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COLLECTIVE ACTIONS FOR ENVIRONMENTAL MONITORING AND CONSERVATION: CITIZEN SCIENCE, INFORMAL ENVIRONMENTAL EDUCATION, AND PARTICIPATORY APPROACH

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Esame finale anno 2022

‘Alone, we can do so little; together we can do so much’

Helen Keller

To all those who have shared this journey with me

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INTRODUCTION

1.1 BIODIVERSITY, MONITORING AND CONSERVATION

The term ‘biodiversity’ was first coined in the mid-1980s, referring to the concept of biological diversity (Colwell, 2014). Nowadays, biodiversity is a widely used term for which there is still no clear and unified definition (DeLong, 1996; Swingland, 2013). A clear definition of the term is needed for its use in environmental policy, conservation management, and for national and regional research projects funding. For the purposes of this paper, we will use the definition of biodiversity from the UN Convention on Biological Diversity: ‘*the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity) and of ecosystems (and the interactions therein)*’ (Boenigk et al., 2015).

Biodiversity plays a central role in human life and well-being through the provision of several ecosystem services (all the benefits that a healthy ecosystem provides to society). Over the past 30 years, the research interest on the benefits of the natural environment to human health and well-being has increased (Hoyle et al., 2019a), as well as the anthropogenic pressures on the environment that have led to climate change, biodiversity loss, landscape and ecosystem changes, invasive species, as well as ocean and land use changes (Kosanic and Petzold, 2020). In order to assess the impact of these human-driven issues, environmental monitoring is an important tool because it collects data that can be used for the development of management plans for protection and conservation (Niemelä, 2000), but also for the development of sustainable use of natural resources.

Tracking and understanding biodiversity losses requires a wide data collection effort from small regional scale to the global one over a long-term time scale (Magurran et al., 2010a; Bellard et al., 2012; Jetz et al., 2012) and considerable investment by government agencies, that are often underfunded (Watson and Novelly, 2004; Sharpe and Conrad, 2006). However, this task cannot be accomplished by scientists and resource managers alone, but requires the joint effort of all stakeholders who use the environment professionally or in their leisure time, including the general public (Hochachka et al., 2012; Pimm et al., 2014). Indeed, public participation could in some cases overcome funding problems and allow long-term monitoring at local, regional, national, or international levels. Citizen participation in scientific research is referred to as 'citizen science'. In the field of conservation biology and environmental monitoring citizen science is fundamental, given the vastness of the complexity and scale of current ecological problems, extremely difficult, if not impossible, to be faced without the help and involvement of citizens (McKinley et al., 2017).

1.2 CITIZEN SCIENCE

The term citizen science was recorded for the first time in an issue of the MIT Technology Review from January 1989 in the article 'Lab for the Environment' (Haklay et al., 2021). In 1990's the term 'citizen science' was also used to describe two different kind of activities: Irwin (1995) used the term to describe research projects carried out by citizen groups from the design to the implementation, while Bonney (1996) used the term to identify research projects developed by professional scientists with the participation of citizen for the data collection (Elliott, 2019). Nowadays, there are several definitions of 'citizen science' depending on purposes and approaches used in different contexts. The common aspect of all these definitions is that the public, hence not professional researchers, takes part in the scientific process, with different level of engagement: citizens could be used like sensors to collect data or, in the extreme citizen science, researchers and citizens work together from the problem identification to the data analysis (Haklay et al., 2013). 'Citizen scientists' are people that choose to spend their free time to engage in scientific projects, from physics to biology, agriculture and food sciences, with a wide development in environmental sciences (Ryan et al., 2018).

Although the definition of the term 'citizen science' is quite recent, non-specialists' citizens have been recording data for decades. One of the longest citizen science projects is the Audubon Christmas Bird Count, started in 1900 in North America by the ornithologist Frank M. Chapman who proposed a new 'Christmas Bird Census' tradition to count birds during the holidays rather than hunt them[1]. Since 121 years, from December 14th through January 5th, each year tens of thousands of volunteers throughout the Americas take part in the bird census to assess the health of their populations, and to help guide conservation action (Dunn et al., 2005; Soykan et al., 2016; Meehan et al., 2019). Christmas Bird Count trends are also used by BirdLife International[2] to deliver status recommendations to the International Union for Conservation of Nature (IUCN), creators of the Red List of Threatened Species[3], and by the North American Bird Conservation Initiative (NABCI) to produce their State of the Birds conservation vulnerability assessment for North American bird species. Christmas Bird Count trends are particularly useful for species not otherwise observed in their remote northern breeding grounds, especially those that breed in poorly surveyed boreal forests or Arctic tundra (Meehan et al., 2019). Another example of long-term citizen science project is Reef Check, dedicated to the conservation of tropical coral reefs and temperate kelp forests, started in 1997

[1] https://www.audubon.org/conservation/history-christmas-bird-count
[2] http://datazone.birdlife.org/species/search
[3] https://www.iucnredlist.org/

and developed in more than 40 countries worldwide[4]. Environmental challenges are also addressed by the Earthwatch program, developed in 1971 with the engagement of more than 130 countries worldwide[5].

The nowadays huge explosion of citizen science projects is due to different factors such as: 1) the development of easily available tools for dissemination, information and engagement of the public (such as internet, smart phones, etc.), and 2) the increasing awareness among scientists that the public represents a free source of work, skills and even finance (Silvertown, 2009). In fact, the development of information and communication technologies (ICTs) has expanded the scope and range of data collection from geographic information research (e.g., geographic data collection projects) to social science and epidemiological studies (e.g., projects examining the relationship between environmental issues and human health) (Kullenberg and Kasperowski, 2016; Hecker et al., 2018).

The first quantitative review about the use of citizen science in biodiversity projects analysed 388 projects and found that the involvement of ~1.3 million volunteers has resulted in an annual in-kind contribution of up to $2.5 billion (Theobald et al., 2015). Only 12% of the 388 projects analysed by Theobald et al., (2015) published articles in peer-reviewed scientific journals, showing that the citizen science movement is still achieving a small fraction of its potential impact on the scientific community. The birth of associations that connect citizens, scientists, projects, and institutions has led to a huge development of this method and its related impact worldwide. In the European landscape, the European Citizen Science Association (ECSA) is bridging citizens with science, promoting the use of citizen science projects outcomes in decision-making processes, and promoting a participatory sustainable development[6].

Worldwide is increasingly common for research and educational institutions, as well as managers of natural areas, to use citizen science to support their studies and monitoring programs (Freiwald et al., 2018; Wyler and Haklay, 2019; Garcia-Soto et al., 2021). Citizen science is becoming increasingly important to increase scientific literacy and societal trust in science and to promote participatory and transparent decision-making. It is also attracting increasing interest from policy makers, government officials and non-governmental organizations (Turbé et al., 2019). The growing policy interest for citizen science is due to different factors, such as: i) the spreading understanding of the importance of citizen science within Science, Technology, Engineering, and Math (STEM) and also humanities

[4] https://www.reefcheck.org/about-reef-check/
[5] https://earthwatch.org/research/research-focus-areas
[6] https://ecsa.citizen-science.net/

studies; ii) the relevance of the information gathered through citizen science projects for policy implementation; iii) the growing evidence for the reliability of data collected by volunteers, the amount of data produced and the number of citizens involved (Haklay, 2015). The role of citizens is also becoming increasingly important in European Union (EU) policies. The next European research and innovation program, Horizon Europe 2021-2027, will support citizen engagement in research and innovation through EU missions to connect citizens with science and public policy[7]. In the Mission Starfish 2030 program, citizens are the protagonists of one of the five overarching goals for 2030 and a target of this program for the 2025 checkpoint is that 20% of data collection comes from citizen science initiatives[8]. These are only some examples of the increasing importance of citizen science in the European funding programs, where citizen science will be a cross-cutting theme for all missions.

1.3 RECREATIONAL CITIZEN SCIENCE IN THE MARINE ENVIRONMENT PROTOCOL

Although citizen science projects can be developed in most of the fields and environments, in the maritime context are particularly challenging because they require different security, skills, logistics, accessibility, and equipment issues compared to terrestrial environment (Goffredo et al., 2004, 2010; Gillett et al., 2012; Forrester et al., 2015). This explains the relatively low presence of citizen science projects in the marine environment (Garcia-Soto et al., 2021). Since the 1990s, when people's interest in scuba diving as a recreational activity exploded, it has been possible to conduct research programs in the marine environment that seek to recruit recreational divers as volunteers by taking advantage of their natural interest in marine diversity (Foster-Smith and Evans, 2003; Goffredo et al., 2004, 2010). Citizen science in the marine environment can be used to monitor shallow water organisms (up to a depth of 40 meters, the Professional Association of Diving Instructors (PADI) limit for recreational divers) over a wide geographic and temporal range (Goffredo et al., 2010; Bramanti et al., 2011; Gommerman and Monroe, 2012).

Haklay (2013) has defined four different level of engagement in citizen science programs that reflect four types of projects: i) ‘Crowdsourcing’ represents the lowest level of citizen participation, is not required previous knowledge on the subject and it usually ask citizens to report observations; ii) “Distributed intelligence’ requires previous knowledge from citizens and more effort to participate;

[7] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/missions-horizon-europe/adaptation-climate-change-including-societal-transformation_en
[8] https://pq-ue.ani.pt/content/eventos/12332_relatorio-da-missao-starfish.pdf

iii) 'Participatory science' involves citizens in problem identification, method development and data collection; iv) 'Extreme citizen science' allows the interaction between researchers and citizens in all the research steps. A review of marine citizen science projects in the North Sea, showed that the most frequent level of engagement is the crowdsourcing one (69%), followed by the distributed intelligence (25%) (Garcia-Soto et al., 2021). Higher levels of participation require more effort from participants, while a crowdsourcing approach is more feasible and successful in terms of number of participants involved.

The crowdsourcing approach has been used and tested since 1999 by the Marine Science Group (MSG) of the University of Bologna, where I performed my PhD research. The MSG developed the 'recreational citizen science protocol' that allows divers and snorkelers to participate in scientific data collection while increasing their environmental knowledge and awareness without compromising their recreational enjoyment (Goffredo et al., 2004, 2010). In fact, this recreational approach does not require to modify volunteers' diving activity (e.g., dive time, dive site, depth, etc.) to take part into the study. The engagement of volunteers is based on a pyramidal scheme where research team members, through project partners, organize training events for professional divers on the project objectives and methods. Diving professionals in turn involve recreational divers into the project and data collection process. The use of an illustrated questionnaire helps non-specialists of the marine environment to recognize studied organisms and collect data. This recreational citizen science approach has been used by the MSG in the last 22 years within several projects:

- 'Mediterranean Hippocampus Mission'[9] (1999-2001) to evaluate the status and distribution of the two Mediterranean seahorse species, *Hippocampus hippocampus* and *Hippocampus ramulosus* along the Italians' coasts. During the 3-year study, 2,536 volunteers were involved and collected 8,827 questionnaires.
- 'Mediterranean Underwater Biodiversity Project (SPA project)'[10] (2002-2005) to i) involve large numbers of recreational divers in data collection about the Mediterranean biodiversity; ii) validate this new volunteer-based monitoring approach and evaluate volunteers' data reliability; iii) develop a volunteer sightings-based index model for evaluating the status of

[9] Goffredo, S., Piccinetti, C., & Zaccanti, F. (2004). Volunteers in marine conservation monitoring: a study of the distribution of seahorses carried out in collaboration with recreational scuba divers. Conservation Biology, 18(6), 1492-1503.

[10] Goffredo, S., Pensa, F., Neri, P., Orlandi, A., Gagliardi, M. S., Velardi, A., ... & Zaccanti, F. (2010). Unite research with what citizens do for fun: "Recreational monitoring" of marine biodiversity. Ecological Applications, 20(8), 2170-2187.

the marine environment. During the four-year study, 3,825 divers completed 18,757 questionnaires.

- 'Scuba Tourism for the Environment (STE project)'[11] (2007-2015) to: i) collect information on the presence and abundance of key coral reef taxa in the Red Sea; ii) improve volunteers' environmental awareness, by engaging them in practical environmental education activities. During nine-years of data collection, 16,164 volunteers were involved in the project resulting in 35,650 completed questionnaires.
- 'Sea Sentinel – Divers United for the Environment' (2017 – on going), developed as a follow-up study of the previous SPA project (2002-2005), to: i) collect data about the Mediterranean biodiversity status; ii) compare results of SPA project with current data, to investigate possible variations in Mediterranean biodiversity status; iii) increase citizen environmental awareness.

As part of these projects, MSG has also developed a protocol for assessing the reliability of volunteer data to strengthen the credibility of this research method in the scientific community.

1.4 RELIABILITY OF DATA COLLECTED BY VOLUNTEERS

Citizen science projects vary widely in topic, objectives, activities, and scope, but the common goal is to collect reliable data that can be used for scientific and policy purposes to implement environmental management and protection plans (Forrester et al., 2015; Van der Velde et al., 2017). Despite the growing amount of citizen science projects, some scientists remain skeptics about the quality of data collected by volunteers (Crall et al., 2011; Aceves-Bueno et al., 2017). However, volunteers involved in citizen science projects can produce data with sufficient to high accuracy (Foster-Smith and Evans, 2003; Goffredo et al., 2010; Kosmala et al., 2016), although some cases of insufficient volunteer data quality have been reported (Foster-Smith and Evans, 2003; Galloway et al., 2006; Delaney et al., 2008; Silvertown, 2009; Hunter et al., 2013).

Aceves-Bueno et al. (2017), in a review of 63 studies in ecology and environmental science in which citizens scientists' data were compared with professionals' ones (hereafter reference), found that only 21.5% of the studies focused on the marine systems. Of those projects, most were of short duration (only 2.8% lasting between 1 and 5 years), the number of citizens tested for accuracy analysis were very small in most cases, in fact only in two cases more than 1,000 people were tested. As reported

[11] Branchini, S., Pensa, F., Neri, P., Tonucci, B. M., Mattielli, L., Collavo, A., ... & Goffredo, S. (2015). Using a citizen science program to monitor coral reef biodiversity through space and time. Biodiversity and conservation, 24(2), 319-336.

in the review by Aceves-Bueno et al. (2017), more than 10 different statistical methods were used to assess the accuracy of data collected by volunteers, but they could be categorized in three main groups based on the reported result: i) percentage of agreement, ii) P value, and iii) correlations. Percentage of agreement analysis showed that in 55.2% of the comparisons the percentage of agreement between data collected by volunteers and those collected by the reference was equal or greater than 80%. The P value analysis, with significant values ≤ 0.05, resulted not significant in 61.6% of the observation indicating negligible differences between volunteers and the reference. Correlation analysis considered $r \geq 0.5$ as a moderate to strong correlation between the data, with 50.6% of the observations above this threshold. The last analysis conducted by Aceves-Bueno et al. (2017) is a qualitative one, and it showed that, in 73% out of the 63 analyzed papers, authors described positively the contribution of citizen science while only in eight papers the performance of citizen scientists was considered negatively. The authors of the review identified two main reasons for these differences: 1) the use of multiple comparisons between data collected by the citizens and those collected by professionals may allow the authors to identify certain tasks for which citizen science data are sufficiently accurate; 2) there is not a unique definition of terms (e.g., reliable) and thresholds, so it is upon research design and researcher's judgment to decide whether data are accurate enough for a given purpose.

The MSG outcomes in this field showed that in most cases volunteers were able to collect good quality of data performing similarly to conservation volunteer divers that followed a pre-determined transect for the project (Goffredo et al., 2010; Branchini et al., 2015b).

1.5 ENVIRONMENTAL EDUCATION AND PARTICIPATORY APPROACH

While data quality assessment is crucial, it is not the only scope of citizen science. In fact, this method can also have an educational value. In some cases, this type of project could engage the tourism sector in developing a more sustainable business while raising awareness of tourism. More specifically, projects that aim to collect data or protect the natural environment could be included in the tourism offer, with a win-win result for tourism agencies, who have added value to their offer, for scientists, who can collect data, and for tourists, who can expand their knowledge in an informal setting.

Learning experiences that take place in informal and casual settings tend to educate people better than formal settings, such as school (Bueddefeld and Van Winkle, 2018), and can also lead to more appropriate behaviors that enhance people's conservation efforts (Padua, 1994). Environmental education programmes can raise public awareness of environmental challenges and promote pro-environmental behavior and attitudes to minimize the negative impacts of human activities on the

natural world (Hungerford and Volk, 1990; Kollmuss and Agyeman, 2002; Steg and Vlek, 2009; Wals et al., 2014; Branchini et al., 2015a; Wynes and Nicholas, 2017).

Therefore, communication, education, and participatory actions are key tools and strategies for a change of conservation paradigm (Jiménez et al., 2015; Wali et al., 2017; Burgos-Ayala et al., 2020). Adaptive, participatory and transdisciplinary approaches will allow to achieve sustainable development and biodiversity conservation in a new vision of cooperation and multidisciplinary approach on a landscape scale, with significant socio-ecological implications (Agnoletti et al., 2015). This new vision is based on participatory approaches that bridge science and society while actively involving policy makers and stakeholders (Peano et al., 2021).

1.7 SCOPE OF MY PHD

My research interests are based on the methodology of the participatory approach. For this reason the aims of my PhD research were to: i) analyze the reliability of data collected by volunteers during the STE (2007-2015) and SPA (2002-2005) + DUE (2017-2020) projects; ii) evaluate the long-term impact of environmental education activities performed during the STE project following the study of Branchini et al., (2015); iii) evaluate the short and long-term impact of Glocal Education project (2016-2019); iv) coordinate DUE project activities and data collection (2017-2020) to monitoring the biodiversity status of studied sites for a follow up study of SPA project (2002-2005); v) develop a questionnaire to investigate people's perceptions of natural sites and characteristics they give importance to, in order to have a more inclusive understanding of what might need to be prioritised in considering management of natural sites.

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CHAPTER 2.

RELIABILITY OF DATA COLLECTED BY VOLUNTEERS: A NINE-YEAR CITIZEN SCIENCE STUDY IN THE RED SEA

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Reliability of Data Collected by Volunteers: A Nine-Year Citizen Science Study in the Red Sea

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The quality of data collected by non-professional volunteers in citizen science programs is crucial to render them valid for implementing environmental resources management and protection plans. This study assessed the reliability of data collected by non-professional volunteers during the citizen science project Scuba Tourism for the Environment (STE), carried out in mass tourism facilities of the Red Sea between 2007 and 2015. STE involved 16,164 volunteer recreational divers in data collection on marine biodiversity using a recreational citizen science approach. Through a specifically designed questionnaire, volunteers indicated which of the seventy-two marine taxa surveyed were observed during their recreational dive, giving an estimate of their abundance. To evaluate the validity of the collected data, a reference researcher randomly dived with the volunteers and filled in the project questionnaire separately. Correlation analyses between the records collected by the reference researcher and those collected by volunteers were performed based on 513 validation trials, testing 3,138 volunteers. Data reliability was analyzed through 7 parameters. Consistency showed the lowest mean score (51.6%, 95% Confidence Interval CI 44.1–59.2%), indicating that volunteers could direct their attention to different taxa depending on personal interests; Percent Identified showed the highest mean score (66.7%, 95% CI 55.5–78.0), indicating that volunteers can correctly identify most surveyed taxa. Overall, results confirmed that the recreational citizen science approach can effectively support reliable data for biodiversity monitoring, when carefully tailored for the volunteer skills required by the specific project. The use of a recreational approach enhances massive volunteer participation in citizen science projects, thus increasing the amount of sufficiently reliable data collected in a reduced time.

Keywords: citizen science, reliability, data quality, volunteers, biodiversity monitoring

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INTRODUCTION

Institutions and natural resource managers are often under fund restrictions, which odds with the need to collect fundamental data to implement conservation strategies (Lewis, 1999; Foster-Smith and Evans, 2003; Jetz et al., 2012; Forrester et al., 2015; McKinley et al., 2017). Effective conservation strategies must also integrate public input and engagement in designing solutions (McKinley et al., 2017). Involving volunteers in data collection for monitoring activities can be a cost-effective strategy to complement or replace the information collected by professionals (Starr et al., 2014). Citizen science projects can improve environmental education of volunteers, increase scientific knowledge and allow the collection of large datasets (Foster-Smith and Evans, 2003; Bonney et al., 2009; Sullivan et al., 2009; Jordan et al., 2011; Branchini et al., 2015b; Callaghan et al., 2019). Participating in a citizen science project can have an educational role both in the short and long term, with the retention of acquired environmental awareness after years (Branchini et al., 2015a; Meschini et al., 2021).

Observations of the natural world, including weather information, plants and animals distribution, astronomical phenomena and many other data have been recorded for decades by citizens (Miller-Rushing et al., 2012; Bonney et al., 2014). One emblematic example come from ornithology, with the Audubon Society's annual Christmas bird counts, started in 1900 and it still engaging 60–80,000 volunteers annually (Forrester et al., 2015). Nowadays millions of volunteers are participating in many scientific research projects by collecting, categorizing, transcribing and analyzing data (Dickinson et al., 2012; Callaghan et al., 2019). Ultimately, citizen science presents an enormous potential to influence policy and guide resource management by producing datasets that would be otherwise unobtainable (Kosmala et al., 2016).

