on the number of observed green turtles per survey, their sex and approximate size, and the analysis of the photos.

Results and Discussion: *Overall results*— In total, 88 official surveys were carried out over the study period that resulted in a total of 396 sightings of green turtles. Twelve trained citizen scientists carried out a total of 30 additional opportunistic surveys, reporting a total of 122 sightings. Due to the irregular survey effort, it is not possible to make conclusions on the relative abundance of green turtles in the bay or on the seasonality of sightings. A more consistent level of effort is needed, especially during the winter months, when fewer visitors go to Marsa Abu Dabbab. Nevertheless, we can say that the bay is used year-round, and the number of sightings per survey seems to increase towards the end of the nesting season, starting in September (Fig. 2).

Photo-identification—Through photo-id, a total of 38 individuals were identified. Twenty of these individuals had been previously reported during systematic surveys in 2011-2013, while out of the newly identified individuals, seven were observed over multiple months and eleven were seen only over a month or two.

Population structure—Out of the individual turtles recorded during the surveys, 53% were classified as adults (n = 20), 21% were classified as sub-adults (n = 8) and 18% were classified as juveniles (n = 7). For 8% of the turtles (n = 3), information on the carapace length was not available (Fig. 3). Sex was determined for all the 20 adult green turtles. The female:male ratio was 0.5:1. This result is different to the previously reported 1:1 female:male ratio for the Marsa Abu Dabbab area (Mancini *et al.* 2013), but can be the result of a more intensive survey at the beginning and at the end of the nesting season (May to September) when males have been more frequently observed at feeding grounds (Mancini *et al.* 2013).

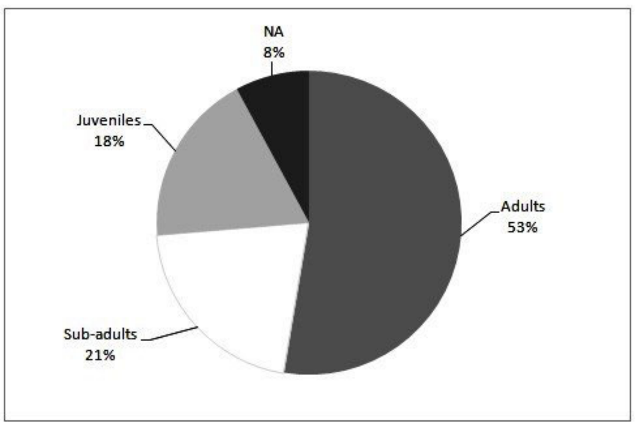

Figure 3. Age class of individual green turtles identified during the surveys from January to December 2016.

Residency—The use of photo-identification at the same site over time allowed us to identify long-term green turtle residents (i.e., 20 individuals that were observed at first during 2011-2013; Mancini *et al.* 2013). It also allowed us to follow up on individual growth rates and sexual maturity; three turtles that were considered juveniles or sub-adults during the 2011-2013 survey reached the sub-adult or adult stage, which allowed us to identify their sex (one male and two females). Furthermore, a long-term resident of the bay was found dead, possibly as a consequence of a shark bite (Fig. 4).

Finally, a newly observed turtle was identified carrying a flipper tag from a nesting beach in Saudi Arabia (Fig. 5). While this migration is not new, it highlights the importance of feeding areas on the Egyptian Red Sea coast for adult green turtles in the region.

Figure 4. The use of photo-id techniques over multiple years allowed us to identify a long-term green turtle resident of Marsa Abu Dabbab that was found dead (Photo: M. Montagna).

People's perception and behaviour—The visitors who were involved in the turtle monitoring showed a great interest in the project and saw this as further motivation to engage in water activities like diving or snorkeling with the dive centre (Fig. 6).

They also showed great enthusiasm for learning about the threats marine turtles are facing and took over the role of 'turtle ambassadors' during their solo surveys, contributing to the prevention of

Figure 5. The use of photo-id coupled with flipper tagging allowed to identify a transient female green turtle coming from nesting grounds in Saudi Arabia (Photo: M. Montagna).

misbehaviour like touching or grabbing turtles while at the bottom, and explaining the best ways to approach turtles to uninformed tourists. This aspect is particularly important in Marsa Abu Dabbab where hundreds of tourists are sent into the water with no proper briefing or information and sometimes take serious risks for a 'selfie' with a turtle.

Figure 6. Visitors who took part in the marine turtle monitoring program showed great interest and enthusiasm and initiated an opportunistic survey (Photo: A.R. Taher).

Conclusions and future work—Underwater marine life is one of the main attractions of the Egyptian Red Sea; however, extensive awareness programs are needed to inform dive and snorkeling guides, as well as most tourists, on the correct way to observe and interact with wildlife. The use of citizen science data collection protocols coupled with photo-identification seems to have the potential to not only improve our knowledge of endangered species in the region, but also to serve as a positive and active way to promote behavioural changes in tourists.

In the future, we hope to add a seagrass monitoring program to better understand green turtles' use of Marsa Abu Dabbab. Furthermore, we hope to continue to involve visitors in our marine turtle monitoring in a more consistent way and have a better idea of how many turtles inhabit the bay regularly and occasionally in order to provide important information to the authorities that can be used to implement targeted conservation measures.

Acknowledgements: The authors would like to thank Blue Ocean Diving Centre, its managers and staff and all the visitors who provided data to the turtle monitoring program, namely Gerry and Wout Van Koot, Paolo Magnani, Mauro Giacomelli, Maura Uggeri, Dario Capra, Luca Secchi, Altea Bellani, Petra Wahl, Pierpaolo Aresti, Ottavio

Fareri and Patrick Schyns. We are grateful to Dr Jillian Hudgins and Dr Abdulmaula A. Hamza for providing useful comments to improve this manuscript. Special thanks to Penny Bristow for editing previous versions of this article. AM would like to dedicate this article to the memory of Mr Amr Ali, HEPCA managing director, a great visionary and dear friend who was instrumental in initiating the TurtleWatch Egypt project.

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