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Unearthing marine biodiversity through citizen science - the Spot the Jellyfish and the Spot the Alien Fish campaign case studies from the Maltese Islands (Central Mediterranean)

Alan DEIDUN^{1*} & Arnold SCIBERRAS²

Citizen science is the collaboration between scientists and the general public as volunteers to gather and/or analyse data relating to phenomena in the natural world which, due to a number of attributes, are difficult to monitor through conventional scientific methods. There is much scope for marine citizen science, including fields such as on land and along shorelines (e.g. reports on stranded organisms, reports on stranded litter and organic matter), in shallow waters (e.g. monitoring of changes in protected benthic communities, coral and artificial reef monitoring) and in the open sea (e.g. sampling from ships of opportunity, ferry boxes for underwater sampling).

The Spot the Jellyfish citizen science campaign was launched in June 2010 by the Physical Oceanography Research Group at the University of Malta and the International Ocean Institute (IOI), with the support of the Malta Tourism Authority (MTA), Blue Flag Malta and a number of environmental NGOs. The initial aim of the campaign was to educate the younger generations about jellyfish species occurring within Maltese waters, but the campaign was soon extended to the national scale, with the installation of seaside panels in over 30 embayments on the islands, the design of a downloadable A4 poster featuring the twelve most common jellyfish species and the development of a tailor-made website (www.ioikids.net/jellyfish) which allows the seamless recording of the salient attributes of jellyfish species sightings, including location, date, species and abundance. Jellyfish sighting reports are validated prior to being approved and plotted on an online map. Since its inception, the campaign has received over 1,300 validated reports from the public and has led to the unearthing of a number of previously-unrecorded gelatinous species from Maltese waters. These species include the nomadic jellyfish (*Rhopilema nomadica*), first recorded through the campaign from Maltese waters in 2011, and the Australian spotted jellyfish (*Phyllorhiza punctata*), the barbed-wire jellyfish (*Apolemia uvaria*), the hula skirt

¹ Department of Geosciences, University of Malta, Msida MSD 2080 Malta

² Animal Kingdom Ltd. 136, Ditch street, Paola

* Corresponding author. E-mail: alan.deidun@um.edu.mt

siphonophore (*Physophora hydrostatica*) and the egg-yolk jellyfish (*Phacellophora camtschatica*), all first recorded from the same waters in 2017. These new records bring the total of macroscopic gelatinous species known from the water column of Maltese nearshore waters to over 40, spanning over phyla such as Ctenophora, Cnidaria (Cubozoa, Hydrozoa [also including the Siphonophora], Scyphozoa) and Chordata (Thaliacea, including salps and doliolids). The campaign was bestowed informally with the title of good practice as an example of citizen science by the SciStarter Blog run by the University of Pennsylvania (<https://blog.scistarter.com/2010/08/spot-the-jellyfish-here-or-in-malta/#sthash.ROm8JTCm.qr0EZgx8.dpbs>).

In 2017, a second marine citizen science campaign, Spot the Alien Fish (www.aliensmalta.eu), was launched by the Department of Geosciences at the University of Malta and the IOI. This campaign sought to capitalise on the lessons learned from the implementation of the Spot the Jellyfish campaign, translating into a larger (A3) campaign poster, printed on both sides and in a laminated, splash-proof format to allow its seaside deployment. A total of thirty-six fish species are featured on the campaign poster, with an arrow underscoring the origin of each fish species (west, through the Straits of Gibraltar for species of Atlantic origin, or east, through the Suez Canal, for Lessepsian species). Since the inception of the campaign, two previously-unrecorded fish species were recorded from Maltese nearshore waters – the Guinea angelfish (*Holacanthus africanus*) and the Azure damselfish (*Chrysiptera hyanacea*), with two individuals of the former species being caught by recreational fishermen and one individual of the latter species being recorded on video by a SCUBA diver. Numerous reports of additional non-indigenous fish species, most notably *Fistularia commersonii*, *Siganus luridus*, *Seriola fasciata* and *Cephalopholis taeniops*, were submitted through the campaign portal, assisting administrators in tracking population trends for these species. The second record for Maltese nearshore waters of the African moonfish (*Selene dorsalis*) also emerged through this marine citizen science campaign.

Venomous and toxic fish species are also highlighted on the same poster. In both marine citizen science campaigns, the public is solicited to also submit reports of unidentified species not necessarily included on the campaign posters and to retain, if possible, the individuals in question, if caught, either in a frozen state (in the case of fish) or in a bucket full of seawater (in the case of jellyfish) for subsequent collection by the campaign administration team. The submission of good-quality photographs to accompany sighting reports was also encouraged for both campaigns. The two campaigns are regularly promoted with important national stakeholders, including snorkelers, SCUBA diving clubs, sailing clubs, angling and recreational fishing (e.g. spearfishing and spinning) clubs and professional fishermen, whilst a prominent online presence is maintained through the submission of regular posts on the two campaign social media *ad hoc* groups/pages.

The status and profile of citizen science within the marine realm in Europe is such that it has prompted the European Marine Board (EMB) an authoritative pan-European think tank, to dedicate Position Paper no. 23 ('Advancing Citizen Science for Coastal and Ocean Research') to citizen science. Within such a Position Paper, the EMB lists the short-term and long-term priority action areas to advance marine citizen science. The short-term action areas include the identification of knowledge gaps where citizen science can play a role, the development of a framework and guidelines for marine citizen science initiatives, the building of competencies across multiple disciplines to support the growth of marine citizen science and the promotion of ocean literacy to encourage participation amongst civil society on marine citizen science initiatives. The importance of marine citizen science campaigns, including the two described in this study, is all the more obvious when one considers the proposal by UNESCO for an International Decade (2021-2030) of Ocean Science for Sustainable Development.