Citizen science is blooming across a range of disciplines in natural and social sciences, as well as humanities (Lukyanenko et al., 2019). A large body of environmental research is based on citizen science (e.g., biology, conservation and ecology); anyway, the development of information and communication technologies (ICT) have expanded the scale and scope of data collection from geographic information research (e.g., projects for geographic data collection) to social sciences and epidemiology studies (e.g., projects that study the relationship between environmental issues and human health) (Kullenberg and Kasperowski, 2016; Hecker et al., 2018). Citizen science is becoming of central importance to reinforce literacy and societal trust in science and foster participatory and transparent decision-making[1]. It is also gaining an increasing interest for policy makers, government officials and non-governmental organizations (Turbé et al., 2019). Data collected through citizen science are a non-traditional data source that is giving a contribution to measure the United Nations (UN) Sustainable Development Goals (Fritz et al., 2019). The role of citizens is becoming central also in European Union (EU) policies, such as the Horizon 2020 funding program[2]. The next European Research and Innovation Program Horizon Europe includes a specific mission supporting this process by connecting citizens with science and public policy[3]. In the Mission Starfish 2030 program, citizens are protagonists of one of the five overarching objectives for 2030 and one goal of this program for the 2025 checkpoint, is that 20% of data collection comes from citizen science initiatives[4]. Those are some examples of the increasing importance that citizen science is gaining in European funding programs, where citizen science will be a transversal topic to all missions.

Citizen science projects vary extensively in subject matter, objectives, activities, and scale, but the common goal is collecting reliable data to be used for scientific and policy making purposes for implementing environmental management and protection plans (Forrester et al., 2015; Van der Velde et al., 2017). Volunteers involved in citizen science projects can produce data with sufficient to high accuracy (Foster-Smith and Evans, 2003; Goffredo et al., 2010; Kosmala et al., 2016), although some cases of insufficient volunteer data quality have been reported (Foster-Smith and Evans, 2003; Galloway et al., 2006; Delaney et al., 2008; Silvertown, 2009; Hunter et al., 2013).

Data collection in citizen science projects usually addresses easy-to-recognize organisms, with interest on qualitative and semi-quantitative data that can be useful for management plans (Bramanti et al., 2011). The marine environment data collection is particularly challenging because it requires swimming or scuba diving skills in addition to the usual sampling difficulties (Goffredo et al., 2004, 2010; Gillett et al., 2012; Forrester et al., 2015). Citizen science in the marine environment can be used to monitor shallow water organisms (up to 40 meters depth, the Professional Association of Diving Instructors (PADI) limit for recreational scuba skills) over a large geographical and temporal extension (Goffredo et al., 2010; Bramanti et al., 2011; Gommerman and Monroe, 2012). Several studies analyzed the correlation between data collected by professionals and volunteers on a single taxonomic group, such as fishes (Darwall and Dulvy, 1996; Holt et al., 2013), e.g., sharks (Ward-Paige and Lotze, 2011) or corals (Bramanti et al., 2011; Marshall et al., 2012; Forrester et al., 2015) showing that volunteers were able to collect good quality data that could be used to complement professional data and describe population trends in spatial and temporal scales.

The aim of this study was to replicate the standardized methodology used in Goffredo et al. (2010) and Branchini et al. (2015b) to assess the quality of data collected by non-specialist volunteers on seventy-two Red Sea taxa during the recreational citizen science project Scuba Tourism for the Environment (STE). Previous reported studies were, respectively, based on 38 and 61 validation trials, in this study we analyzed 513

[1]https://cordis.europa.eu/programme/id/H2020_IBA-SWAFS-Citizen-2019

[2]https://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society

[3]https://ec.europa.eu/info/horizon-europe_en

[4]https://ec.europa.eu/info/publications/mission-starfish-2030-restore-our-ocean-and-waters_en

validation trials mainly performed in Egypt between 2007 and 2015. Our study used a recreational survey protocol based on casual diver observations. This protocol allowed divers to carry out their normal recreational activities and ensured the reliability of collected data through standardized data collection (Branchini et al., 2015b). To evaluate the possible influence of independent variables (date, team size, diving certification level, depth and dive time on volunteers data quality, we used correlation analyses using Spearman rank correlation and distance-based redundancy linear modeling (DISTLM) to test the contributions of independent variables to data variability.

MATERIALS AND METHODS

From 2007 to 2015 16,164 recreational scuba divers in mass tourism facilities and diving centers in the Red Sea were involved in the citizen science project Scuba Tourism for the Environment (STE). Project goal was to monitor coral reef biodiversity in the Red Sea, using specifically developed illustrated questionnaires. A first section of the questionnaire was dedicated to volunteer environmental education to limit human impact on the reef and increase volunteer awareness on the vulnerability of coral reefs (**Supplementary Figure 1**). The second section of the questionnaire consisted in seventy-two photographs of target taxa, chosen because they are: (i) representative of the main ecosystem trophic levels, (ii) expected to be common and abundant in the Red Sea, and (iii) easily recognizable by non-specialist volunteers (**Supplementary Figure 2**). These characteristics were selected to increase the accuracy of data collected by volunteers (Goffredo et al., 2004, 2010). The third section of the questionnaire was dedicated to the collection of personal information (i.e., name, address, email, level of diving

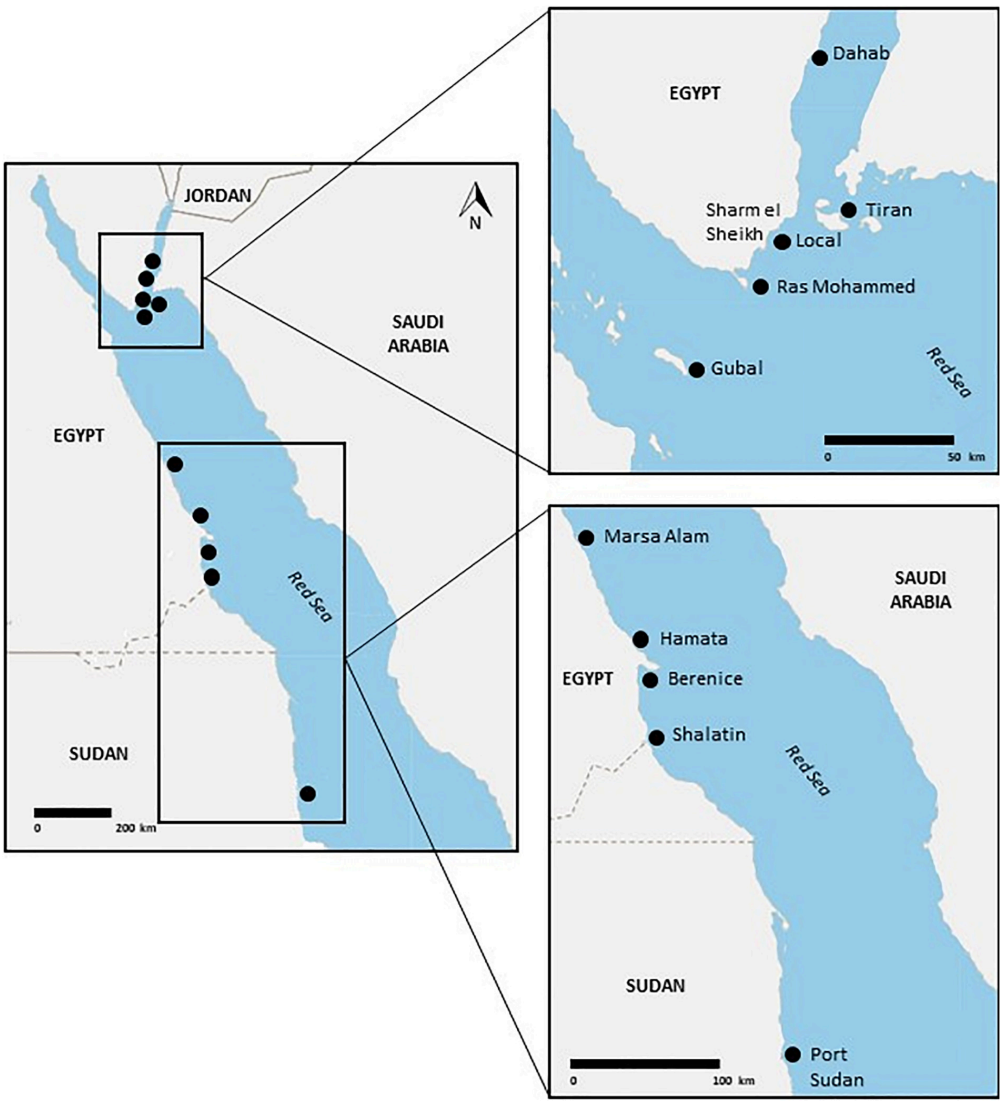

FIGURE 1 | Red Sea map with black dots indicating sites in which data for the reliability analysis were collected.

certification and diving agency), technical information about the dive (i.e., place, date, depth, dive time, duration of the dive), type of habitat explored (i.e., rocky bottom, sandy bottom or other habitat) and the data collection table about sighted taxa with an estimation of their abundance (**Supplementary Figure 3**). The abundance estimation of each taxon was based on literature (Wielgus et al., 2004) and databases[5], and expressed in the three categories "rare," "frequent" or "abundant." Completing questionnaires shortly after the dive facilitated the quality control of collected data. The STE project used a recreational citizen science approach (Goffredo et al., 2004, 2010; Branchini et al., 2015b) in which normal recreational diving features and volunteer behavior are not modified by project participation. Researchers of the STE project performed an annual training session for scuba instructors of the diving centers involved in the project, based on the methodology used for the study and obtained results. This allowed scuba instructors to directly involve their clients in data collection. The STE project received the approval of the Bioethics Committee of the University of Bologna (prot. 2.6). Data were treated confidentially, exclusively for institutional purposes (art. 4 of Italian legislation D.R. 271/2009 – single text on privacy and the use of IT systems). Data treatment and reporting took place in aggregate form.

Data Validity Assessment

To assess the validity of data collected by volunteers, records of 3,138 volunteer were compared with those collected by a marine biologist of the Marine Science Group of the University of Bologna ("control diver") during 513 validation trials mainly performed in Egypt (**Figure 1**). The characteristics of the validation trials were: (1) the control diver dived with at least three volunteers; (2) the validation trial did not affect the diving center normal choice of dive site; (3) the dive was conducted between 9.00 am and 4.00 pm; (4) after the dive, the control diver filled in the questionnaire apart from volunteers, as to avoid interference with volunteers data recording (Goffredo et al., 2010). For each trial, the inventory of each taxa (with abundance ratings) sighted by the control diver was correlated with that collected by each volunteer to verify their similarity (Darwall and Dulvy, 1996; Foster-Smith and Evans, 2003; Aceves-Bueno et al., 2017). To measure the quality of volunteer data, 7 reliability parameters were used: Accuracy, Consistency, Percent Identified, Correct Identification, Correctness of Abundance Ratings, Similarity, Reliability (**Table 1**). Non-parametric statistical tests were used for the analysis: (1) Spearman rank correlation coefficient, to evaluate the accuracy of data collected by volunteers in comparison to those obtained by the control diver; (2) Cronbach's alpha (α) correlation, to evaluate the reliability of collected data between each volunteer and the control diver; and (3) Czekanowski proportional similarity index (SI) to obtain a measure of similarity between each volunteer and the control diver ratings (Goffredo et al., 2010). Tests results were reported as mean with 95% Confidence Interval (CI) (Sale and Douglas, 1981; Darwall and Dulvy, 1996). For the Similarity and Reliability parameters the lower bound (calculated from 95% Confidence Interval (CI) of the mean values) was used (Goffredo et al., 2010). We also examined the effect of date, team size (the number of participants present in each validation trial), diving certification level of each participant, depth and dive time on volunteer accuracy using the Spearman's rank correlation coefficient. All these statistical analyses were computed using the SPSS 22.0 statistical software. Using PRIMER v6, distance-based redundancy linear modeling (DISTLM) with a test of marginality was also performed, based on Euclidean distance, to test the contributions of variables to data variability.

[5]http://www.gbif.org; http://www.marinespecies.org

RESULTS

The mean accuracy of each validation trial ranged from 38.2 to 81.5%, with 94.2% of trials with mean accuracy between 40 and 70% (**Supplementary Table 1**; **Figure 2**). Accuracy

TABLE 1 | Reliability parameters used to analyze data collected by volunteers (modified from Goffredo et al., 2010).

Parameter	Definition and derivation of parameter
Accuracy	Similarity of volunteer-generated data to reference values from a control diver measured as Spearman rank correlation coefficient (rho) and expressed as a percentage in the text. This measure of accuracy is assumed to encompass all component sources of error.
Consistency	Similarity of data collected by separate volunteers during the same dive. This was measured as rank correlation coefficient and expressed as percentage in the text. This measure of consistency is assumed to encompass all component source of error.
Percent identified	The percentage of the total number of taxa present that were recorded by the volunteer diver. The total number of taxa present was derived from the control diver data (i.e., we assumed the taxa recorded by the control diver to be all the taxa present).
Correct identification	The percentage of volunteers that correctly identified individual taxa when the taxon was present.
Correctness of abundance ratings (CAR)	This analysis quantified the correctness in abundance ratings made by the volunteer. It has been expressed as the percentage of the 72 surveyed taxa whose abundance has been correctly rated by the volunteer (i.e., the value of the rating indicated by the volunteer was equal to the reference value recorded by the control diver).
Similarity index	Measure of similarity between each volunteer and the control diver ratings, using Czekanowski proportional similarity index.
Reliability	Measure of reliability between each volunteer and the control diver ratings, using Cronbach alpha (α) correlation.

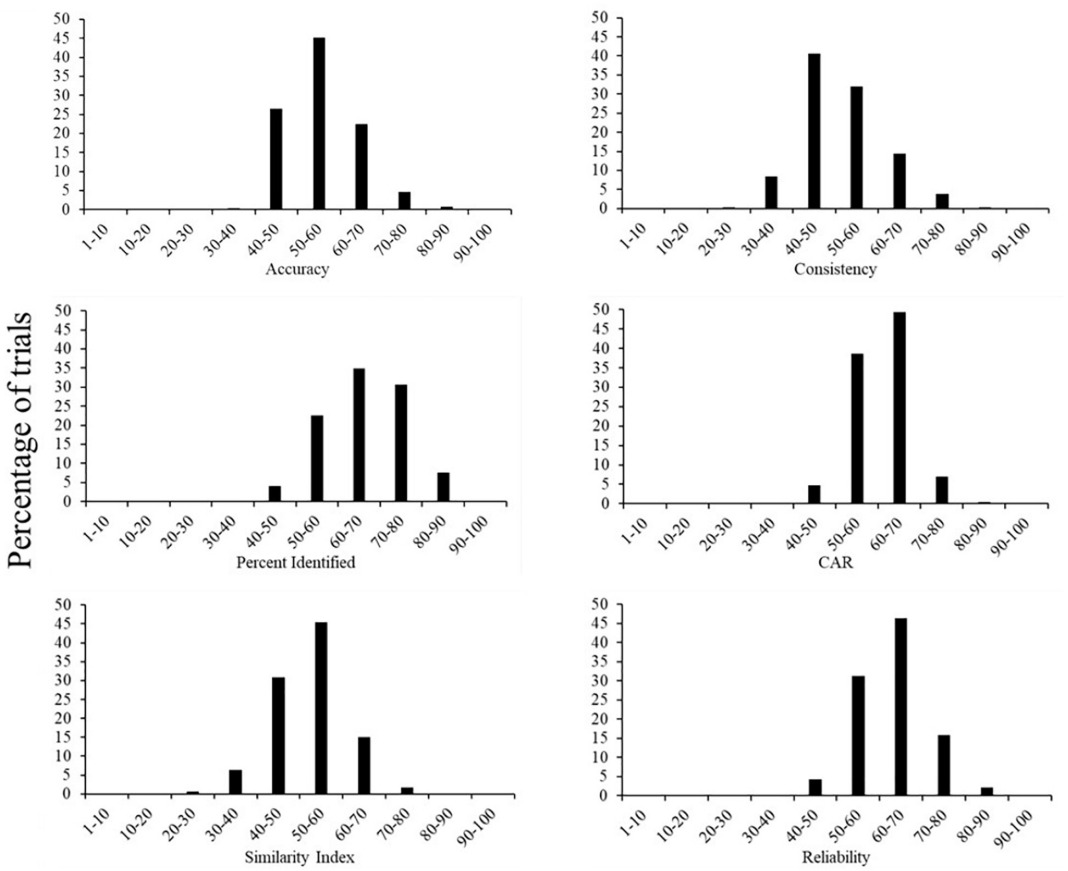

FIGURE 2 | Quality of data collected by volunteers in the 513 validation trials performed during the 9-year research project STE (2007–2015). Distribution of data is divided in classes depending on the mean score percentage that each validation trial achieved for the studied parameters. For the parameters Similarity Index and Reliability the reference score is the lower bound calculated from 95% CI of the mean values.

TABLE 2 | Correlations between reliability parameters and independent variables.

	Date	Team size	Diving certification level	Depth	Dive time
Accuracy	0.120**	0.063	0.242***	−0.022	0.122**
Consistency	−0.022	−0.077	0.165***	−0.049	0.117**
Percent identified	−0.005	−0.020	0.272***	0.009	0.164***
CAR	0.110*	0.135**	−0.020	−0.084	0.016
Similarity Index	0.032	0.107*	0.253***	−0.004	0.186***
Reliability	0.029	0.212***	0.200***	−0.024	0.145***

*Reported number are Spearman Rho (ρs) values, significance of correlation is indicated as *** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$.*

was positively correlated with: date (ρs = 0.120, N = 513, $p < 0.01$, **Table 2**; **Figure 3**), volunteers scores increased with years, with a score increase of 2.8% between the start and the end of the project (**Table 3**); volunteer diving certification level (ρs = 0.242, N = 513, $p < 0.001$, **Table 2**; **Figure 4**), volunteers scores increased with higher divers certification level, with an increase of 17.3% between beginners and professional divers (**Table 3**); dive time (ρs = 0.122, N = 513, $p < 0.01$, **Table 2**; **Figure 4**), volunteers scores increased with time spent underwater, with an increase of 11.6% between short and long dives (**Table 3**). Accuracy was not correlated with team size (ρs = 0.063, N = 513, p = 0.151, **Table 2**) and depth (ρs = −0.022, N = 513, p = 0.620, **Table 2**).

The mean consistency of each validation trial ranged from 28.0 to 85.3%, with 86.9% of trials with mean consistency between 40 and 70% (**Supplementary Table 1**; **Figure 2**). Consistency was positively correlated with: volunteer diving certification level (ρs = 0.165, N = 513, $p < 0.001$, **Table 2**; **Figure 4**), volunteers scores increased with higher divers certification level, with a score increase of 13.6% between beginners and professional divers (**Table 3**); dive time (ρs = 0.117, N = 513, $p < 0.01$, **Table 2**; **Figure 4**), volunteers scores increased with time spent underwater, with an increase of 17.7% between short and long dives (**Table 3**). Consistency was not correlated with date (ρs = −0.022, N = 513, p = 0.615, **Table 2**), team size (ρs = −0.077, N = 513, p = 0.81, **Table 2**) and depth (ρs = −0.049, N = 513, p = 0.271, **Table 2**).

The mean percent identified of each validation trial ranged from 40.2 to 90.9%, with 88.1% of trials with mean percentage of identified between 50 and 80% (**Supplementary Table 1**;

Figure 2). Percent identified was positively correlated with: volunteer diving certification level ($\rho s = 0.272$, $N = 513$, $p < 0.001$, **Table 2**; **Figure 4**), volunteers scores increased with higher divers certification level, with a score increase of 21.4% between beginners and professional divers (**Table 3**); dive time ($\rho s = 0.164$, $N = 513$, $p < 0.001$, **Table 2**; **Figure 4**), volunteers scores increased with time spent underwater, with an increase of 17.1% between short and long dives (**Table 3**). Percent identified was not correlated with date ($\rho s = -0.005$, $N = 513$, $p = 0.904$, **Table 2**), team size ($\rho s = -0.020$, $N = 513$, $p = 0.656$, **Table 2**) and depth ($\rho s = 0.009$, $N = 513$, $p = 0.831$, **Table 2**).

The mean correct identification of each taxon varied from 3.8 to 94.7%, with a positive correlation between the number of validation trials in which the taxon was present and the level of correct identification performed by volunteers ($\rho s = 0.610$, $N = 77$, $p < 0.001$), with a score increase of 21.5% between less present and most present taxa (**Table 4**; **Figure 5**).

The mean correctness of abundance ratings (CAR) of each validation trial ranged from 41.1 to 82.3%, with 94.9% of trials with mean CAR between 50 and 80% (**Supplementary Table 1**; **Figure 2**). CAR was positively correlated with: date ($\rho s = 0.110$, $N = 513$, $p < 0.05$, **Table 2**; **Figure 3**), volunteers scores increased with years, with a score increase of 7.8% between the start and the end of the project (**Table 3**) and team size ($\rho s = 0.135$, $N = 513$, $p < 0.01$, **Table 2**; **Figure 3**), volunteers scores increased with number of present divers, with a score increase of 6.9% between small and big groups (**Table 3**). CAR was not correlated with volunteer diving certification level ($\rho s = -0.020$, $N = 513$, $p = 0.657$, **Table 2**), depth ($\rho s = -0.084$, $N = 513$, $p = 0.057$, **Table 2**) and dive time ($\rho s = 0.016$, $N = 513$, $p = 0.721$, **Table 2**).

