



# Getting the most out of citizen science for endangered species such as whale shark

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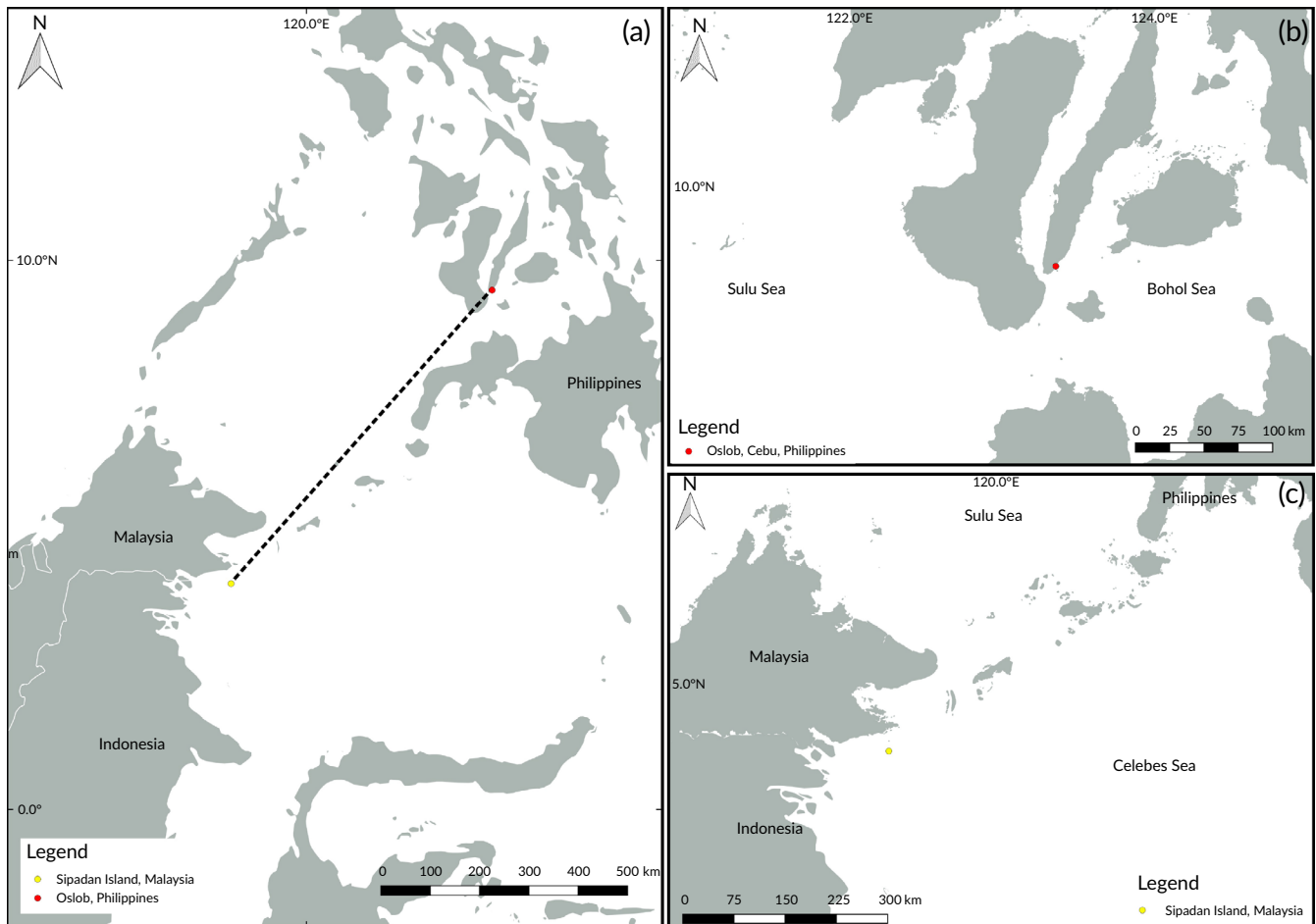
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## 1 | OPINION PIECE

Citizen science, by which the general public can be engaged to participate in scientific programmes, is a widely used approach particularly when studying enigmatic species, or species in areas that are logistically difficult to access (Dickinson *et al.*, 2010; Middleton, 2001; Sullivan *et al.*, 2009). For uniquely identifiable species like manta rays *Mobula alfredi* Krefft 1868 (Marshall *et al.*, 2011), green turtles *Chelonia mydas* Linnaeus 1758 (Araujo *et al.*, 2016) or humpback whales *Megaptera novaeangliae* Borowski 1781 (Katona *et al.*, 1979), citizen science programmes can reliably collect photographic identification (henceforth photo-ID) data to understand movements and population dynamics (Bruce *et al.*, 2014; Germanov & Marshall, 2014; Williams *et al.*, 2017, respectively). For whale sharks *Rhincodon typus* Smith 1828, photo-ID is currently employed across all major hotspots worldwide, relying on the stable spot patterns on the animals (Arzoumanian *et al.*, 2005). The slow-moving, surface-dwelling nature of the whale shark makes it an ideal target species for photo-ID that can also employ members of the public as citizen scientists (e.g., Norman *et al.*, 2017). By complementing datasets, or purely relying on photo-ID data from the public, we now have a better of understanding of whale sharks at various sites, including Southern Leyte in the Philippines (Araujo *et al.*, 2017), the Arabian Gulf (Robinson *et al.*, 2016) and Ningaloo Reef, Australia (Davies *et al.*, 2013) amongst others. Citizen science can thus generate a considerable number of observations that would otherwise not be feasible through conventional research, which has now benefited from accessible technologies (e.g., underwater cameras, smartphones).