The mean lower bound of the Czekanowski proportional similarity index (SI) of each validation trial ranged from 27.3 to 78.8%, with 91.2% of trials with mean SI between

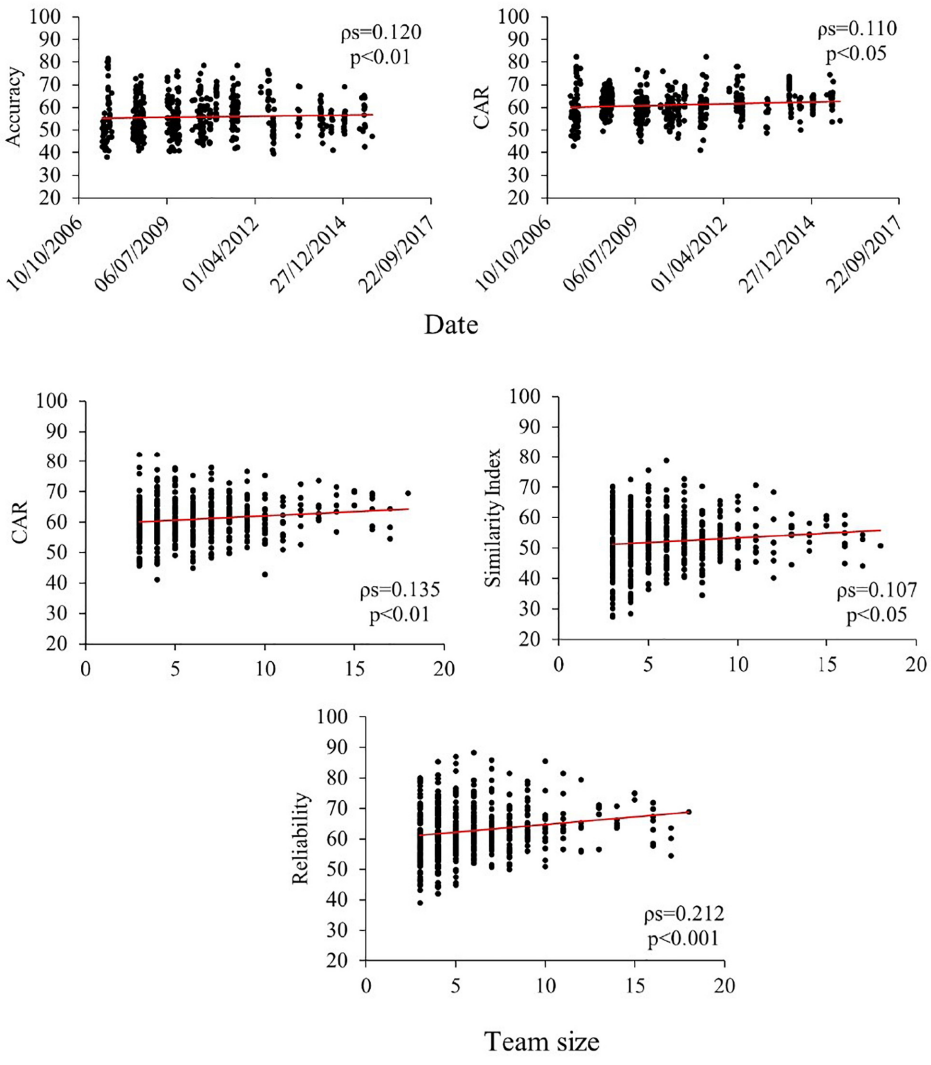

FIGURE 3 | Significant correlations between reliability parameters (Accuracy, CAR, Reliability, and Similarity Index) and independent variables (Date and Team Size). Results based on the 513 validation trials. Indicated in red the trendline of the correlations. ρs = Spearman correlation coefficient.

TABLE 3 | Percentage of increase of reliability parameters depending on independent variables.

	Date	Team size	Diving certification level	Depth	Dive time
Accuracy	2.837	–	17.349	–	11.586
Consistency	–	–	13.570	–	17.674
Percent identified	–	–	21.432	–	17.115
CAR	7.772	6.914	–	–	–
Similarity index	–	8.746	21.223	–	21.432
Reliability	–	12.430	11.138	–	11.046

This increase has been calculated from the trend line equation, using minimum and maximum value for each independent variable.

40 and 70% (**Supplementary Table 1**; **Figure 2**). A 194 trials (37.8%) performed with levels of precision below the sufficiency threshold (SI, 95% CI lower bound $\leq$ 50%); 317 trials (61.8%) scored a sufficient level of precision (SI, 95% CI lower bound $>$ 50% $\leq$ 75%), and 2 trials (0.4%) scored high levels of precision (SI, 95% CI lower bound $>$ 75% $\leq$ 100%). SI was positively correlated with: team size ($\rho s = 0.107$, $N = 513$, $p < 0.05$, **Table 2**; **Figure 3**), volunteers scores increased with number of present divers, with a score increase of 8.7% between small and big groups (**Table 3**); volunteer diving certification level ($\rho s = 0.253$, $N = 513$, $p < 0.001$, **Table 2**; **Figure 4**), volunteers scores increased with higher divers certification level, with a score increase of 21.2% between beginners and professional divers (**Table 3**); dive time ($\rho s = 0.186$, $N = 513$, $p < 0.001$, **Table 2**; **Figure 4**), volunteers scores increased with time spent underwater, with an increase of 21.4% between short and long dives (**Table 3**). SI was not correlated with date ($\rho s = 0.032$, $N = 513$, $p = 0.465$, **Table 2**) and depth ($\rho s = -0.004$, $N = 513$, $p = 0.924$, **Table 2**).

The mean lower bound reliability (α) of each validation trial ranged from 38.9 to 88.4%, with 93.4% of trials with

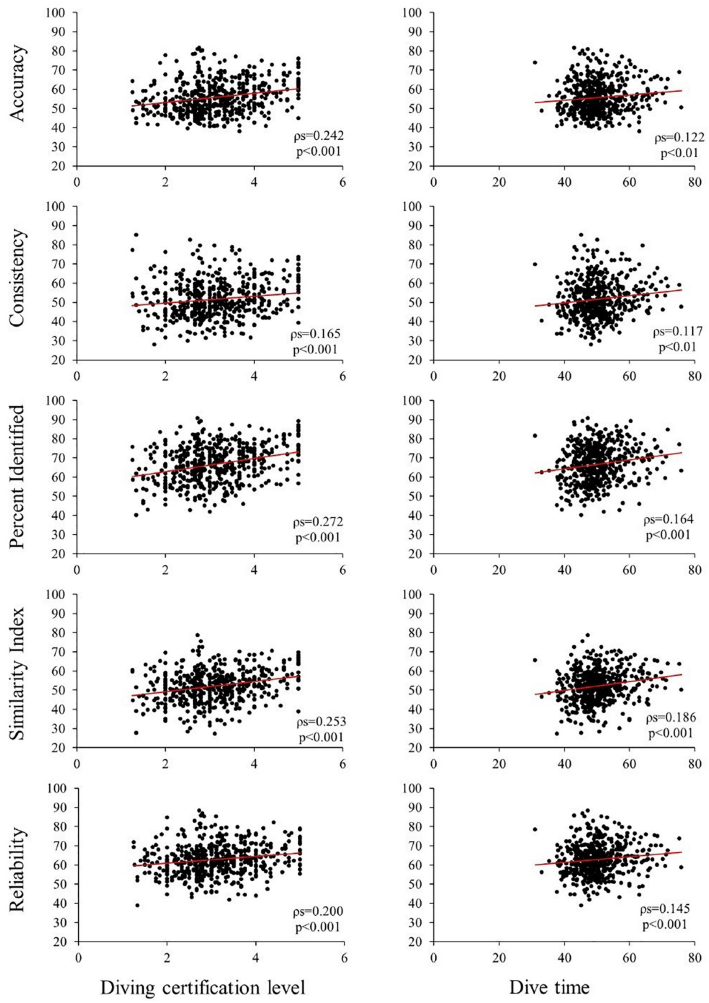

FIGURE 4 | Significant correlations between the studied reliability parameters (Accuracy, Consistency, Percent Identified, Similarity Index, and Reliability) and the independent variables Diving certification level and Dive time. Results based on the 513 validation trials. Indicated in red the trendline of the correlations. ρs = Spearman coefficient value.

TABLE 4 | Results of the correct identification analysis with mean score of correct identification performed by volunteers for each taxon.

Taxon		Correct identification			
Common name	**Scientific name**	**Mean**	**N**	**95% CI**	
2-fire coral	*Millepora sp.*	94.7	507	93.6	95.7
5-sea fan	*Subergorgia hicksoni*	91.8	415	90.2	93.4
4-soft tree coral	*Dendronephthya sp.*	91.1	494	89.7	92.4
23-tbigfin reef squid	*Sepioteuthis sp.*	90.0	1	–	–
46-parrotfishes	Scaridae	85.1	475	83.6	86.7
35-groupers	Epinephelinae	83.9	488	82.3	85.6
42-butterflyfishes	Chaetodontidae	83.9	488	82.3	85.5
22-squids	Seepidae	83.3	2	50.7	100
9-plating acropora	*Acropora sp.*	83.3	462	81.5	85.1
44-Red Sea clownfish	*Amphiprion bicinctus*	82.1	392	80.0	84.2
1-tube sponge	*Siphonochalina sp.*	82.1	418	80.2	84.0
3-leather coral	*Sarcophyton sp.*	80.7	497	78.7	82.6
56-sharks	Squaliformes	80.7	55	73.0	88.4
20-tridacnae	*Tridacna sp.*	79.4	456	77.5	81.3
18-spanish dancer	*Hexabranchus sanguineus*	77.0	7	57.5	96.5
– broken corals		76.9	459	74.9	79.0
62-partially or totally dead corals		76.7	440	74.5	78.9
12-mushroom corals	Fungiidae	76.0	466	74.0	77.9
49-caranxes	Carangidae	74.0	417	71.6	76.5
60-turtles	Cheloniidae	73.7	85	68.0	79.4
63-bleached corals		73.2	337	70.8	75.6
32-giant moray	*Gymnothorax javanicus*	72.5	204	68.4	76.6
7-sea whips	Ellisellidae	71.5	337	69.0	74.1
13-lettuce coral	*Turbinaria sp.*	70.9	284	67.8	74.0
47-barracuda	*Sphyraena sp.*	70.7	117	65.1	76.2
8-sea carpet host anemones	Stichodactylidae	69.8	412	67.4	72.2
37-humpback batfish	*Platax sp.*	68.5	147	63.8	73.1
10-porcupine coral	*Seriatopora hystrix*	68.4	372	65.9	70.9
45-humphead wrasse – Napoleon fish	*Cheilinus undulatus*	68.1	218	64.0	72.2
50-lionfish	*Pterois sp.*	65.8	304	62.8	68.8
41-map angel	*Pomacanthus maculosus*	65.4	257	62.4	68.4
Other sponges		65.0	441	62.6	67.4
57-blue-spotted stingray	*Taeniura lymma*	64.1	221	60.2	68.0
54-blow fishes	Tetraodontidae	64.0	381	61.0	66.9
11-bubble coral	*Plerogyra sp.*	63.1	344	60.1	66.0
14-pineapple coral	Faviidae	62.8	330	60.1	65.5
52-titan triggerfish	*Balistoides viridescens*	59.2	206	55.3	63.2
51-spotted flatheads	Platycephalidae	56.6	66	49.2	64.0
39-glassfishes	Pempheridae	56.2	155	51.2	61.2
Other corals		55.5	465	52.7	58.3
58-manta	*Manta sp.*	54.5	1	–	–
34-squirrelfish	*Sargocentron sp.*	54.4	365	51.6	57.1
40-goatfishes	Mullidae	54.0	329	50.9	57.1
15-black coral	*Antipathes sp.*	51.9	313	48.8	55.1
6-red sea fans	Melithaeidae	51.2	259	47.7	54.7
48-sohal surgeonfish	*Acanthurus sohal*	50.9	201	47.1	54.7
36-blackspotted rubberlip	*Plectorhinchus gaterinus*	50.6	144	45.8	55.4
38-red bass	*Lutjanus bohar*	50.5	310	47.3	53.7
61-dolphins	Delphinidae	49.0	12	28.9	69.1
– sediment covered corals		48.7	330	45.9	51.6
Other bony fishes		46.0	427	43.1	48.9
21-wing oyster	*Pteria sp.*	45.2	235	41.6	48.8
53-boxfishes	Ostraciidae	44.8	160	40.5	49.2
– litter		44.8	284	41.2	48.4
29-spiny starfish	*Acanthaster planci*	42.3	9	21.9	62.7
27-sea cucumbers	Holothuroidea	41.5	77	35.3	47.6
55-porcupinefishes	Diodontidae	39.9	97	34.0	45.8
19-coriacea	*Chromodoris quadricolor*	39.9	61	32.1	47.6
59-torpedo	*Torpedo sp.*	38.0	5	5.1	70.9
other rays and torpedoes		36.0	24	23.3	48.8
26-sea lilies	Crinoidea	34.3	198	30.4	38.3
24-banded boxer shrimp	*Stenopus hispidus*	31.2	29	19.8	42.6
43-longnose hawkfish	*Oxycirrhites typus*	29.1	53	21.8	36.5
28-pearl red star	*Fromia sp.*	27.6	13	13.7	41.4
16-Christmas tree worm	*Spirobranchus sp.*	26.6	177	23.2	30.1
33-needlefishes	Syngnathidae	26.3	68	20.1	32.5
Other cephalopods		25.3	6	4.0	46.7
Other sea slugs		22.7	62	16.7	28.8
30-fire urchin	*Asthenosoma sp.*	21.9	14	8.2	35.6
Other decapods		20.2	49	12.7	27.7
Other sea urchins		18.7	200	15.5	22.0
31-pencil urchin	*Phyllacanthus sp.*	17.9	7	0	41.7
Other bivalves		16.9	151	14.0	19.9
Other starfishes		15.8	32	9.4	22.1
Other sedentary worms		15.3	71	10.5	20.0
17-cowries	Cypraedae	15.1	6	1.1	29.2
25-hermit crabs	Diogenidae	3.8	4	0	11.4

N is the number of trials in which the taxon was present (based on control diver sights).

mean reliability between 50 and 80% (**Supplementary Table 1**; **Figure 2**). Only 23 trials (4.5%) performed with an insufficient level of reliability (α, 95% CI lower bound $\leq$ 50%); 160 trials (31.2%) scored acceptable relationship with the control diver census (α, 95% CI lower bound $>$ 50% $\leq$ 60%); 238 trials (46.4%) scored an effective reliability level census (α, 95% CI lower bound $>$ 60% $\leq$ 70%); 92 trials (17.9%) performed from definitive to very high levels of reliability census (α, 95% CI lower bound $>$ 70% $\leq$ 100%). Reliability was positively correlated with: team size ($\rho s = 0.212$, $N = 513$, $p < 0.001$, **Table 2**; **Figure 3**), volunteers scores increased with number of present divers, with a score increase of 12.4% between small and big groups (**Table 3**); volunteer diving certification level ($\rho s = 0.200$, $N = 513$, $p < 0.001$,

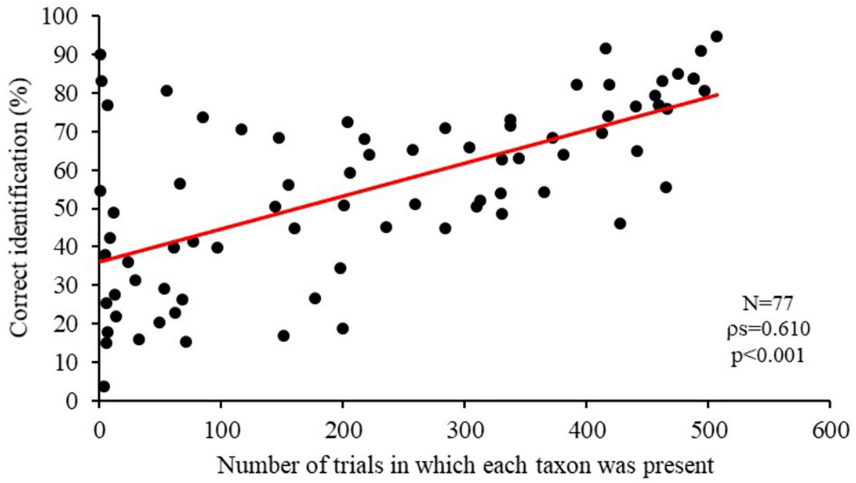

FIGURE 5 | Significant correlation between the percentage of correct identification performed by volunteers (expressed as mean percentage for each taxon) and number of trials in which each taxon was present (based on the control diver sighted). Based on 72 studied taxa, litter presence and sight of damaged corals (see **Table 3**). Indicated in red the trendline of the correlations. N = number analyzed organisms; ρs = Spearman coefficient value.

Table 2; **Figure 4**), volunteers scores increased with higher divers certification level, with an increase of 11.1% between beginners and professional divers (**Table 3**); dive time ($\rho s = 0.145$, $N = 513$, $p < 0.001$, **Table 2**; **Figure 4**), volunteers scores increased with time spent underwater, with an increase of 11.0% between short and long dives (**Table 3**). Reliability was not correlated with date ($\rho s = 0.029$, $N = 513$, $p = 0.515$) and depth ($\rho s = -0.024$, $N = 513$, $p = 0.591$) (**Table 2**).

Distance-based redundancy linear modeling analysis showed that the two variables "diving certification level" and "dive time" comprehensively explained about 82.7% of data variability, while the variable "team size" explained 13% of variability (**Table 5**; **Figure 6**).

DISCUSSION

Notwithstanding the large number of studied species, the accuracy of validation trials was promising, with most trials achieving a mean score between 50 and 70%. As pointed out by correlation and DISTLM analyses, most reliability parameters were positively correlated with the diving certification level, indicating that more experienced divers collected more accurate data. A possible explanation could be that expert divers have major confidence with the diving equipment and their underwater skills in comparison to beginner divers, allowing them focus more on the surrounding environment (Goffredo et al., 2010; Branchini et al., 2015b). Also, the dive time was positively correlated with most reliability parameters, suggesting that longer dives lead to higher data accuracy possibly because divers have more time to look around them and identify organisms.

Two reliability parameters (Accuracy and CAR) showed a positive correlation with the date. Although they are only two of seven parameters, this could suggest that citizen science projects should aim at a long-term duration due to the possibility to improve its implementation through feedbacks from volunteers, thus improving data quality.

Three reliability parameters (CAR, Similarity Index and Reliability) were positively correlated with team size, differently from previous studies where these relationships were not significant (Goffredo et al., 2010; Branchini et al., 2015b). This result could likely be related to presence of big groups belonging to the same diving school, that may be more guided by the instructor while filling in the questionnaire after the dive respect to single independent divers. Moreover, big groups of divers that stay close to each other to prevent the group from dispersing, could survey the marine environment in a more similar way to the control diver compared to small groups in which divers are free to dive. The anonymous data analysis did not allow us to test this aspect.

The lowest score within the analyzed reliability parameters was obtained by the Consistency parameter, with 86.9% of trials with mean consistency between 40 and 70%. This result is in line with previous studies that used the recreational approach and is likely related to the different personal interests of volunteers which made them focus on different species (Branchini et al.,

TABLE 5 | Results of distance-based linear modeling analysis.

Marginal tests

Variable	SS	Pseudo-F	P	Prop.
Date	487.48	1.1263	0.300	2.20E-03
Team size	2595.6	6.0544	0.006	1.17E-02
Diving certification level	11007	26.699	0.001	4.97E-02
Depth	377.51	0.87175	0.381	1.70E-03
Dive time	4336.2	10.196	0.001	1.96E-02

SS = Sum of Squares, P = p-value, Prop. = Proportion of variance explained.

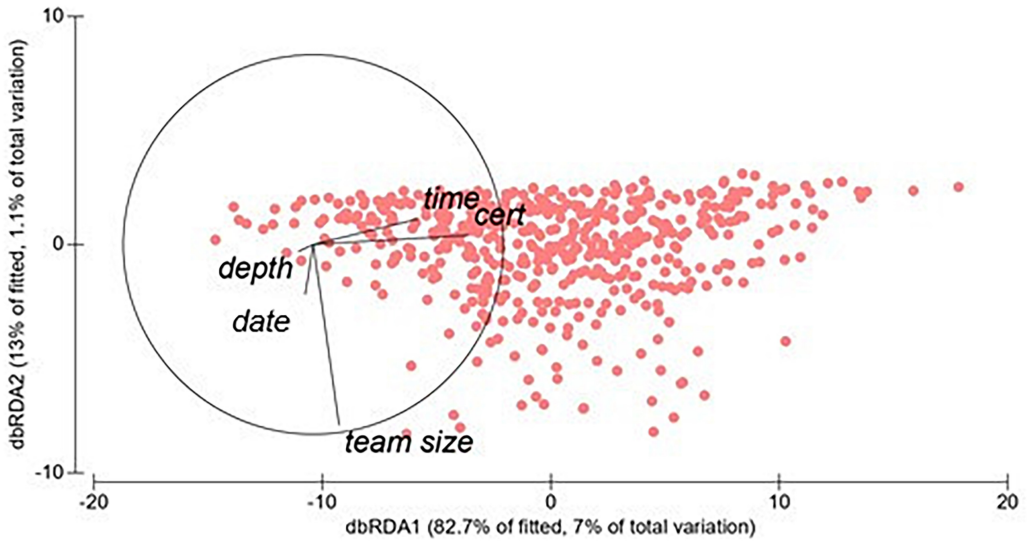

FIGURE 6 | Results of distance-based linear modeling analysis. Variables in the graphs: depth of the scuba diving activity), date of the validation trial, time is the amount of minutes spent underwater, cert is the diving certification level of volunteers and team size is the number of divers present in each validation trial.

2015b). For example, divers interested in macro photography may have focused their attention on small benthic organisms, while others interested in large pelagic fish (e.g., sharks) may have focused their attention away from the reef. Higher consistency results have been found using intensive training program in marine life identification and survey techniques (Mumby et al., 1995; Forrester et al., 2015). While an intense training could increase the consistency of data collected, it will drastically reduce the number of volunteers involved. This could limit the educational role of citizen science projects on volunteers for the lower number of involved volunteers.

The Czekanowski proportional similarity index (SI) showed that volunteers abundance ratings were below the sufficiency threshold in 37.8% validation trials, indicating that volunteers could encounter difficulties in abundance estimation as already found in other studies (Gillett et al., 2012; Done et al., 2017).

The wide variability of mean scores of the Correct Identification parameter could be due to the difficulty for volunteers to see and report the presence of less common or evident taxa (e.g., hermit crab that is frequently found between the rocks and blends in very well), while they performed better in recording the most common, well-known and straightforward species, as previously observed (Goffredo et al., 2010; Cox et al., 2012; Bernard et al., 2013; Branchini et al., 2015b; Forrester et al., 2015; Kosmala et al., 2016).

Previous studies that used the same methodology were performed, respectively, on 38 (Goffredo et al., 2010) and 61 validation trials (Branchini et al., 2015b). This study analyzed 513 validation trials that confirms previous trends permitting to generalize our results. A new result of this study is the team size variable as possible predictor for volunteers data quality, indicating that future data reliability studies should also consider this parameter.

As highlighted by different authors (Lewandowski and Specht, 2015; Kosmala et al., 2016; Specht and Lewandowski, 2018), a limitation of the approach used in this and other studies (Bell, 2007; Oscarson and Calhoun, 2007; Delaney et al., 2008; Aceves-Bueno et al., 2017) is that using professional or expert data, in the case of our study the "control diver," as reference for evaluating volunteer data would also need an evaluation of correctness of the data collected by professionals or experts (Specht and Lewandowski, 2018). In this study control divers were marine biologist of the Marine Science Group trained in the project specifics that spent some weeks monitoring the biodiversity of the surveyed sites, which should assure a good quality of collected data.

In citizen science projects it is fundamental to develop suitable tasks for volunteers to assure good data quality collection (Schmeller et al., 2009; Magurran et al., 2010; Tulloch et al., 2013; Kosmala et al., 2016; Brown and Williams, 2019). In the present study data quality was assured: (1) by asking volunteers to fill the questionnaire soon after the dive, to avoid possible species oversight; (2) by training scuba instructors on the methodology of STE data collection on an annual basis (during public events) or on site when the control diver was present in the diving centers.

Moreover the overall data accuracy of this study was comparable to that performed in other projects by volunteer divers on precise transects (Mumby et al., 1995; Darwall and Dulvy, 1996; Goffredo et al., 2010; Done et al., 2017). This suggest that data from citizen science programs can complement professional datasets with sufficiently accurate data, increasing the possibility of researchers to estimate species richness and providing valuable information on species distributions that are relevant for the detection of the biological consequences of global change (Soroye et al., 2018).

Volunteers quality of data varies with tasks, they perform better at identifying iconic or well-known species while they can be confused by cryptic, rare or unknown specie (Kosmala et al., 2016; Swanson et al., 2016). Some of the methods used to improve

the quality of data collected by volunteers are training programs or the request of prequalification via a skill test and the use of ongoing feedback on the volunteers identification for long-term engaged volunteers (Danielsen et al., 2014; Kosmala et al., 2016; van der Wal et al., 2016). Volunteers improve their data accuracy by gaining experience with a project, so a long-term engagement could bring to higher quality of data collected (Weir et al., 2005; Crall et al., 2010; Kelling et al., 2015).

Scuba Tourism for the Environment project was developed in collaboration with several mass tourism facilities and diving centers. During the project, annual meetings with Ministry of Tourism of the Arab Republic of Egypt were carried out to give management and conservation suggestions based on project results.

CONCLUSION

This project provided additional evidence that "recreational" (Goffredo et al., 2004, 2010) and "easy and fun" (Dickinson et al., 2012) citizen science is an efficient and effective method to recruit many volunteers and provide reliable data if well designed (Branchini et al., 2015b). The recreational citizen science approach used in the present study can be exported to different countries and used as a valuable tool by local governments and marine managers to achieve large-scale and long-term data collection, required in a fast-changing world where climate change and anthropogenic pressure on natural resources are leading to fast environmental changes worldwide.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Bioethics Committee of the University of Bologna. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SG, SB, MMe, CM, AM, and EC collected data during the STE project. MMe, MMa, LL, MD, MTr, EN, MTi, RB, SB, PN, and SG analyzed the data. MMe, MMa, CM, EC, FP, AM, SF, and SG wrote the manuscript. SG supervised the research. All authors discussed the results and participated to the scientific discussion.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2021.694258/full#supplementary-material

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Conflict of Interest: 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.

CHAPTER 3.

RELIABILITY ANALYSIS OF DATA COLLECTED BY VOLUNTEERS DURING AN EIGHT-YEARS CITIZEN SCIENCE PROJECT IN THE MEDITERRANEAN SEA

Manuscript in preparation

RELIABILITY ANALYSIS OF DATA COLLECTED BY VOLUNTEERS DURING AN EIGHT-YEAR CITIZEN SCIENCE PROJECT IN THE MEDITERRANEAN SEA

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Abstract

It is becoming increasingly popular to involve the public in the collection of scientific data to support long-term environmental monitoring, known as citizen science (CS). CS projects exist in many fields and environments, and although the marine environment covers more than 70% of the planet's surface, it seems to be particularly underrepresented in the relevant scientific literature, given the challenges associated with this environment (e.g. the inaccessibility of this environment and the particular skills required). Since 1999, the Marine Science Group at the University of Bologna has been using a recreational CS method and has shown that it can ensure sufficient data quality while collecting a larger amount of data. In this study, we sought to update the reliability analysis of the study conducted by Goffredo et al. (2010) in the Mediterranean Sea, using the recreational citizen science protocol. Despite the large number of species studied and the recreational dive profile, the accuracy obtained in the validation tests was promising. The reliability of the data was analysed using 7 parameters. All parameters achieved an average score between 50 and 80%. The parameters with the lowest average score were the similarity index and consistency. Overall, the results confirmed that the recreational citizen science approach can provide reliable data for biodiversity monitoring if it is carefully tailored to the volunteer skills required for the specific project. While intensive training could increase the consistency of the data collected, it would drastically reduce the number of volunteers involved. This could limit the reach of citizen science projects for volunteers, as the number of volunteers involved would be lower.

Introduction

Lack of funding for institutions and agencies could lead to gaps in knowledge about the presence and distribution of organisms in the environment. In countries such as the United States of America and some European countries, it has become increasingly popular to engage the public in the collection of scientific data to support long-term environmental monitoring (Donnelly et al., 2014), the so-called citizen science (CS). One of the main purposes of CS monitoring projects is to collect reliable data from which changes in trend and diversity of wildlife can be observed. CS projects also help to increase volunteers awareness of environmental issues (e.g. climate change, biodiversity loss), involve the general public in the scientific process and provide access to large amounts of data that would otherwise not be obtainable (Bonney et al., 2009a; Silvertown, 2009; Donnelly et al., 2014). Up to 85% of worldwide species-level data requested by governments are collected by volunteers (Kelling et al., 2019). CS projects exist in many fields and environments, and even if marine environment covers more than 70% of the planet's surface, it seems to be particularly underrepresented in the related scientific literature, given the challenges associated with this environment (e.g. inaccessibility of this environment and particular skills requested) (Sandahl and Tøttrup, 2020). Marine-related projects may particularly profit from citizen science, especially given the importance of the instrumental and capacity-building benefits that citizen science can provide for the marine environment. In fact, large numbers of volunteers can increase temporal and spatial monitoring coverage, which is particularly significant for marine projects, as it is estimated that more than 80% of the oceans are unmapped and unobserved[12] (Sandahl and Tøttrup, 2020). However, this method has led to considerable debate among academics and institutions regarding the applicability of data collected by non-scientifically trained recorders in decision making processes (Bonney et al., 2009b; Goffredo et al., 2010; Donnelly et al., 2014; Branchini et al., 2015; Meschini et al., 2021). While carrying out a project about coastal marine debris, Van der Velde et al. (2017) found that volunteer citizen scientists are able to collect data of a comparable quality to that of researchers when under supervision and training. These results are also supported by previous studies that involved students in citizen science projects (Delaney et al., 2008; Roy et al., 2012; Van der Velde et al., 2017). Given the nature of the citizen science method, some challenges need to be considered in the design of the study, such as volunteer lack of field experience and the type of training and direction required for the project outcomes. As has been pointed out by several authors, despite their potential for error

[12] https://oceanservice.noaa.gov/facts/exploration.html

and bias, the data collected can be of great use in examining broader patterns and long-term trends (Foster-Smith and Evans, 2003; Dickinson et al., 2010; Van der Velde et al., 2017). The underwater marine environment is even more challenging given the necessity of additional skills such as scuba diving or swimming. Some projects, such as Reef Check and the Fish Survey Project, employ the traditional CS method, which requires volunteers to undergo a long training in order to participate in data collection. In alternative, the use of a recreational CS method allows volunteers to participate in projects with minimum training, all without altering their original leisure activity. The latter approach has been developed and used by the Marine Science Group of the University of Bologna since 1999 and showed that this could ensure sufficient data quality while collecting a larger amount of data in a short period of time (Goffredo et al., 2010). In this study, we sought to update the reliability analysis of the study performed by Goffredo et al. (2010) in the Mediterranean Sea using the recreational citizen science protocol. In the previous study, we presented the reliability analysis results of the project SPA - Mediterranean Underwaters Project, that involved 3825 volunteers between 2002 and 2005 in Mediterranean biodiversity data collection. From 2017, a new CS project called DUE - Divers United for the Environment, has been developed according to the SPA model to continue the marine biodiversity monitoring of the Mediterranean Sea. Here we present the preliminary revised data to give a more in-depth analysis of volunteer data quality. We present results of a total of eight years of monitoring activity through these two citizen science projects developed by the Marine Science Group, at the University of Bologna.

Methods

During the eight years of monitoring activity by SPA (2002-2005) and DUE (2017- 2020), a total of 6243 recreational scuba divers and snorkelers were involved in the projects along the Italian coasts, both in diving centers and coastal touristic facilities. The methodology used for the DUE project was the same as the previous work to have a standardized approach, subsequently described in brief (for an in-depth description please refer to Goffredo et al. (2010)). Both projects' goal was to monitor the Mediterranean Sea biodiversity, using specifically-developed illustrated questionnaires. The only difference between the questionnaires used in the two projects was that in the DUE we added a "back cover" page with information about the plastics issue and the impacts caused in marine ecosystems, more specifically in the Mediterranean Sea. The section with photographs to identify the surveyed taxa and the one with a form to record data remained the same. Four vegetal taxa and 57 animal taxa were surveyed during these projects. The main characteristics of surveyed taxa were: i) previously well known by volunteer recreational divers or easily recognizable; ii) benthic species (highly mobile

pelagic species were not censed); iii) historically found throughout the entire Mediterranean Sea; iv) representative of each of the main trophic levels. These characteristics allowed non-professional volunteers to collect data through realistic and achievable tasks. The data collection section was composed by three parts: i) personal information (i.e., name, address, email, diving certification and diving agency); ii) technical information about the dive (i.e., place, date, depth, dive time, dive duration) and type of habitat explored (i.e., rocky bottom, sandy bottom or other habitat); iii) data about sighted taxa with an estimation of their abundance. Both projects used a recreational citizen science approach (Goffredo et al., 2004, 2010; Branchini et al., 2015) in which regular recreational diving features and volunteer behavior are not modified for project participation. Researchers of the DUE project performed an annual training session for scuba instructors of the diving centers involved in the project, based on the methodology used for the study and obtained results. This allowed scuba instructors to directly involve their clients in data collection. The DUE project received the approval of the Bioethics Committee of the University of Bologna (Prot. 118078). Data were treated confidentially, exclusively for institutional purposes (art. 4 of Italian legislation D.R. 271/2009 – single text on privacy and the use of IT systems). Data treatment and reporting took place in aggregate form.

Data validity assessment

To assess the validity of data collected by volunteers, records of 479 volunteers were compared with those collected by a marine biologist of the Marine Science Group of the University of Bologna ("control diver") during 77 validation trials. The characteristics of the validation trials were the same used in the previous study by Goffredo et al., (2010): i) the control diver dived with at least three volunteers; ii) the validation trial did not affect the diving center usual choice of dive site; iii) the dive was conducted between 9.00 am and 4.00 pm; iv) after the dive, the control diver filled in the questionnaire apart from volunteers, as to avoid interference with volunteers data recording. For each trial, the inventory of each taxa (with abundance ratings) sighted by the control diver was correlated with that collected by each volunteer to verify their similarity (Darwall and Dulvy, 1996; Foster-Smith and Evans, 2003; Goffredo et al., 2010; Aceves-Bueno et al., 2017; Meschini et al., 2021). To measure the quality of volunteer data, seven reliability parameters were used: Accuracy, Consistency, Percent Identified, Correct Identification, Correctness of Abundance Ratings, Similarity, Reliability (Table 1). Nonparametric statistical tests were used for the analysis: 1) Spearman rank correlation coefficient to assess the accuracy of the data collected by the volunteers compared to that of the

control diver; 2) Cronbach's alpha (α)-correlation to assess the reliability of the data collected between each volunteer and the control diver; and 3) Czekanowki's proportional similarity index (SI) to provide a measure of the similarity between the scores of each volunteer and the control diver (Goffredo et al., 2010; Branchini et al., 2015; Meschini et al., 2021). Tests results were reported as mean with 95% Confidence Interval (CI) (Sale and Douglas, 1981; Darwall and Dulvy, 1996). For the Similarity and Reliability parameters, the lower bound (calculated from the 95% CI of the means) was used (Goffredo et al., 2010). We also examined the effects of date, team size (the number of participants in each validation trial), diving certification level of each participant, depth and dive time on volunteer accuracy using the Spearman's rank correlation coefficient. All statistical analyses were calculated using SPSS 22.0 statistical software.

Results

The mean accuracy of each validation trial ranged from 38.4-94.3%, with 85.7% of trials with mean accuracy between 50-90% (Fig. 1; Supplementary Materials (SM) Table 1 (T1)). Accuracy was not correlated with any independent variables (Table 2). The mean consistency of each validation trial ranged from 39.0-92.6%, with 68.8% of trials with mean consistency between 50%-80% (Fig. 1; Table 1 SM). Consistency was not correlated with independent variables (Table 2). The mean percent identified of each validation trial ranged from 29.5-94.4%, with 83.1% of trials with mean percentage of identified between 50-90% (Fig. 1; SM T1). The only significant correlation with Percent Identified was date ($\rho s=-0.254$, $N=77$, $p<0.05$; Table 2). The mean correct identification of each taxon varied from 0-92.9%, with a positive correlation between the number of validation trials in which the taxon was present and the level of correct identification performed by volunteers ($\rho s=0.497$, $N=56$, $p<0.001$; Table 3). Six rare taxa were not present (not recorded by the control diver) in any of the 77 validation trials. The mean correctness of abundance ratings (CAR) of each validation trial ranged from 67.3-98.4%, with 93.5% of trials with mean CAR between 70-100% (Fig. 1; SM T1). CAR was not correlated with any independent variable (Table 2). The mean lower bound of the Czekanowki's proportional similarity index (SI) of each validation trial ranged from 28.9% to 84.3%, with 81.8% of trials with mean lower bound SI between 40-80% (Fig. 1; SM T1). Thirty-six trials (46.8%) performed with levels of precision below the sufficiency threshold (SI, 95% CI lower bound ≤50%; Fig. 1); 38 trials (49.4%) scored a sufficient level of precision (SI, 95% CI lower bound >50% ≤75%; Fig. 1), and 3 trials (3.9%) scored high levels of precision (SI, 95% CI lower bound >75% ≤100%; Fig. 1). SI was correlated with team size ($\rho s=0.266$, $N=77$, $p<0.05$; Table 2), indicating that volunteers scores increased when a higher number of divers were present during the dive. The mean lower bound

reliability (α) of each validation trial ranged from 35.3% to 94.5%, with 80.5% of trials with mean reliability between 50-80% (Fig. 1; SM T1). Three trials (3.9%) performed with an insufficient level of reliability (α, 95% CI lower bound ≤50%; Fig. 1); 9 trials (11.7%) scored acceptable relationship with the control diver census (α, 95% CI lower bound >50% ≤60%; Fig. 1); 27 trials (35.1%) scored an effective reliability level census (α, 95% CI lower bound >60% ≤70%; Fig. 1); 38 trials (49.3%) performed from definitive to very high levels of reliability census (α, 95% CI lower bound >70% ≤100%; Fig. 1). Reliability was not correlated with independent variables (Table 2).

Discussion

Despite the large number of species studied and the recreational dive profile (i.e., divers followed the normal recreational dive path for a given dive site rather than the pre-established transects), the accuracy achieved during the validation trials was promising. All the parameters achieved an average score between 50 and 80%, indicating that the accuracy was comparable to that obtained by volunteer divers in other projects (Mumby et al., 1995; Darwall and Dulvy, 1996) or in community-based land monitoring on accurate transects (Foster-Smith and Evans, 2003). The parameters that had the lowest mean score were similarity index and consistency. This result is similar to previous studies that used the recreational approach and is likely related to the different personal interests of volunteers that led them to focus on different species (Branchini et al., 2015; Meschini et al., 2021). In fact, divers interested in macro-photography may have focused their attention on small benthic organisms, while others interested in large pelagic fish (e.g., sharks) directed their attention away from the reef. Greater similarity and consistency of results was found when an intensive training program in marine life identification and study techniques was conducted (Mumby et al., 1995; Forrester et al., 2015; Meschini et al., 2021). While intensive training could increase the consistency of data collected, it would drastically reduce the number of volunteers involved. This could limit the outreach of citizen science projects for volunteers, as the number of volunteers involved would be smaller. Czekanowski's proportional similarity index (SI) showed that volunteers' abundance scores were below the sufficiency threshold in 46.8% of validation trials, suggesting that volunteers may encounter difficulties in estimating abundance, as already noted in other studies (Gillett et al., 2012; Done et al., 2017). The large variability in the mean scores for the Correct Identification parameter could be due to volunteers finding it difficult to identify and report less common or less evident taxa, or even to fill the "other" category present in the questionnaire (e.g. other hexacorals, other gastropods, etc.), while they performed better in recording the most common, familiar, and simple species, as already found in previous studies (Goffredo et al., 2010; Cox et al., 2012; Bernard et al., 2013; Branchini et al., 2015; Forrester et al., 2015; Kosmala et al., 2016; Meschini et al., 2021). As

pointed out by several authors (Lewandowski and Specht, 2015; Kosmala et al., 2016; Specht and Lewandowski, 2018), a limitation to the recreational citizen science approach is that using professional or expert data (in the case of our study, the "control diver"), as reference for assessing volunteer data would also require an assessment of the reliability of the data collected by the professionals or experts (Specht and Lewandowski, 2018). In this study, the control divers were marine biologists from the Marine Science Group (MSG), who were trained in the specifics of the project and present at the studied sites for a few weeks at a time, which should ensure the quality of the data collected. In Citizen Science projects, it is essential to develop appropriate tasks for volunteers to ensure high quality data collection (Schmeller et al., 2009; Magurran et al., 2010; Tulloch et al., 2013; Kosmala et al., 2016; Meschini et al., 2021). In the present study, as well as in previous MSG studies (Goffredo et al., 2010; Branchini et al., 2015; Meschini et al., 2021), data quality was ensured by (1) by asking volunteers to complete the questionnaire soon after the dive to avoid possible overlooking of species; (2) by training diving instructors in the data collection methodology annually (during public events) or on-site, when the control diver was present at diving centers.

Conclusions

This project provided additional evidence that "recreational" (Goffredo et al., 2004, 2010; Branchini et al., 2015; Meschini et al., 2021), "easy and fun" (Dickinson et al., 2012) citizen science can be an efficient and effective way to recruit many volunteers and provide reliable data if well designed. The citizen science approach used in this study can be exported to different countries and used by local governments and marine managers as a valuable tool to complement and expand the range of traditional monitoring methods (Dickinson et al., 2010).