The utility of citizen science for monitoring enigmatic species is illustrated by the whale shark – the world's largest extant fish that inhabits tropical and warm temperate waters globally (Rowat & Brooks, 2012). The species is known to aggregate in areas linked to primary productivity, and has been documented to feed on sergestid shrimps (Rohner *et al.*, 2015), fish eggs (Robinson *et al.*, 2016), small fishes (Boldrocchi & Bettinetti, 2019) and provisioned food amongst others (Araujo *et al.*, 2014). These predictable aggregations make the species an ideal candidate for marine wildlife tourism as well as for citizen science programmes, which are now being utilized or under development across sites globally where they occur (Norman *et al.*, 2017). Given the growth in marine wildlife tourism globally (Cisneros-Montemayor & Sumaila, 2010), the fact that the Professional Association of Diving Instructors (PADI) has certified >27 million divers to date (www.padi.com) and the current accessibility to underwater cameras or waterproof smartphones, harnessing the potential of the general public to collect data is imperative and within reach.

Oslob in Cebu, Philippines (Figure 1), is the world's largest whale shark watching destination, receiving >500,000 tourists annually (Oslob Tourism Office, 2019). Whale sharks in Oslob are provisioned daily, year-round, to facilitate the human–shark interaction (Araujo *et al.*, 2014). A team of researchers has conducted in-water photo-ID daily at the site since March 2012. On 4 December 2017 a juvenile female whale shark of estimated 4.5 m total length was identified in Oslob for the first time and assigned the international unique whale shark identification number P-1159 on Wildbook for Whale Sharks (Figure 2a,b). This individual was resighted on four different days in Oslob during December 2017. Interestingly, this shark was sighted again in Oslob precisely a year later, on 4 December 2018, yet never



**FIGURE 1** Map of the Sulu-Sulawesi Marine Ecoregion (a) with insets to Oslob, Cebu, the Philippines (b), and Pulau Sipadan, Sabah, Malaysia (c). The dotted line represents a straight line of 800 km between sites

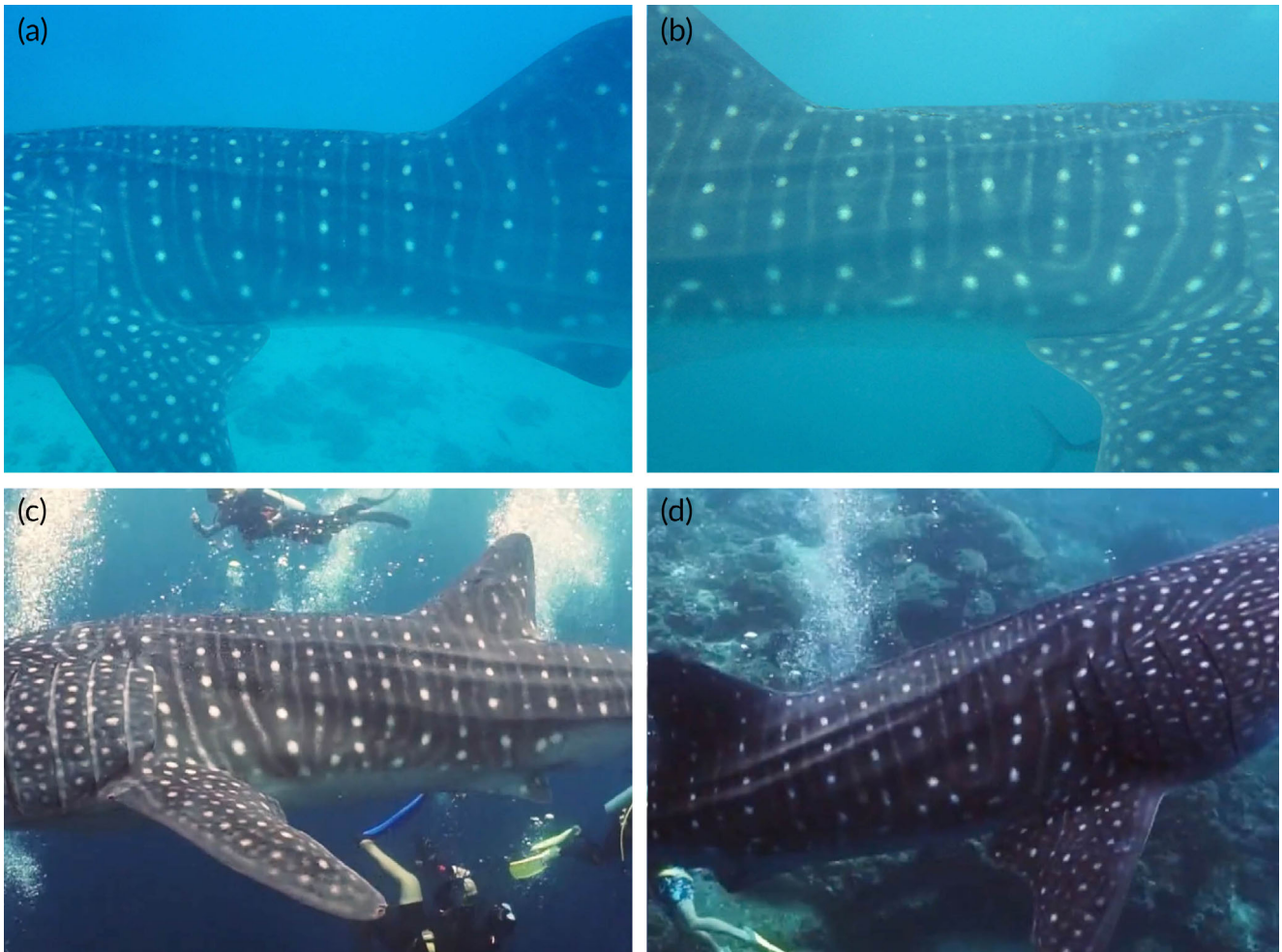
re-sighted at four other monitoring sites in the Philippines (Southern Leyte, Donsol, Puerto Princesa and Tubbataha Reefs Natural Park; authors, unpublished data).