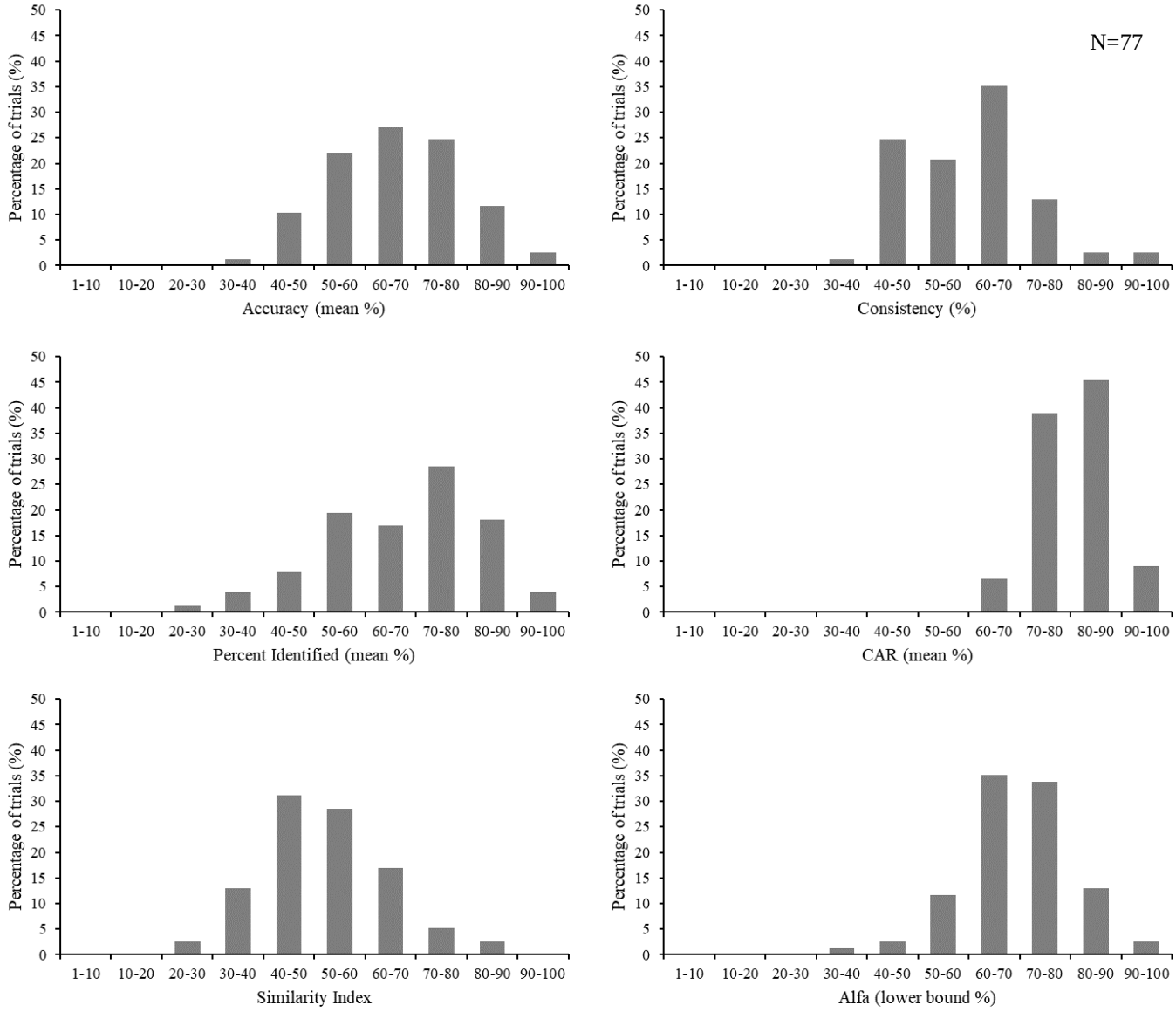

Figure 1. Quality of data collected by volunteers in the 77 validation trials performed during the eight years monitoring activity of SPA (2002-2005) and DUE project (2017-2020). Distribution of data is divided in classes depending on the mean score percentage that each validation trial achieved for the studied parameters. For the parameters Similarity Index and Reliability, the reference score is the lower bound calculated from 95% CI of the mean values.

Table 1. Reliability parameters used to analyze data collected by volunteers (from Meschini et al. 2021).

Parameter	Definition and derivation of parameter
Accuracy	Similarity of volunteer-generated data to reference values from a control diver measured as Spearman rank correlation coefficient (rho) and expressed as a percentage in the text. This measure of accuracy is assumed to encompass all component sources of error.
Consistency	Similarity of data collected by separate volunteers during the same dive. This was measured as rank correlation coefficient and expressed as percentage in the text. This measure of consistency is assumed to encompass all component source of error.
Percent Identified	The percentage of the total number of taxa present that were recorded by the volunteer diver. The total number of taxa present was derived from the control diver data (i.e., we assumed the taxa recorded by the control diver to be all the taxa present).
Correct Identification	The percentage of volunteers that correctly identified individual taxa when the taxon was present.
Correctness of Abundance Ratings (CAR)	This analysis quantified the correctness in abundance ratings made by the volunteer. It has been expressed as the percentage of the 72 surveyed taxa whose abundance has been correctly rated by the volunteer (i.e., the value of the rating indicated by the volunteer was equal to the reference value recorded by the control diver).
Similarity Index	Measure of similarity between each volunteer and the control diver ratings, using Czekanowki's proportional similarity index.
Reliability	Measure of reliability between each volunteer and the control diver ratings, using Cronbach alpha (α) correlation.

Table 2. Correlations between reliability parameters and independent variables.

	Date	Team size	Diving certification level	Depth	Dive time
Accuracy	-0.020	0.024	-0.015	-0.069	-0.135
Consistency	-0.006	0.065	-0.076	-0.140	0.073
Percent Identified	-0.254*	0.121	-0.117	-0.035	-0.081
CAR	-0.067	0.029	0.088	-0.147	-0.140
Similarity Index	-0.210	0.266*	0.200	-0.035	-0.118
Reliability	-0.009	0.143	-0.010	-0.107	-0.069

Reported number are Spearman Rho (rs) values. significance of correlation is indicated as * = $p < 0.05$.

Table 3. Correct identification of organisms by volunteers. Correct identifications were generated from a maximum sample size of 77 validation trials performed at the stations listed in SM T1. In the table are reported the common names of studied organisms with their reference code (e.g., 17/M damselfish) that appeared into the filling form in the questionnaire. N is the actual sample size for each taxon (i.e., presence frequency, the number of validation trials in which the taxon was present). Refer to Table 1 for definition of "correct identification".

Common name	Correct Identification			
	Mean	95% CI		N
1/C mediterranean tapeweed	92.9	88.8	97.0	49
3/A precious red coral	91.7	81.8	100	9
17/M damselfih	88.9	84.6	93.2	69
1/A mermaid's wine glass	85.1	77.0	93.3	35
4/A snakelocks anemone	84.2	73.9	94.4	21
17/L salema	80.7	71.9	89.6	40
17/C moray eel	80.6	71.3	90.0	27
4/B yellow cluster anemone	80.3	72.6	87.9	32
8/B cuttle fish	78.6	36.6	100	2
other fishes	76.1	69.3	82.8	60
3/B violescent sea-whip	75.3	52.4	98.2	8
6/A giant tun	75.0	-	-	1
5/A Mediterranean fanworm	74.2	64.8	83.5	39
9/B common spiny lobster	73.5	45.8	100	5
17/N rainbow wrasse	71.7	65.3	78.0	61
9/C spider crab	71.4	57.0	85.9	5
6/C dotted sea slug	71.0	48.7	93.3	11
2/B stony sponge	70.3	61.6	78.9	35
1/B sea rose	69.3	60.2	78.3	44
8/A common octopus	67.4	46.0	88.7	6
other sponges	67.0	59.4	74.6	59
10/B sea lace	66.7	53.4	80.0	18
other crinoids	66.7	-	-	1
7/A fan shell	66.6	54.0	79.3	21
litter	65.8	56.2	75.4	31
other echinois	65.8	58.1	73.5	49
other sea stars	65.6	57.7	73.5	46
10/A false coral	65.4	55.9	74.9	43
17/H dusky grouper	64.7	51.4	77.9	28
other octocorals	63.7	52.2	75.3	29
other vegetals	62.7	55.2	70.2	59
2/A chicken liver sponge	61.1	46.1	76.1	9
16/A red sea-squirt	60.6	51.4	69.7	43
other holoturians	56.2	46.3	66.1	45
11/A feather star	55.3	22.6	87.9	6
other ophiuroids	52.9	14.6	91.1	5
other decapods	52.6	31.1	74.2	13
other sedentary worms	50.7	40.2	61.2	46
14/A smooth brittlestar	50	0.0	100	2
4/C cylinder anemone	48.3	29.6	66.9	15
17/I sea raven	47.7	31.8	63.5	11
other gastropods	45.3	33.7	57.0	25
other hexacorals	43.5	33.6	53.4	42
other bivalves	43.1	20.7	65.5	12

Table 3. ***cont.***

6/B purple dye murex	41.7	10.4	72.9	4
other bryozoans	34.2	14.2	54.2	10
other ascidians	33.7	2.3	65.1	6
15/A red lance urchin	33.3	-	-	1
17/O anglerfish	25.0	0.0	74.0	2
12/A royal cucumber	14.3	-	-	1
3/C red dead men's fingers	0.0	-	-	1
7/B wing shell	0.0	-	-	1
9/A European lobster	0.0	-	-	1
13/A pentagon sea star	0.0	-	-	1
17/A common torpedo	0.0	-	-	1
17/F short-snouted seahorse	0.0	-	-	1
other cephalopods	-	-	-	0
9/D box crab	-	-	-	0
17/B thornback ray	-	-	-	0
17/D John Dory	-	-	-	0
17/E long-snouted branched seahorse	-	-	-	0
17/G flying gurnard	-	-	-	0

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Supplementary Materials

Table 1SM. Quality of volunteer-generated data; results of the 77 validation trials performed during the eight-year research projects (2002–2005+ 2017-2020). Parameter definitions are in Table 1 and in Materials and methods. Values in parentheses are 95% Confidence Interval (CI).

Station name	Date	Team size	Certification level	Depth (m)	Dive time (min)	Accuracy	Consistency	Percent Identified	CAR	SI	Reliability (α)
2002											
Gorgonie	25/04/02	9	3.0 (2.1 - 3.9)	20.7 (19.0 - 22.4)	42.1 (40.6 - 43.4)	62.5 (53.3 - 71.7)	43.4 (38.5 - 48.4)	67.5 (60.5 - 74.5)	81.7 (78.4 - 85.0)	59.7 (52.2 - 67.1)	75.7 (66.6- 84.8)
Punta della madonna	02/06/02	7	2.4 (1.6 - 3.3)	25.6 (19.6 - 31.6)	37.3 (32.1 - 42.4)	42.7 (34.6 - 50.8)	44.3 (36.3 - 52.2)	64.8 (47.8 - 81.9)	72.8 (69.3 - 76.4)	44.1 (37.2 - 51.0)	55.1 (47.2- 63.0)
Scogliera parco marino	15/06/02	7	2.3 (1.3 - 3.3)	4.3 (3.8 - 4.8)	63.4 (58.4 - 68.5)	57.6 (50.0 - 65.2)	52.3 (47.8 - 56.7)	63.8 (49.0 - 78.6)	80.6 (78.7 - 82.6)	55.1 (43.4 - 66.7)	68.8 (58.1- 79.5)
Tato point	22/06/02	10	1.7 (1.3 - 2.1)	28.0 (25.8 - 30.2)	43.3 (39.5 - 47.1)	54.2 (48.7 - 59.6)	61.9 (58.3 - 65.4)	58.5 (53.3 - 63.6)	79.5 (77.7 - 81.3)	57.8 (54.4 - 61.2)	77.3 (73.5- 81.1)
Calafuria	23/06/02	10	1.8 (1.0 - 2.6)	13.3 (10.8 - 15.7)	58.4 (54.5 - 62.4)	54.8 (50.6 - 58.9)	49.5 (44.2 - 54.8)	65.3 (58.6 - 72.0)	76.0 (73.6 - 78.3)	52.4 (46.6 - 58.3)	64.0 (55.7- 72.3)
Ancorone	24/08/02	6	1.5 (0.8 - 2.2)	17.1 (15.4 - 18.8)	46.1 (43.2 - 48.9)	70.4 (54.2 - 86.5)	65.4 (56.3 - 74.5)	79.5 (72.0 - 86.9)	84.1 (76.3 - 92.0)	67.4 (49.6 - 85.1)	78.2 (62.8- 93.7)
Gorgonie	25/08/02	9	1.4 (0.9 - 2.0)	16.6 (14.9 - 18.3)	40.3 (40.0 - 40.7)	69.8 (58.1 - 81.4)	58.2 (51.8 - 64.6)	83.3 (76.3 - 90.4)	85.3 (78.9 - 91.7)	65.7 (53.0 - 78.4)	82.7 (75.0- 90.4)
Tato point	25/08/02	10	1.4 (1.0 - 1.8)	17.6 (16.2 - 18.9)	42.9 (41.5 - 44.2)	66.1 (56.8 - 75.5)	60.5 (56.0 - 65.0)	78.0 (68.0 - 88.0)	82.4 (76.4 - 88.5)	63.0 (54.8 - 71.1)	81.6 (76.3- 87.0)
Scoglione	04/10/02	4	2.7 (1.6 - 3.8)	15.8 (14.3 - 17.2)	49.0 (42.5 - 55.5)	57.6 (40.7 - 74.4)	48.5 (43.7 - 53.3)	75.0 (58.7 - 91.3)	82.3 (70.0 - 94.5)	51.3 (28.9 - 73.8)	77.4 (62.6- 92.2)
Secca del turco	04/10/02	5	3.0 (2.4 - 3.6)	22.6 (19.8 - 25.5)	44.0 (40.1 - 47.9)	49.0 (39.8 - 58.1)	49.3 (42.4 - 56.2)	60.0 (46.1 - 73.9)	80.6 (78.9 - 82.4)	50.4 (40.3 - 60.6)	69.9 (60.0- 79.7)
Scoglione	05/10/02	7	1.6 (0.8 - 2.3)	14.1 (12.8 - 15.4)	55.7 (52.3 - 59.1)	38.4 (26.4 - 50.4)	39.0 (28.5 - 49.5)	57.1 (39.9 - 74.4)	73.3 (68.9 - 77.6)	39.0 (29.5 - 48.4)	52.2 (35.3- 69.1)
Secca del turco	05/10/02	7	2.7 (2.2 - 3.3)	24.5 (21.5 - 27.5)	37.1 (35.1 - 39.2)	53.8 (47.0 - 60.6)	50.6 (43.9 - 57.4)	54.0 (45.2 - 62.8)	85.7 (83.2 - 88.2)	56.3 (46.7 - 66.0)	77.4 (67.2- 87.5)
2003											
Cartellino	11/05/03	4	2.3 (1.3 - 3.2)	21.5 (20.5 - 22.5)	48.5 (45.6 - 51.4)	68.5 (53.0 - 84.0)	60.8 (50.0 - 71.5)	77.3 (58.0 - 96.5)	67.7 (59.1 - 76.4)	67.6 (54.7 - 80.6)	79.7 (66.7- 92.8)
Calafuria	18/05/03	6	2.0 (1.1 - 2.9)	10.3 (7.4 - 13.2)	45.0 (44.0 - 46.0)	80.7 (63.6 - 97.9)	56.1 (45.1 - 67.1)	85.2 (71.8 - 98.6)	89.0 (80.3 - 97.7)	66.8 (46.3 - 87.2)	79.5 (64.0- 95.0)
Cala fetente	23/05/03	6	2.3 (1.5 - 3.2)	7.7 (5.9 - 9.4)	33.0 (30.2 - 35.8)	68.0 (57.4 - 78.6)	49.5 (41.3 - 57.7)	70.8 (55.8 - 85.9)	94.1 (92.1 - 96.0)	63.1 (50.7 - 75.5)	84.5 (73.2- 95.8)
Capo spartivento	24/05/03	6	3.0 (2.0 - 4.0)	21.5 (16.2 - 26.8)	42.5 (41.1 - 43.9)	67.0 (55.2 - 78.8)	61.1 (56.5 - 65.7)	72.0 (60.4 - 83.6)	74.7 (68.2 - 81.2)	70.5 (60.9 - 80.1)	82.9 (76.1- 89.7)
Grotta azzurra	24/05/03	11	2.5 (1.6 - 3.3)	15.8 (12.9 - 18.6)	47.5 (43.3 - 51.6)	52.3 (44.9 - 59.7)	57.0 (53.4 - 60.6)	73.9 (67.9 - 79.8)	68.3 (63.9 - 72.8)	54.1 (48.9 - 59.3)	66.9 (60.6- 73.1)
Civitata	07/06/03	7	1.4 (0.8 - 2.0)	11.4 (10.8 - 11.9)	50.4 (49.6 - 51.3)	90.1 (87.2 - 93.1)	90.5 (88.5 - 92.5)	93.2 (91.3 - 95.1)	92.6 (88.9 - 96.4)	88.9 (84.3 - 93.4)	94.7 (92.3- 97.0)
Formiche	08/06/03	5	1.4 (0.6 - 2.2)	13.2 (11.9 - 14.5)	49.8 (46.0 - 53.6)	67.7 (65.2 - 70.2)	74.9 (69.7 - 80.2)	77.9 (72.8 - 82.9)	73.5 (70.3 - 76.8)	66.5 (63.6 - 69.5)	79.5 (77.3- 81.6)
Forbici	04/07/03	15	2.1 (1.4 - 2.7)	16.6 (14.5 - 18.6)	48.6 (44.0 - 53.2)	61.5 (55.8 - 67.1)	55.0 (52.7 - 57.4)	67.4 (60.1 - 74.6)	73.1 (70.4 - 75.8)	58.6 (53.9 - 63.3)	72.7 (67.2- 78.1)
Picchi di pablo	05/07/03	9	2.7 (1.9 - 3.4)	18.1 (14.6 - 21.6)	43.8 (35.3 - 52.3)	59.0 (52.3 - 65.6)	51.5 (46.1 - 56.8)	71.4 (61.3 - 81.6)	73.8 (70.0 - 77.7)	56.7 (50.4 - 62.9)	73.0 (66.7- 79.3)
Scoglio del remaiolo	26/07/03	6	1.0 (0.0 - 0.0)	16.7 (15.2 - 18.1)	41.7 (40.4 - 43.0)	80.1 (70.1 - 90.1)	76.4 (70.0 - 82.8)	86.1 (78.3 - 93.9)	84.1 (76.4 - 91.9)	76.8 (66.9 - 86.8)	86.7 (78.7- 94.7)
Secca di fonza	26/07/03	6	1.0 (0.0 - 0.0)	17.4 (15.9 - 18.9)	39.3 (38.9 - 39.6)	74.3 (54.6 - 94.1)	57.9 (47.9 - 68.0)	76.4 (55.8 - 97.0)	84.7 (73.8 - 95.6)	74.0 (53.8 - 94.2)	83.3 (68.4- 98.3)
Spiaggia di portoazzurro	07/11/03	11	1.5 (0.8 - 2.1)	6.9 (6.0 - 7.7)	30.0 (29.4 - 30.6)	72.7 (59.3 - 86.0)	54.2 (47.6 - 60.8)	64.8 (47.7 - 81.9)	90.8 (86.9 - 94.7)	65.2 (49.2 - 81.2)	80.6 (68.6- 92.6)
2004											
Punta della fica	28/05/04	6	2.3 (1.7 - 3.0)	16.0 (11.7 - 20.2)	41.7 (41.3 - 42.1)	68.1 (59.7 - 76.4)	62.8 (56.9 - 68.7)	64.6 (56.4 - 72.7)	81.7 (77.3 - 86.2)	65.5 (57.7 - 73.3)	83.2 (75.9- 90.4)
Formiche	30/05/04	10	1.5 (0.9 - 2.1)	12.9 (12.0 - 13.8)	47.1 (45.0 - 49.2)	69.4 (64.8 - 74.0)	65.8 (61.1 - 70.4)	75.6 (68.3 - 82.9)	73.9 (72.3 - 75.5)	66.5 (62.5 - 70.5)	81.5 (78.4- 84.7)
Calafuria	13/06/04	14	1.5 (0.9 - 2.0)	7.0 (6.5 - 7.5)	38.3 (37.9 - 38.7)	63.1 (55.8 - 70.5)	72.0 (69.0 - 74.9)	62.2 (55.6 - 68.9)	84.2 (81.6 - 86.8)	64.9 (57.9 - 71.8)	82.6 (77.5- 87.6)
Scoglio del remaiolo	23/07/04	12	1.8 (1.0 - 2.5)	11.8 (11.0 - 12.7)	44.4 (42.2 - 46.7)	68.6 (62.3 - 74.9)	63.3 (59.8 - 66.8)	80.8 (73.0 - 88.5)	77.0 (70.7 - 83.3)	64.7 (57.2 - 72.3)	81.5 (76.7- 86.4)
Corbelli	24/07/04	19	1.5 (1.0 - 2.0)	12.1 (11.1 - 13.0)	46.9 (45.4 - 48.4)	71.2 (63.3 - 79.1)	61.3 (58.9 - 63.7)	74.6 (68.3 - 80.8)	80.6 (75.4 - 85.9)	70.0 (62.6 - 77.4)	83.1 (77.9- 88.4)
Scoglio del remaiolo	24/07/04	18	1.5 (1.0 - 2.0)	11.8 (11.5 - 12.2)	51.1 (49.8 - 52.3)	76.0 (70.3 - 81.8)	65.9 (63.7 - 68.1)	85.8 (81.2 - 90.3)	80.8 (76.7 - 85.0)	73.7 (67.9 - 79.4)	85.7 (81.3- 90.1)
Capo focardo	25/07/04	10	1.6 (0.8 - 2.4)	7.0 (6.3 - 7.6)	42.7 (42.3 - 43.1)	84.7 (78.9 - 90.6)	81.2 (77.9 - 84.6)	85.2 (80.5 - 89.9)	87.3 (82.2 - 92.3)	81.5 (75.6 - 87.5)	90.9 (87.2- 94.6)
Cannelle	27/11/04	8	1.8 (0.8 - 2.7)	10.1 (6.8 - 13.3)	40.1 (37.1 - 43.2)	78.6 (62.7 - 94.4)	64.6 (56.0 - 73.2)	84.2 (74.3 - 94.0)	86.7 (78.2 - 95.2)	77.7 (61.8 - 93.5)	84.4 (69.7- 99.2)
Picchi di pablo	28/11/04	13	1.5 (0.9 - 2.1)	10.2 (9.2 - 11.1)	47.3 (41.8 - 52.7)	73.4 (61.6 - 85.2)	64.4 (60.2 - 68.7)	74.8 (60.8 - 88.9)	75.7 (68.0 - 83.3)	68.3 (56.1 - 80.5)	82.6 (74.7- 90.5)
2005											
Cala dei turchi	27/10/05	3	4.2 (2.5 - 5.8)	23.3 (20.1 - 26.6)	45.7 (43.3 - 48.0)	80.6 (63.6 - 97.6)	67.5 (55.4 - 79.7)	79.6 (57.6 - 100.0)	85.5 (77.5 - 93.4)	80.8 (68.4 - 93.1)	92.6 (87.1- 98.2)
Spiaggia di portoazzurro	29/10/05	9	1.7 (0.8 - 2.5)	8.2 (7.2 - 9.3)	45.0 (43.0 - 47.0)	75.3 (66.0 - 84.6)	71.4 (66.6 - 76.1)	76.3 (69.4 - 83.2)	87.1 (83.0 - 91.1)	73.2 (65.3 - 81.1)	85.2 (76.5- 93.9)
Punta secca di caprara	27/10/05	3	3.5 (2.0 - 5.0)	26.7 (20.1 - 33.2)	46.3 (42.7 - 50.0)	88.5 (77.9 - 99.1)	74.6 (66.2 - 82.9)	84.1 (67.7 - 100.0)	88.2 (82.6 - 93.7)	85.0 (73.6 - 96.4)	94.9 (89.6- 100.0)
Scoglio del remaiolo	30/10/05	10	1.6 (0.8 - 2.4)	12.7 (10.7 - 14.6)	45.6 (39.4 - 51.9)	74.4 (64.0 - 84.8)	71.7 (67.7 - 75.6)	77.9 (69.6 - 86.1)	94.6 (90.8 - 98.4)	71.5 (61.3 - 81.6)	83.8 (76.3- 91.3)
Cala caffè	31/10/05	5	3.5 (2.3 - 4.7)	20.6 (18.3 - 22.9)	45.4 (44.6 - 46.2)	82.0 (69.8 - 94.2)	68.3 (60.3 - 76.4)	85.7 (73.5 - 97.9)	86.5 (77.7 - 95.2)	83.3 (71.7 - 94.8)	91.1 (83.2- 99.0)

Station name	Date	Team size	Certification level	Depth (m)	Dive time (min)	Accuracy	Consistency	Percent Identified	CAR	SI	Reliability (α)
2017											
Capo di Stella	11/11/17	4	1.0 (0.0 - 0.0)	20.5 (14.3 - 26.7)	40.5 (39.9 - 41.1)	55.8 (46.6 - 65.0)	43.0 (36.0 - 49.9)	47.5 (32.3 - 62.7)	72.2 (68.2 - 76.1)	50.9 (36.4 - 65.5)	73.4 (67.3- 79.5)
Coralline	09/12/17	3	2.0 (0.0 - 0.0)	20.0 (0.0 - 0.0)	36.0 (34.9 - 37.1)	62.6 (44.3 - 80.8)	41.4 (13.3 - 69.5)	58.0 (37.5 - 78.5)	72.6 (66.3 - 78.9)	55.4 (41.2 - 69.7)	73.1 (61.2- 85.1)
Corbelli	12/11/17	4	1.0 (0.0 - 0.0)	10.3 (9.8 - 10.8)	48.0 (0.0 - 0.0)	58.9 (40.6 - 77.2)	56.5 (46.9 - 66.1)	50.0 (27.8 - 72.2)	75.0 (70.4 - 79.6)	51.5 (36.9 - 66.2)	74.7 (65.7- 83.7)
La crociata	09/04/17	5	2.6 (1.4 - 3.8)	26.4 (23.3 - 29.5)	43.6 (42.8 - 44.4)	78.3 (65.7 - 90.9)	69.1 (61.6 - 76.5)	74.0 (59.7 - 88.3)	84.8 (80.9 - 88.8)	76.4 (65.0 - 87.8)	90.1 (82.6- 97.5)
Formiche della Zanca 1	28/05/17	3	2.0 (0.0 - 0.0)	16.3 (12.7 - 20.0)	53.3 (52.0 - 54.6)	52.6 (44.2 - 61.1)	43.1 (28.6 - 57.5)	63.9 (58.4 - 69.3)	75.3 (71.5 - 79.1)	55.1 (51.0 - 59.3)	73.5 (67.5- 79.6)
Formiche della Zanca 2	28/05/17	3	1.0 (0.0 - 0.0)	15.0 (0.0 - 0.0)	42.0 (0.0 - 0.0)	62.4 (57.5 - 67.2)	53.3 (44.9 - 61.7)	59.3 (52.0 - 66.5)	73.7 (69.4 - 77.9)	57.6 (51.5 - 63.8)	75.5 (73.0- 77.9)
Le gorgonie	09/04/17	5	2.6 (1.4 - 3.8)	28.8 (27.8 - 29.8)	42.2 (40.8 - 43.6)	78.3 (65.7 - 90.9)	72.0 (64.8 - 79.1)	76.3 (64.5 - 88.1)	82.3 (77.1 - 87.5)	76.1 (65.6 - 86.7)	88.2 (81.2- 95.2)
Punta della Madonna	27/05/17	9	1.3 (1.0 - 1.7)	12.4 (11.7 - 13.0)	43.9 (41.5 - 46.2)	64.5 (55.7 - 73.3)	55.7 (50.1 - 61.2)	54.7 (45.2 - 64.1)	71.3 (67.3 - 75.4)	56.3 (48.4 - 64.3)	77.2 (71.0- 83.4)
Punta morcone	11/11/17	5	1.0 (0.0 - 0.0)	12.9 (10.0 - 15.9)	41.6 (35.0 - 48.2)	75.0 (63.5 - 86.4)	63.9 (56.3 - 71.5)	69.0 (56.8 - 81.2)	77.7 (73.3 - 82.1)	66.4 (53.4 - 79.5)	82.2 (72.4- 92.0)
Punta nasuto	28/05/17	3	1.3 (0.7 - 2.0)	9.7 (9.0 - 10.4)	47.0 (45.0 - 49.0)	64.9 (48.8 - 81.0)	62.5 (49.8 - 75.2)	51.3 (38.0 - 64.6)	85.5 (82.3 - 88.6)	58 (46.1 - 69.9)	82.8 (73.9- 91.6)
Scoglietto 1	27/05/17	3	1.0 (0.0 - 0.0)	30.0 (0.0 - 0.0)	41.7 (41.0 - 42.3)	78.6 (60.9 - 96.2)	78.6 (60.9 - 96.2)	71.9 (51.0 - 92.8)	83.3 (74.7 - 92.0)	68.9 (49.0 - 88.7)	85.5 (73.7- 97.3)
Scoglietto 2	27/05/17	3	2.0 (0.0 - 0.0)	13.7 (10.0 - 17.3)	47.3 (46.0 - 48.6)	70.2 (57.7 - 82.8)	69.6 (61.4 - 77.8)	68.5 (52.7 - 84.3)	78.0 (74.2 - 81.8)	66.3 (58.2 - 74.5)	81.6 (74.4- 88.9)
Scoglietto 3	27/05/17	4	1.0 (0.0 - 0.0)	20.0 (0.0 - 0.0)	45.3 (35.9 - 54.6)	67.0 (51.7 - 82.2)	64.2 (48.0 - 80.4)	51.4 (34.5 - 68.2)	79.4 (73.9 - 85.0)	57.7 (40.8 - 74.6)	82.0 (70.9- 93.1)
2018											
Grotta de Grongo	11/11/18	3	1.0 (0.0 - 0.0)	17.1 (15.4 - 18.8)	43.3 (41.6 - 45.1)	47.8 (39.1 - 56.4)	40.5 (4.3 - 76.7)	60.0 (20.8 - 99.2)	81.2 (77.4 - 85.0)	39.3 (35.2 - 43.4)	65.5 (58.1- 72.8)
La fenicia	30/11/18	3	1.0 (0.0 - 0.0)	3.7 (3.0 - 4.3)	54.0 (50.1 - 57.9)	57.8 (45.8 - 69.8)	57.4 (45.8 - 69.1)	81.0 (68.6 - 93)	75.3 (70.7 - 80)	56.2 (48.0 - 64)	73.4 (66.8- 80)
Le formiche	01/12/18	3	2.0 (0.0 - 4.0)	23.3 (16.8 - 29.9)	39.9 (29.3 - 50.5)	70.3 (43.7 - 96.9)	55.9 (40.1 - 71.6)	78.8 (57.4 - 100)	84.9 (80.4 - 89.5)	63.6 (42.5 - 84.8)	81.9 (54.4- 100)
Punta morcone	03/06/18	3	1.0 (0.0 - 0.0)	12.0 (11.9 - 12.0)	43.3 (41.6 - 45.1)	80.9 (55.7 - 100)	66.7 (40.5 - 92.9)	81.5 (55.3 - 100)	89.8 (77.4 - 100)	80.4 (49.3 - 100)	89.9 (71.8- 100)
Punta nasuto	02/12/18	3	1.0 (0.0 - 0.0)	33.7 (30.0 - 37.3)	28.0 (0.0 - 0.0)	72.5 (52.8 - 92.1)	65.2 (49.0 - 81.4)	78.1 (50.5 - 100)	76.9 (64.7 - 89.0)	71.9 (50.4 - 93.5)	81.6 (68.8- 94)
Spiaggia di Morcone	01/06/18	5	1.8 (0.2 - 3.4)	3.9 (3.1 - 4.7)	55.4 (51.1 - 59.7)	55.0 (44.6 - 65.4)	61.0 (52.1 - 69.9)	59.1 (38.6 - 80)	72.6 (68.1 - 77.1)	53.9 (42.3 - 65.4)	68.9 (59.3- 78.5)
2019											
Calafuria	31/05/19	4	3.0 (0.7 - 5.3)	6.9 (5.0 - 8.8)	81.5 (74.9 - 88.1)	53.2 (41.6 - 64.7)	54.4 (45.9 - 62.9)	45.3 (39.4 - 51.2)	75.4 (70.2 - 80.6)	47.0 (42.4 - 51.5)	69.1 (58.3- 79.8)
Capo stella1	15/06/19	3	1.3 (0.7 - 2.0)	15.0 (0.0 - 0.0)	47.2 (42.9 - 51.6)	78.5 (68.4 - 88.5)	65.8 (64.2 - 67.4)	87.2 (77.1 - 97.2)	88.2 (83.6 - 92.8)	77.7 (68.8 - 86.5)	88.6 (85.3- 91.9)
Capo stella 2	16/06/19	4	1.0 (0.0 - 0.0)	21.5 (4.8 - 38.2)	48.4 (46.2 - 50.6)	70.0 (52.3 - 87.6)	57.4 (51.1 - 63.6)	70.0 (52.1 - 88)	81.5 (70.3 - 92.6)	69.6 (54.3 - 84.8)	81.6 (68.8- 94.3)
Grottoni	19/10/19	5	1.2 (0.8 - 1.6)	10.0 (0.0 - 0.0)	59.0 (58.1 - 59.9)	49.8 (46.9 - 52.7)	62.1 (54.5 - 69.6)	36.7 (30.1 - 43.2)	77.1 (75.0 - 79.2)	42.2 (34.0 - 50.3)	72.8 (66.7- 79.0)
La manza	20/10/19	5	1.4 (0.9 - 1.9)	9.2 (4.9 - 13.6)	47.2 (46.5 - 47.9)	47.7 (44.0 - 51.3)	49.5 (42.9 - 56.0)	29.5 (24.1 - 35.0)	71.3 (70.7 - 71.9)	38.6 (34.9 - 42.3)	74.9 (72.5- 77.3)
Le corbelle	14/06/19	3	1.3 (0.7 - 2.0)	14.7 (14.0 - 15.3)	48.7 (47.4 - 50.0)	75.4 (50.9 - 99.8)	64.9 (49.2 - 80.7)	80.0 (57.4 - 100)	91.9 (84.6 - 99)	67.9 (38.7 - 97.2)	74.1 (44.7- 100)
Monterosso alga	30/10/19	7	3.0 (0.0 - 0.0)	0.0 (0.0 - 0.0)	40.0 (0.0 - 0.0)	88.4 (83.9 - 92.8)	80.8 (77.9 - 83.7)	88.8 (82.8 - 94.8)	87.8 (85.9 - 89.7)	76.3 (71.7 - 80.9)	89.0 (86.1- 92.0)
Paguro	11/05/19	6	4.0 (3.1 - 4.9)	13.5 (11.1 - 15.9)	42.7 (37.4 - 47.9)	51.6 (41.1 - 62.0)	46.5 (36.9 - 56.1)	51.5 (45.6 - 57.5)	83.6 (81.5 - 85.7)	47.0 (42.2 - 51.8)	67.0 (60.0- 74.1)
Punta della Fica	18/10/19	4	1.0 (0.0 - 0.0)	10.0 (0.0 - 0.0)	49.9 (48.2 - 51.6)	68.4 (62.3 - 74.6)	72.9 (64.1 - 81.7)	58.3 (47.2 - 69.5)	83.5 (82.7 - 84.3)	52.1 (43.5 - 60.7)	74.9 (69.8- 80.0)
Secca del Turco	19/10/19	4	1.0 (0.0 - 0.0)	21.0 (0.0 - 0.0)	53.3 (47.2 - 59.3)	60.9 (48.2 - 73.5)	63.4 (49.2 - 77.7)	40.9 (29.4 - 52.4)	85.9 (83.2 - 88.6)	47.8 (37.4 - 58.3)	80.1 (73.7- 86.4)
Torre del Porto	20/10/19	3	1.3 (0.7 - 2.0)	10.8 (9.2 - 12.4)	51.7 (49.9 - 53.4)	45.5 (40.3 - 50.8)	43.6 (41.9 - 45.2)	38.1 (33.4 - 42.8)	77.4 (72.6 - 82.2)	44.6 (40.8 - 48.3)	71.4 (69.2- 73.5)
Spiaggia della Fenicia	12/07/19	3	2.7 (1.4 - 4.0)	5.0 (0.0 - 0.0)	120 (0.0 - 0.0)	94.3 (88.1 - 100)	92.6 (89.1 - 96.1)	90.9 (80.6 - 100)	98.4 (96.6 - 100)	90.7 (81.1 - 100)	97.2 (94.5- 100)
2020											
Formiche della Zanca	05/07/20	3	2.2 (1.1 - 3.3)	17.3 (9.6 - 25.0)	51.3 (49.6 - 53.1)	45.5 (42.8 - 48.2)	49.3 (29.0 - 69.6)	46.2 (37.4 - 54.9)	75.8 (69.2 - 82.4)	42.7 (37.8 - 47.7)	60.8 (56.5- 65.1)
Formiche della Zanca	18/10/20	6	1.6 (0.8 - 2.4)	13.0 (11.6 14.4)	58.8 (57.8 - 59.7)	64.0 (55.6 - 72.3)	45.2 (37.3 - 53.1)	52.8 (39.5 - 66)	67.5 (65.4 - 69.5)	54.7 (42.9 - 66.6)	76.7 (68.9- 84.5)
La madonnina1	17/10/20	4	1.7 (0.6 - 2.8)	19.3 (17.8 20.7)	37.0 (0.0 - 0.0)	55.5 (44.5 - 66.4)	50.0 (37.1 - 62.8)	54.3 (48.8 - 59.8)	67.7 (60.6 - 74.9)	55.0 (46.5 - 63.5)	71.4 (60.9- 81.9)
La madonnina2	17/10/20	4	1.3 (0.7 - 2.0)	13.3 (11.2 15.3)	42.5 (40.2 - 44.8)	58.9 (47.4 - 70.3)	42.0 (32.3 - 51.7)	61.9 (47.1 - 76.7)	71.4 (65.1 - 77.6)	57.4 (45.0 - 69.9)	73.3 (66.1- 80.5)
Punta della Madonna	17/10/20	3	2.0 (0.0 - 4.0)	12.2 (4.4 19.9)	38.3 (33.6 - 43.0)	49.8 (45.2 - 54.3)	43.5 (14.7 - 72.2)	50.0 (33.7 - 66.3)	79.6 (78.5 - 80.6)	51.5 (50.0 - 53.0)	73.1 (69.5- 76.7)
Punta nasuto	04/07/20	3	1.8 (0.8 - 2.7)	14.3 (7.7 21.0)	42.0 (40.0 - 44.0)	75.1 (68.8 - 81.5)	63.9 (53.8 - 74.0)	94.4 (83.6 - 100)	87.1 (83.9 - 90.3)	57.8 (54.5 - 61.1)	78.7 (73.0- 84.4)
Punta nasuto	18/10/20	4	2.1 (0.9 - 3.4)	16.5 (13.5 19.5)	46.0 (44.0 - 48.0)	54.1 (41.3 - 66.9)	43.4 (36.6 - 50.1)	32.9 (21.4 - 44.4)	67.3 (63.4 - 71.3)	48.6 (31.1 - 66.0)	69.7 (58.5- 80.9)
Spiaggia della Fenicia	03/07/20	4	3.3 (1.6 - 4.9)	4.7 (2.3 7.0)	81.3 (55.2 - 100)	84.1 (68.5 - 99.8)	79.3 (70.1 - 88.4)	82.1 (68.7 - 95.5)	94.8 (90.8 - 98.7)	76.0 (59.5 - 92.5)	89.7 (80.6- 98.9)

CHAPTER 4.

ENVIRONMENTAL AWARENESS GAINED DURING A CITIZEN SCIENCE PROJECT IN TOURISTIC RESORTS IS MAINTAINED AFTER 3 YEARS SINCE PARTICIPATION

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Environmental Awareness Gained During a Citizen Science Project in Touristic Resorts Is Maintained After 3 Years Since Participation

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Tourism is one of the largest economic sectors in the world. It has a positive effect on the economy of many countries, but it can also lead to negative impacts on local ecosystems. Informal environmental education through Citizen Science (CS) projects can be effective in increasing citizen environmental knowledge and awareness in the short-term. A change of awareness could bring to a behavioral change in the long-term, making tourism more sustainable. However, the long-term effects of participating in CS projects are still unknown. This is the first follow-up study concerning the effects of participating in a CS project on cognitive and psychological aspects at the basis of pro-environmental behavior. An environmental education program was developed, between 2012 and 2013, in a resort in Marsa Alam, Egypt. The study directly evaluated, through paper questionnaires, the short-term (after 1 week or 10 days) retention of knowledge and awareness of volunteers that had participated in the activities proposed by the program. After three years, participants were re-contacted via email to fill in the same questionnaire as in the short-term study, plus a new section with psychological variables. 40.5% of the re-contacted participants completed the follow-up questionnaires with a final sample size of fifty-five people for this study. Notwithstanding the limited sample size, positive trends in volunteer awareness, personal satisfaction regarding the CS project, and motivation to engage in pro-environmental behavior in the long-term were observed.

Keywords: citizen science, ecotourism, sustainable tourism, informal education, environmental education

INTRODUCTION

Human ecological footprint is continuously increasing and human activities play a great role in environmental change, from climate change to pollution and biodiversity loss (Vitousek, 1997; Templado, 2014; Goudie, 2018). Among human activities, tourism is one of the largest economic sectors in the world with a remarkable long-term growth rate in the scale and value of international

tourism (UNWTO, 2017; Sharpley, 2018). The year 2016 had the highest growth in worldwide international arrivals, with a total of 1,235 million tourists, 3.9% more than in 2015, and a revenue of US$ 1,220 billion (UNWTO, 2017). Overall, tourism is a multidimensional industry that impacts economy, society and the environment (Cooper, 2008; Carrillo and Jorge, 2017). The constant increase of tourism has determined positive impacts on the economic growth and expansion of many nations, specifically in developing countries (Durbarry, 2004; Lee and Chang, 2008; Dritsakis, 2012). However, it has also led to negative direct and indirect impacts on local ecosystems, such as habitat fragmentation, land, water and air pollution, and biodiversity loss (Saenz-de-Miera and Rosselló, 2014; Tang, 2015). For example, tourism is one of the causes of severe damages and stress of coral reefs, the most biodiverse marine ecosystems on Earth (Roberts et al., 2002; Shaalan, 2005; Davenport and Davenport, 2006; Taizeng et al., 2019). The construction and operation of touristic structures are often the cause of local degradation of coral reefs as a function of sedimentation, changes in shorelines, oil spills and increased production of waste (Shaalan, 2005; Sadeghian, 2019). Tourist activities also lead to direct reef damage due to inappropriate and careless behavior during snorkeling and scuba diving excursions (Hawkins et al., 1999; Betti et al., 2019).

Egypt, and in particular the Red Sea region, has undergone massive tourist development since the early 1990s. Between 2012 and 2016, more than 45 million international tourists entered the country, making tourism one of Egypt's leading source of income, crucial to its economy. To help preserve the natural and cultural heritage, such a growing tourism sector should be managed and well-designed (UNWTO, 2017).