On 28 October 2019, a team of divers in Pulau Sipadan, Sabah, Malaysia (Figure 1), encountered a whale shark along the fringing reef, at 15 m deep. The team opportunistically collected footage of the encounter (video: <https://tinyurl.com/so4dw63>), and shared it on a social media group, monitored by a local non-government organisation, Scuba Junkie SEAS. The footage was subsequently uploaded onto the international whale shark database Wildbook for Whale Sharks and it was positively identified as P-1159. Visual inspection of the left and right flanks of the whale shark (Figure 2c,d) by the authors confirmed the identity of the individual animal. The minimum straight distance between Oslob and Pulau Sipadan is ~800 km, highlighting the long-distance, cross-boundary capabilities of the species.

This is the first recorded whale shark movement between the Philippines and Malaysia through photo-ID, and the first relying on citizen science data. This data builds on work by Araujo *et al.* (2019) that documented, through the use of pop-up archival tags, movement between Honda Bay, Palawan, Philippines, and Sabah, Malaysia. Araujo *et al.* (2019) also documented the first international match

using photo-ID and citizen science between the Philippines and Indonesia, similar to that reported here. The whale shark was listed in Appendix I of the Convention on Migratory Species of the United Nations in 2017 (UNEP/CMS, 2017). Although the species is known to have limited regional connectivity as explored through photo-ID and molecular techniques (*e.g.*, Andrzejczek *et al.*, 2016; Prebble *et al.*, 2018), some movement does occur, with some regions showing more movement (*e.g.*, Gulf of Mexico, Hueter *et al.*, 2013) than others (Western Indian Ocean, Prebble *et al.*, 2018).

The whale shark movement from the Philippines to Malaysia reported here highlights the need for joint conservation and management plans for broad-ranging species, particularly in areas of high biodiversity importance like the Sulu-Sulawesi Marine Ecoregion (Micalot *et al.*, 2006). A minimum code of conduct should be created as a baseline for interacting with this species, as should be information and education campaigns targeting stakeholders (*e.g.*, fishing communities, local governments, *etc.*). We encourage the development of participatory science programmes involving citizen scientists following standardized protocols (see Rigby *et al.*, 2019), which can play a key role in understanding the movements and ecology of enigmatic species like the whale shark (*e.g.*, Norman *et al.*, 2017). For whale sharks



**FIGURE 2** Left and right identification images for P-1159 in Oslob, Cebu, the Philippines, in December 2017 (a, b), and in Pulau Sipadan, Sabah, Malaysia in October 2019 (c, d)

specifically, the use of the free global database Wildbook for Whale Sharks ([www.whaleshark.org](http://www.whaleshark.org)) is an advantageous way of centralizing data for the species that also facilitates citizen scientists' engagement. Data collection through a unified platform has the advantage of standardizing data collection and, as such, maximizing data and usability for science and conservation. Similar platforms are available for other taxa (e.g., ©MantaMatcher for manta rays, ©Internet of Turtles for marine turtles, ©eBird for birds, etc.), and involvement of the general public is within reach to facilitate research programmes. Such involvement of the general public is also an excellent opportunity to educate and engage them on best practices when interacting with focal species and the importance of adhering to Codes of Conduct, as stipulated for whale sharks, for example, under the CMS Concerted Actions for whale sharks (UNEP/CMS/CA, 2017).

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**CONTRIBUTIONS**

All authors conceived and prepared the manuscript. G.A., A.R.I., C.G.L. and J.L. collected and analysed the data.

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