Sustainable tourism aims to respond to the negative effects of mass tourism on the environment by making optimal use of resources, maintaining essential ecological processes, and helping to conserve natural heritage and biodiversity (McKercher and Du Cros, 2003; Weaver, 2020). Sustainable tourism is not a particular kind of tourism but "an overriding approach to tourism development and management applicable to all the segments of the tourism industry" (Weaver, 2006). Sustainable tourism must guarantee responsible travel experiences to tourists and socio-cultural protection of the host country (Lansing and De Vries, 2007; Fennell and Cooper, 2020; Weaver, 2020). Within the concept of sustainable tourism, ecotourism is a trend in nature conservation and gives tourists the opportunity of learning about the environment while on vacation (Valentine, 1993; Fennell and Weaver, 2005; Wearing and Neil, 2009; Fennell, 2014). Ecotourism is a complex and synergistic collection of social, ecological and economic dimensions that reflect an ethics-based approach to tourism (Weaver, 2005), where the satisfaction of both conservation and tourism development is critical (Bjork, 2000; Blamey, 2000; Weaver, 2005; Donohoe and Needham, 2006; Fennell, 2014). A specific focus is on environmental education to emphasize the learning content of ecotourism (Kimmel, 1999; Bowers, 2003; Karol and Gale, 2005). There is growing support for an educational approach in ecotourism, which considers an immediate environmental improvement, but also addresses education for sustainability in the long-term (Tilbury, 1995; Steg and Vlek, 2009; Aikens et al., 2016). The Tbilisi Intergovernmental Conference on Environmental Education defined the main objectives of environmental education (Hungerford and Volk, 1990) as: (i) Awareness (to help groups and individuals acquire awareness and sensitivity to the environment and its allied problems); (ii) Knowledge (to help social groups and individuals gain a variety of experience in, and acquire a basic understanding of, the environment and its associated problems); (iii) Attitude (to help groups and individuals acquire a set of values and feelings of concern for the environment and motivation for actively participating in environmental improvement and protection); (iv) Skills (to help social groups and individuals acquire the skills for identifying and solving environmental problems); and (v) Participation (to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems). Environmental education promotes responsible citizenship behavior and increases awareness toward the environment and its related issues to minimize the negative impacts of human actions on the natural world (Hungerford and Volk, 1990; Kollmuss and Agyeman, 2002; Steg and Vlek, 2009; Wals et al., 2014). Knowledge, particularly in the case of environmental issues, is a precursor to environmentally friendly behavior (Geiger et al., 2019). A study conducted among German and Argentinian college students showed that even though cultural background may have some influence, environmental knowledge is key to promoting pro-environmental behavior (Geiger et al., 2018). However, to achieve this behavior as the norm, the mere knowledge of the environment is not enough. Outdoor activities and educational programs have a stronger long-term effect and lead to a positive attitude toward the environment (Drissner et al., 2014).

The Citizen Science (CS) methodology integrates public outreach and scientific data collection (Brossard et al., 2005; Dickinson et al., 2012; Bonney et al., 2014). By directly involving volunteers in collecting data, CS can provide informal learning experiences and can be used as a tool for conservation in various ecosystems (Porter, 2004; Cooper, 2008; Bonney et al., 2009; Johnson et al., 2014). For centuries citizens have recorded their observations of the natural world, including weather information, plant and animal distribution, astronomical phenomena and many others (Miller-Rushing et al., 2012; Bonney et al., 2014). Nowadays, millions of individuals, often not trained as professional scientists, participate in many authentic scientific research projects through data collection, categorization, transcription and analysis (Dickinson et al., 2012; Bonney et al., 2016; Hecker et al., 2018a,b). Today, most citizen scientists work with professional scientists on projects that have been specifically developed to let amateurs be part of the scientific process, while benefiting from an educational point of view (McKinley et al., 2017). Modern CS clearly differentiates from the historical form because now it is an activity potentially available for everyone, not just a privileged few (Silvertown, 2009). The huge explosion of CS projects is due to different factors such as: (1) the development of easily available tools for dissemination, information and engagement of the public (such as internet, smart phones, etc.); and (2) the increasing realization among scientists that the public represent a free source of work, skills

and even finance (Silvertown, 2009). One of the first examples of modern CS projects is the Christmas Bird Count, developed in 1900 by the National Audubon Society in the United States and still ongoing every year (Meehan et al., 2019). Citizens now take part in projects on climate change, entomology, ecological restoration, conservation biology, invasive species, water quality monitoring, population ecology, public health etc. (Cooper, 2016; Grimm, 2017). Almost any project that seeks to collect large spatial and temporal data over a wide geographical area can only succeed with the help of citizen scientists (McKinley et al., 2017). There are different ranges of citizen participation in CS projects, from assisting with data collection and observations, to asking professional researchers to develop a specific research and participate in data analysis (Dickinson et al., 2012; Cooper, 2016; Grimm, 2017). CS combines research with public education, also addressing wider societal impacts by engaging citizens in authentic research experiences and in the scientific process (Bonney et al., 2009; Dickinson et al., 2012; Kobori et al., 2016).

A previous short-term study conducted within the CS biodiversity monitoring project "Scuba Tourism for the Environment" (STE), shows that right after participating in the Environmental Education (EnvEd) program, volunteers increased knowledge of reef biology and ecology, awareness of human impact on the environment, and intention to act in a more environmental-friendly manner (Branchini et al., 2015a). Previously published data for the short-term study were compared to those of the follow-up study presented here. In this research we analyzed, for the first time, the long-term effects of participation in the same CS EnvEd program, in terms of volunteer Knowledge and Awareness retention and effect of psychological variables (Satisfaction, Identification with the CS project, and Motivation to engage in pro-environmental behavior) on the learning process. In particular, we: (1) examined whether short-term scores of Knowledge and Awareness could predict their follow-up values; and (2) assessed the role of widely used psychological variables (José Sanzo et al., 2003; Farmer et al., 2007; Drissner et al., 2014) in maintaining higher scores of Knowledge and Awareness. We hypothesized that volunteers who strongly identified with the CS project, were very satisfied of the EnvEd program and had higher Motivation to engage in pro-environmental behavior would have higher Knowledge and Awareness scores in the follow-up.

MATERIALS AND METHODS

This study was developed within the "Scuba Tourism for the Environment" (STE) project. STE was a CS project in which volunteers were invited to collect data on the status of the Red Sea coral reef biodiversity (Branchini et al., 2015b). The CS project was based in different marine coastal mass touristic resorts that are at the top of the hotel services of the Sharm El-Sheikh and Marsa Alam coasts (Egypt). The contact point for volunteers was a resident biologist involved in the project. Within the STE project, an environmental education (EnvEd, object of this manuscript) program was developed in 2012, in one resort at Marsa Alam (**Figure 1**). Upon arrival, tourists were informed about the possibility to participate in different activities with the biologist during their stay. Tourists interested in the EnvEd program took part in all the following activities, at least once for each:

- A weekly one-hour biology lesson focusing on the Red Sea, covering knowledge in basic reef biology and ecology of the coral reef, awareness of both natural and anthropogenic environmental pressures, and tips on how to minimize direct impact on the reef during marine recreational activities (scuba diving and snorkeling);
- Daily snorkeling excursions and scuba diving excursions with the biologist and the diving center of the resort;
- Daily contact with the biologist at the workstation at the beach for questions and discussions.

To verify the effects of participating in EnvEd program on volunteer reef knowledge and awareness, a questionnaire was created and provided to participants between 2012 and 2013 (see Branchini et al., 2015a). The intention was to continue the study for several years, but the Egyptian political situation led to a coup d'état in July 2013 and the closure of all tourist facilities in Marsa Alam. The short-term questionnaire contained three parts: (1) a section to collect personal and demographic volunteer data; (2) a section to evaluate the level of environmental education; and (3) a section with questions on knowledge of basic coral reef ecology and awareness about the human impact on the environment. Volunteers filled the aforementioned questionnaire twice: once at the beginning of their holiday, before participation in EnvEd program activities (T0), and again at the end of their stay (usually after 7–10 days), after having participated in the EnvEd program related activities (T1) (Branchini et al., 2015a). Biologists of the EnvEd program working in the resort provided the questionnaires directly to volunteers. To detect follow-up effects of the EnvEd program, another questionnaire (follow-up, T2) was created to evaluate the same questions observed in the short-term questionnaire (**Figure 2**), plus psychological questions about Satisfaction, Identification with the CS project, and Motivation to engage in pro-environmental behavior (**Table 1**). We relied on social identity theory (Tajfel and Turner, 1986) and expectancy-value attitude model (Fishbein and Ajzen, 1980) to propose two psychological factors that can influence the learning process and acquisition of pro-environmental behavior related to the CS project, such as Identification and Satisfaction. The follow-up questionnaire was prepared with Qualtrics (Qualtrics, LLC, www.qualtrics.com) and sent out via email, between 2015 and 2016, to a subset of 212 volunteers who had previously compiled both short-term questionnaires (T0 and T1) and who had voluntarily agreed to give their email addresses to be re-contacted for future studies. EnvEd program, within the STE project, and its consent acquisition procedure have received the approval of the Bioethics Committee of the University of Bologna (prot. 2.6). For this study, participants (or parents/guardians in case of minors) gave their consent by signing a declaration inserted in the questionnaires, and their personal data (name and surname) were collected in order

FIGURE 1 | Map of the Red Sea showing with a black star the location of the resort in Marsa Alam that hosted the EnvEd program.

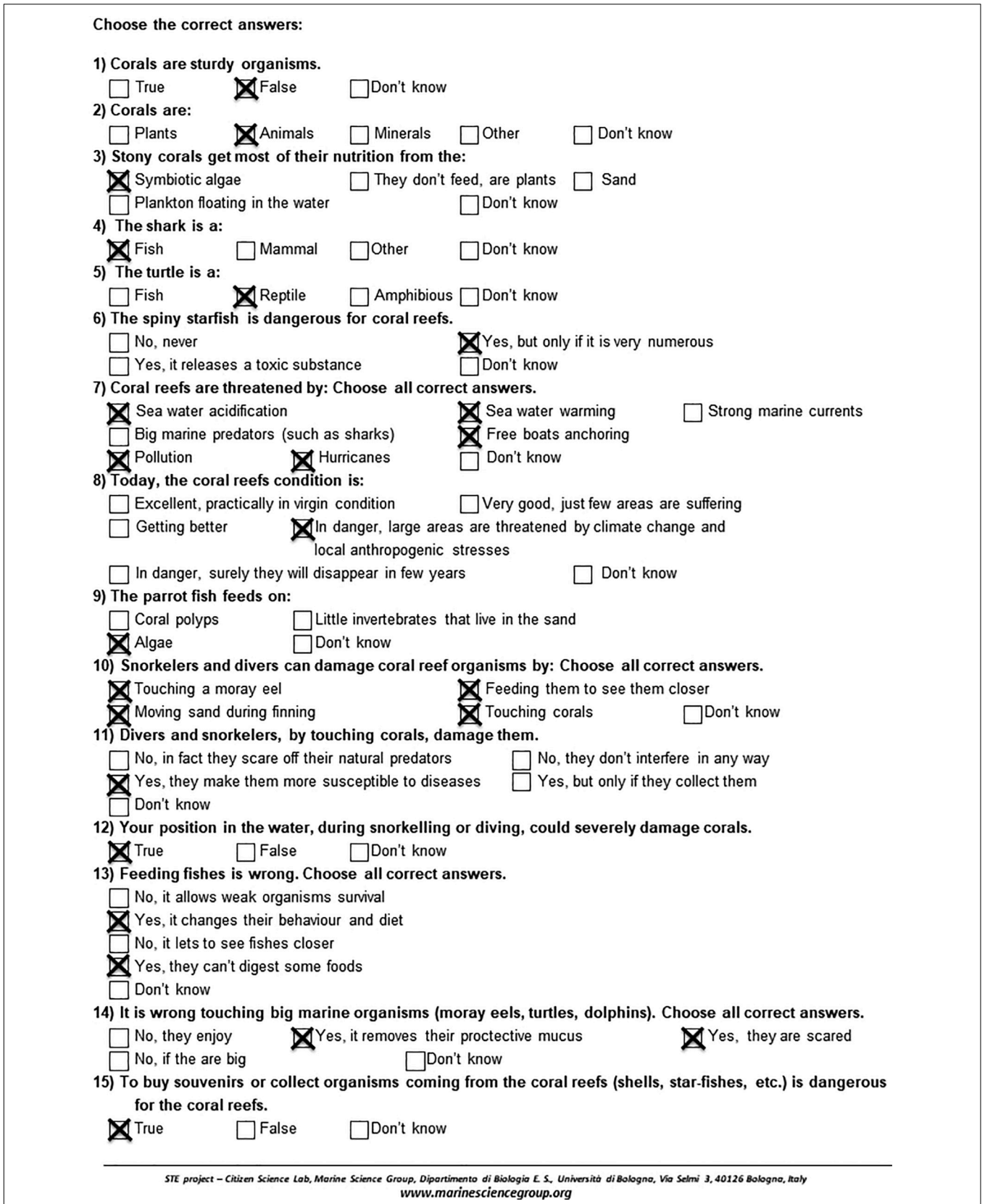
to guarantee the comparison between the initial environmental education assessment and those after participation in project activities (short-term and follow-up). We have treated the data confidentially, exclusively for institutional purposes (art. 4 of Italian legislation D.R. 271/2009 – single text on privacy and the use of IT systems). Data treatment and reporting took place in aggregate form.

Questionnaire Variables

The follow-up questionnaire consisted of three sections, the first two were the same of the short-term questionnaire.

The first section aimed to collect volunteer personal and demographic data to pair questionnaires compiled by the same participant over time.

The second section evaluated the level of environmental education. It contained 15 multiple-choice questions covering two kinds of issues. The first set of questions (nine questions, from number 1 to number 9) covered the Knowledge on basic coral reef biology and ecology. The second set of questions (six questions, from number 10 to number 15) dealt with the Awareness on the impact of human behavior on the environment. There was only one correct answer, except when explicitly stated.



Choose the correct answers:

1) Corals are sturdy organisms.
☐ True ☒ False ☐ Don't know

2) Corals are:
☐ Plants ☒ Animals ☐ Minerals ☐ Other ☐ Don't know

3) Stony corals get most of their nutrition from the:
☒ Symbiotic algae ☐ They don't feed, are plants ☐ Sand
☐ Plankton floating in the water ☐ Don't know

4) The shark is a:
☒ Fish ☐ Mammal ☐ Other ☐ Don't know

5) The turtle is a:
☐ Fish ☒ Reptile ☐ Amphibious ☐ Don't know

6) The spiny starfish is dangerous for coral reefs.
☐ No, never ☒ Yes, but only if it is very numerous
☐ Yes, it releases a toxic substance ☐ Don't know

7) Coral reefs are threatened by: Choose all correct answers.
☒ Sea water acidification ☒ Sea water warming ☐ Strong marine currents
☐ Big marine predators (such as sharks) ☒ Free boats anchoring
☒ Pollution ☒ Hurricanes ☐ Don't know

8) Today, the coral reefs condition is:
☐ Excellent, practically in virgin condition ☐ Very good, just few areas are suffering
☐ Getting better ☒ In danger, large areas are threatened by climate change and local anthropogenic stresses
☐ In danger, surely they will disappear in few years ☐ Don't know

9) The parrot fish feeds on:
☐ Coral polyps ☐ Little invertebrates that live in the sand
☒ Algae ☐ Don't know

10) Snorkelers and divers can damage coral reef organisms by: Choose all correct answers.
☒ Touching a moray eel ☒ Feeding them to see them closer
☒ Moving sand during finning ☒ Touching corals ☐ Don't know

11) Divers and snorkelers, by touching corals, damage them.
☐ No, in fact they scare off their natural predators ☐ No, they don't interfere in any way
☒ Yes, they make them more susceptible to diseases ☐ Yes, but only if they collect them
☐ Don't know

12) Your position in the water, during snorkelling or diving, could severely damage corals.
☒ True ☐ False ☐ Don't know

13) Feeding fishes is wrong. Choose all correct answers.
☐ No, it allows weak organisms survival
☒ Yes, it changes their behaviour and diet
☐ No, it lets to see fishes closer
☒ Yes, they can't digest some foods
☐ Don't know

14) It is wrong touching big marine organisms (moray eels, turtles, dolphins). Choose all correct answers.
☐ No, they enjoy ☒ Yes, it removes their proctective mucus ☒ Yes, they are scared
☐ No, if the are big ☐ Don't know

15) To buy souvenirs or collect organisms coming from the coral reefs (shells, star-fishes, etc.) is dangerous for the coral reefs.
☒ True ☐ False ☐ Don't know

STE project – Citizen Science Lab, Marine Science Group, Dipartimento di Biologia E. S., Università di Bologna, Via Selmi 3, 40126 Bologna, Italy
www.marinesciencegroup.org

FIGURE 2 | Environmental education evaluation questionnaire with highlighted answers. Figure modified from Branchini et al. (2015a).

TABLE 1 | List of psychological questions in the T2 questionnaire and those found to be reliable following the calculation of Cronbach's Alpha coefficient.

Psychological variable	Items present in the T2 questionnaire	Reliable questions	Cronbach's alpha
Satisfaction	(a) EnvEd program activities answered my expectations	X	0.945
	(b) I appreciated the presence of EnvEd program in the activities offered by the resort	X	
	(c) I am happy to have participated in EnvEd program activities	X	
	(d) I am satisfied to have participated in EnvEd program activities	X	
Identification	(a) I feel in line with the ideals promoted by EnvEd program	X	0.970
	(b) I identify myself with EnvEd program	X	
	(c) Members of EnvEd program and I are similar	X	
	(d) The members of EnvEd program share my values and objectives	X	
Motivation	(a) EnvEd program has affected my attitude toward the environment	X	0.945
	(b) In my daily life, I try to remember the importance of protecting the environment	X	
	(c) I believe that ignoring human impact on the environment is ok (REVERSE)		
	(d) I try to remind those around me about the importance of protecting the environment	X	

The second section was analyzed giving a score for each answer. To allow comparison with the previous short-term study, the score was calculated in the same rationale: negative if the answer was wrong, positive if it was correct and zero if it was "I don't know." The value of the score of each question was calculated so that the sum of all correct answers would be +1 and the sum of all the wrong answers −1 and then normalized in a scale from 1 to 10 (Branchini et al., 2015a).

The third section was unique to the follow-up questionnaire and evaluated three psychological variables (**Table 1**): level of Satisfaction in participating in EnvEd program, level of Identification with the CS project and Motivation to engage in pro-environmental behavior. Each variable value was assessed using sets of four sentences (items). Tourists were asked to score how much they agreed with each item ranging from one (not at all) to seven (very much) (Joshi et al., 2015). For the reverse sentence (item c for Motivation), we inverted score ranking. Scores were then normalized in a scale from 1 to 10.

Statistical Analysis

Kolmogorov–Smirnov test of normality and Levene's test for the equality of variances were performed to check for normality and homogeneity of the variable variances. Cronbach's Alpha was performed to check whether an average value for each psychological variable (Satisfaction, Identification and Motivation) could be used and be representative of all items. Standard bivariate Spearman's correlations between all variable (T0, T1, and T2 Knowledge and Awareness, T2 Satisfaction, T2 Identification, and T2 Motivation) combinations were performed to detect the possible association between each variable. One-way Kruskal–Wallis test was conducted to test the differences of Knowledge and Awareness among T0, T1, and T2. All statistical analyses were performed using SPSS version 22 software.

RESULTS

Between 2012 and 2013, 212 volunteers completed the short-term evaluation questionnaire twice: before (T0) and after (T1) participating in EnvEd program activities (Branchini et al., 2015a). Of those 212 volunteers, 148 left their email address and agreed to be re-contacted in the future: these volunteers were invited to complete the follow-up questionnaire (T2) online, 3 years after participation to the EnvEd program. Sixty volunteers [40.5%; 43 men (71.6%), 17 women (28.3%)] out of the 148, that had been re-contacted, completed the follow-up questionnaire online. Five volunteers were discarded because their follow-up questionnaire was erroneously filled. The most represented age group included 31–45-year-olds (n = 22, 40%), followed by 46 to 60-year-olds (n = 19, 34.5%), and 16–30-year-olds (n = 7, 12.7%). The groups under 15 years-olds (n = 3, 5.5%) and over 60 years-olds (n = 4, 7.3%) were the least represented. The level of education of the majority of volunteers was high school (n = 33, 60%). Nine volunteers (16.4%) had a bachelor's degree and 13 (23.6%) had a master's degree. Thirty-two (58.2%) volunteers were snorkelers, 16 (29.1%) were recreational divers and 7 (12.7%) were professional divers.

Reliability Analysis

Cronbach's Alpha showed that an average value among items of two psychological variables (Satisfaction and Identification) was representative of each item. For the Motivation psychological variable, item c did not achieve the threshold of = 0.5 score and we decided to delete it because it was not reliable (Tavakol and Dennick, 2011) and use an average value as done for the other psychological variables (**Table 1**).

Correlational Analysis Between Knowledge, Awareness and Psychological Variables

Table 2 and **Figure 3** shows bivariate Spearman's correlation coefficients for Knowledge, Awareness and psychological variables. Knowledge at T1 (right after participating to the EnvEd program) was positively correlated with Awareness on the impact of human behavior on the environment at T1 (rho = 0.318; $p < 0.05$). Both Knowledge and Awareness at T2 (after 3 years of participation in EnvEd program) correlated positively with Satisfaction toward participating in the project (Knowledge T2 rho = 0.567; $p < 0.001$; Awareness T2 rho = 0.378; $p < 0.001$)

TABLE 2 | Bivariate Spearman's correlation coefficients to evaluate significant correlations among variables (Knowledge, Awareness, Satisfaction, Identification, and Motivation).

1	2	3	4	5	6	7	8	9
1	−0.235	0.057	−0.031	0.194	0.154	0.095	0.096	0.177
2		0.148	0.092	−0.054	0.080	0.046	−0.111	−0.117
3			**0.318***	−0.015	−0.031	−0.235	0.257	0.052
4				0.088	0.139	0.136	0.089	0.112
5					0.202	**0.567****	0.017	**0.273***
6						**0.378****	−0.052	**0.266***
7							−0.163	0.255
8								0.218

*$p < 0.05$; **$p < 0.01$.
1, T0_Knowledge; 2, T0_Awareness; 3, T1_Knowledge; 4, T1_Awareness; 5, T2_Knowledge; 6, T2_Awareness; 7, T2_Satisfaction; 8, T2_Identification; 9, T2 Motivation. Significant values are displayed in bold.

and Motivation to engage in pro-environmental behaviors at T2 (Knowledge T2 rho = 0.273; $p < 0.05$; Awareness T2 rho = 0.266; $p < 0.05$).

One-Way Analysis of Variance

Kruskal–Wallis analysis of variance was conducted to test differences in volunteer scores of Knowledge and Awareness among T0 (before participation), T1 (right after the participation) and T2 (after 3 years). A significant difference was observed among times for Knowledge [$\chi^2(2) = 65.754$, $p < 0.001$], with lower volunteer Knowledge scores at T0 (Mean = 5.97, 95% CI 5.6–6.3) than at T1 (Mean = 8.31, 95% CI 8.0–8.6). Knowledge scores at T2 (Mean = 6.24, 95% CI 5.9–6.6) were significantly lower than those at T1. No significant differences were found between T0 and T2 Knowledge scores. Awareness scores showed a significant difference among times [$\chi^2(2) = 16.501$, $p < 0.001$], with lower Awareness scores at T0 (Mean = 8.42, 95% CI 8.2–8.7) than at T1 (Mean = 9.09, 95% CI 8.9–9.3) and T2 (Mean = 8.78, 95% CI 8.6–9.0). No significant differences were found between T1 and T2.

DISCUSSION

This study is the first descriptive analysis of the long-term effects (after 3 years) of participating in a CS project on volunteer Knowledge about reef biology and Awareness about human impact on the environment.

Three years after participating in the EnvEd program, volunteers forgot their acquired Knowledge notions (**Table 2**). This suggests that volunteers can remember acquired information in the short-term (Branchini et al., 2015a), but not after several years. This result is not so astonishing because some notions may be forgotten after such a long period. As shown by previous studies, information processed in a "shallow" level and for a short period of time tends to be less remembered than the "deeper" ones (Craik and Lockhart, 1972; Cherney, 2008). However, several factors impact retention of knowledge, such as teaching technique, age of the subject, delay between study and the test (Willingham, 2012). Also, AOL (assurance of learning) theories suggest possible future improvement of the study trough a more engaging and targeted approach (Bechtold et al., 2018).

The environmental Awareness scores were significantly higher in the follow-up T2 compared to the short-term T0 that volunteers filled out before taking part in the project. The homogeneity between T1 and T2 Awareness scores result is crucial from an educational point of view because it means that the CS approach can improve volunteer awareness about pro-environmental attitude that could become an entrenched behavior (Chawla and Cushing, 2007). CS has the potential to bring change to volunteer cognition, defined as thoughts, beliefs, skills, and the like (Schunk, 2012).

This study analyzed, for the first time in a CS project, the follow-up relation between psychological variables (Satisfaction, Identification and Motivation) and cognitive variables (acquired Knowledge and Awareness). Obtaining high levels of volunteers Satisfaction and Motivation with the CS programs guarantees that the acquired personal Awareness is better maintained in the long-term (LaBarbera and Mazursky, 1983). This is a first example that participation in a CS project could be a valid tool to promote environmental education with effects that are maintained in the following years, as already demonstrated in other fields and with other methods (Hungerford and Volk, 1990; Tilbury, 1995; DiEnno and Hilton, 2005; Farmer et al., 2007; Drissner et al., 2014). Regarding psychological variables, recreational CS is likely to lead to higher levels of volunteers Satisfaction and Motivation, as project activities are engaging, simple and appealing to volunteers of all ages, gender, education level and diving experience (Meschini et al. submitted to Biological Conservation). To guarantee high levels of volunteer Satisfaction, and therefore lead to higher levels of Awareness and intention to behave eco-sustainably, activities should be accessible to many volunteers, entertaining and straightforward. In this study, we focused on three of the main objectives of environmental education as described in the Tbilisi Declaration (Awareness, Knowledge, and Attitude). These are the basis for achieving the other objectives: skill acquisition in environmental problem solving and increased environmental activism among individuals. Understanding the mechanisms behind successful environmental education is timely and much needed under the current climate circumstances.

Study Limitations

This study was supposed to last longer to increase sample size, but the Egyptian political situation led to a coup d'état in July 2013 and the closure of all tourist facilities in Marsa Alam made impossible to carry on the EnvEd program. Given that the involvement efficiency in a similar CS project (Goffredo et al., 2010) was between 10.1 and 8.5%, we estimate to have contacted between 2,099 and 2,494 volunteers in the site of the study during the 2 years of EnvEd program activities. Although it is quite low, the response rate of this study (40.5%) is in line with Baruch and Holtom (2008) and also with a review by Sheehan (2001), who found that throughout 31 studies over a period of 14 years, the average response rate was 36.83%. The limited sample size and the

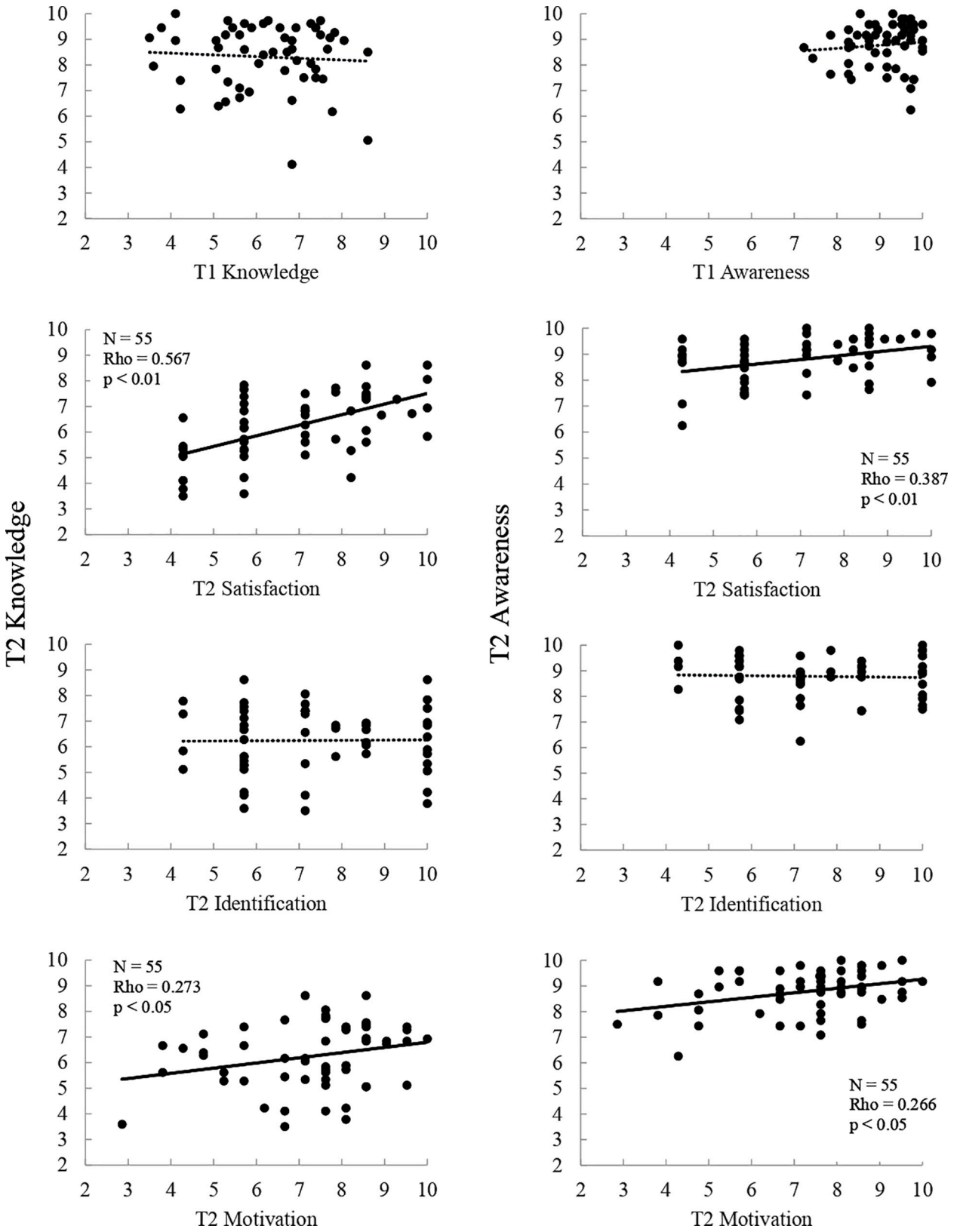


FIGURE 3 | Variation in long-term (T2) Knowledge and Awareness with short-term (T1) Knowledge and Awareness and psychological variables. Continuous black lines represent significant trends (see **Table 2**). Dotted black lines represent non-significant trends (see **Table 2**).

short period of time for this study prevents a broad generalization of the obtained results.

The recreational and voluntarily based nature of the project should also be considered, as participants might not be a reliable sample of the tourist population, because they were already interested and motivated to participate in such activities.

Another limitation of the present study is that psychological variables were only inserted in the follow-up questionnaire to further extend our understanding of the psychological processes that could be involved in the retaining of acquired knowledge and awareness, leading to a partial longitudinal study.

Moreover, given that the present study was pioneer regarding follow-up results of a citizen-science project, it was subject to design flaws. For example, due to the fact that the information required for re-contacting participants (e-mail address) was provided voluntarily, a smaller sample size than participants in T1 was expected (40.5% response rate in our study), since not all of the participants had an e-mail address or were willing to supply such information. Moreover, even those who provided their e-mail address might have not recognized the e-mail subject or sender address after 3 years, might have changed their address, or even make use of anti-spamming software that might prevent the questionnaire from arriving at the volunteer inbox (Saleh and Bista, 2017). To maximize the study response rate, the T2 questionnaire was sent by e-mail with two following reminder e-mails (that occurred after 1 and 2 months from the first e-mail) to the same subject but with the same object for the e-mail.

Nonetheless, the present approach is useful from a conservation point of view, and the aforementioned limitations could be addressed in future studies through different approaches, such as expanding the study over a longer period of time and preferably throughout multiple locations; increasing volunteer contacts, developing shorter questionnaires, sending personalized e-mail messages or even implementing deadlines to the completion of the questionnaires (Porter, 2004).

CONCLUSION

Tourism, with the range of activities it offers, can involve a lot of people and may be useful to address ecosystem conservation and protection issues. Our results suggest that by implementing a widespread use of CS and environmental education programs in resorts and in travel destinations that are popular because of their natural appeal, tourists could learn about the environment in an informal way, while developing awareness toward environmental issues and retaining it in the following years. Tourism could thus become more sustainable by creating lasting awareness changes, which could enhance a behavioral change. Furthermore, with a larger dataset, such outcomes can be of interest to tourism stakeholders which could increase their commitment and efforts towards environmental education programs. Sound environmental management practices can enhance competitiveness associated with travel destinations, and the destination commitment to the environment can influence the potential for sustained market competitiveness (Hassan, 2000). Future research should achieve a more robust sample size, focus on targeted approaches to analyze the follow-up retaining of Knowledge and also analyze whether such motivation to engage in pro-environmental behaviors leads to environmentally responsible actions and behavioral modifications, with tangible positive effects on the environment.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Bioethics Committee of the University of Bologna (prot. 2.6). The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SG, SB, and VA developed the environmental education questionnaire within the "STE-project." SG, SB, FrP, VA, VB, and CC collected data for the long term analysis. MM, EC, FiP, MMT, and CM analyzed the data. MM, FrP, EC, FiP, CM, VB, MMT, and GS wrote the manuscript. SG supervised the research. All authors have discussed the results and participated in the scientific discussion.

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Conflict of Interest: 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.

CHAPTER 5.

EDUCATIONAL BRIEFINGS IN TOURISTIC FACILITIES PROMOTE TOURIST SUSTAINABLE BEHAVIOR AND CUSTOMER LOYALTY

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Educational briefings in touristic facilities promote tourist sustainable behavior and customer loyalty

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Sustainable attitude

ABSTRACT

Ecotourism gives tourists the opportunity to improve knowledge and awareness of environmental issues while on vacation. Recreational environmental education has been proven an effective method to raise perception of human impact on ecosystems. "Glocal Education" is an education project aimed at developing environmental interest in tourists on vacation. The present study assessed the effectiveness of Glocal Education in improving tourist environmental interest. Using specific questionnaires, we evaluated project impact on tourists, tourist satisfaction regarding the project and customer loyalty towards the tour operator hosting the project. The study took place at three mass touristic facilities, where tourists were asked to fill a questionnaire before and after participating in educational activities (e.g., biology lessons, excursions). The average score of both questionnaires was then compared to evaluate possible improvement of tourist knowledge, attitude and awareness. Results showed that such activities had a significantly positive impact on tourist knowledge, attitude and awareness at all localities. High levels of satisfaction and loyalty towards the host tour operator were observed at all sites, which indicate that once a person is briefed about the correct approach to natural systems, they can become increasingly interested in taking action, developing an "advocate" role. This study shows how informal education activities can act as trigger for environmental awareness and behavior among tourists, providing them with the tools, knowledge, and motivation to critically discern what is and isn't environmentally friendly, not only in terms of products and services in their everyday life, but also when choosing their vacation spots.

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1. Introduction

Tourism is currently the world's third largest export category. Since the global economy crisis in 2009, the tourism market has been continuously growing (World Tourism Organization UNWTO, 2017). Furthermore, 2018 saw the highest growth in worldwide international trips since 2010, with a total of 1.3 billion tourists, 7% more than in 2017 (World Tourism Organization UNWTO, 2018), For over 60 years, the tourism industry has been an ever-growing worldwide activity, and while it contributes to society with revenue for the global workforce, it can also impact natural resources and ecosystem services (Holden, 2016), from land and water use to biodiversity loss (Tolvanen and Kangas, 2016) and greenhouse gas emissions (Gössling and Peeters, 2015). It is of interest for the tourism industry to find sustainable ways to use natural systems (European Union Business and Biodiversity Platform, 2010) given the fragile balance that natural destinations survive on. Tourism destinations are often based on benefits from the natural landscape; consequently, environment degradation would bring negative consequences to the tourism sector (Lenzen et al., 2018).

Ecotourism is meant to be a sustainable form of nature-based tourism, preserving biological diversity, maintaining sustainable use of resources, promoting environmental appreciation to travelers and bringing economic benefits for the industry. Ecotourism can also promote the well-being of local communities, promoting local participation and learning experiences (Kiper, 2013). Furthermore, when paired with first-hand experience and environmental education to contextualize the importance of given ecosystem or wildlife species (wildlife tourism), ecotourism encourages the tourist to take action in promoting ecosystem conservation, going as far as to educate other people on the importance of the subject (Ballantyne et al., 2011; Tisdell and Wilson, 2001). Such behaviors are likely to create empathy and enhanced understanding of the delicate balance that nature thrives upon, hence generating social and economic benefits (Buultjens et al., 2016; Tisdell and Wilson, 2001; Ziegler et al., 2018) and thus ensuring that businesses keep profiting and the environment is preserved in the long run (Branchini et al., 2015a; Meschini et al., 2021). However, learning experiences that happen in an informal and carefree setting tend to educate people more than in formal settings, such as in the school environment (Bueddefeld and Van Winkle, 2018), and can also translate to more adequate behavior, reinforcing conservation efforts made by the population surrounding natural areas (de la Torre and Yépez, 2003; Padua, 1994). It is argued that "free-choice" environmental learning experiences, where individuals are in control of their own learning, might promote environmentally sustainable attitudes and behavior, such as increase in empathy, motivation or change in perceptions, lifestyle changes, talking to others about environmental issues, joining volunteer programs, or donating to environmental organizations (Ballantyne and Packer, 2005, 2011).

To promote sustainable behavior through informal education activities, the Marine Science Group, a research group at the University of Bologna, created the Glocal Education project. Glocal Education is an environmental education project aimed to influence the degree of tourists' environmental knowledge, attitude and awareness through recreational activities during their vacation. Project main goals are: 1) creating a training program aimed at increasing environmental education in tourists; 2) studying the effects of the training program on tourist environmental knowledge, attitude and awareness towards the environment in the short and long term; 3) evaluating tourist appreciation for the educational program and whether this affects the level of customer loyalty towards the brand hosting the research project, (i.e., tourist willingness to travel to other destinations, and even pay extra, based on the preference for the tour operator promoting the environmental education project). In the present study, three mass touristic facilities were employed to perform the first stage evaluation (short-term) of the Glocal Education project, assessing: 1) the difference in environmental knowledge, attitude, awareness, and customer loyalty before and after participation in project activities; 2) the influence of demographic factors (sex, age, education and nature contact) not only on the initial level of environmental knowledge, attitude and awareness, but also on their short-term improvement; 3) the degree of tourist satisfaction regarding participation in the project.

2. Method

2.1. The Glocal Education project

Project activities were carried out at three mass touristic facilities managed by Francorosso, a tour operator specialized in package holidays under the Italian Alpitour S.p.A group, operating worldwide. The facilities were in the localities Nosy Be (Madagascar), Dhiggiri and Maayafushi (The Maldives). Upon their arrival, tourists were asked by the Glocal Education biologist to take part in the project. The Glocal Education biologists were BSc or MSc students in biological or natural sciences at the University of Bologna, selected by the Marine Science Group based on their interest and experience in environmental education and previously trained based on the activities to be performed at the touristic facilities and the content covered by the questionnaires.

In case tourists were interested in participating in the Glocal Education Project, the first questionnaire, here referred to as questionnaire T_0, was provided before the first scheduled environment-related activity with the biologist onsite, to assess the environmental background of each tourist. After completion of the T_0 questionnaire (Fig. 1a), tourists were invited to take part in any of the proposed activities, as follows:

- A one-hour introductory lesson focused on island geology, coral reef formation and coral biology (Fig. 1b and 1c);
- An "around-the-island" interactive walk, with explanations on local fauna and flora (Fig. 1d and 1e);
- A further one-hour biology lesson focused on the identification and general biology of local organisms (marine invertebrates, fish, marine reptiles and mammals in the Maldives, and both terrestrial and tropical plant species in Madagascar) (Fig. 1f and 1g);
- Participation in field excursions accompanied by the Glocal Education biologist and local guides. Specifically, snorkeling excursions were organized at the Maldives facilities, and excursions through the primary forest at the facility in Madagascar (Fig. 1h-1k).

All project activities were carried out at least once a week. Tourists could decide freely to attend all or some of the activities. Participation in at least one Glocal Education activity was mandatory to consider the tourist eligible for the Glocal Education project data collection. After conclusion of the last proposed activity, eligible tourists were asked to fill the second questionnaire, here referred to as questionnaire T_1 (Fig. 1l).

2.2. Questionnaire evaluation

The questionnaires were developed by the Department of Psychology of the University of Bologna. Questionnaire T_0 consisted of two parts. Part 1 contained tourist personal data (Fig. A1 in Appendix A), as reported in Table 1. Part 2 contained a series of items, to be answered by the participating tourist, which correspond to the 4 variables knowledge, attitude, awareness, and customer loyalty (Table 2, Fig. A2-A6 in Appendix A). Questionnaire T_1 was also divided in 2 parts. Part 1 asked how many project activities were attended by the tourist during their stay at the touristic facility and part 2 was the same as questionnaire T_0, with the addition of a 5th variable: tourist satisfaction, which accounts for appreciation of the Glocal Education project (Table 2, Fig. A7 in Appendix A). Tourists could indicate only one answer for each item.

The knowledge variable score was calculated by giving the value 0 if the answer was wrong, +2 if it was correct and +1 if it was "I don't know", with a total maximum score of the variable being 20. For the remaining variables (attitude, awareness, tourist satisfaction and

Fig. 1. Glocal Education project activities. Some examples of activities performed by the Glocal Education biologists onsite, at Nosy Be (Madagascar), Dhiggiri and Maayafushi (Maldives): evaluation questionnaires (a and l); biology lessons (b, c, f and g); field excursions (d, e, h, i, j and k). Pictures are freely available on the Glocal Education Project website: http://glocaleducation.eu/.

Table 1
Demographic variables. Personal data requested in part 1 of the questionnaire T_0 and grouping levels of the factors considered in the statistical analysis.

Factor	Questionnaire answers	Level	N[a]		
			Nosy Be	Dhiggiri	Maayafushi
Sex	Male	Male	183	407	251
	Female	Female	259	475	276
Age	Under 15	Under 30	97	183	103
	16–30				
	31–45	31–45	142	325	179
	46–60	Over 46	203	374	245
	Over 60				
Education	Elementary school	High school	272	530	305
	High school diploma				
	Undergraduate degree	College degree	170	352	222
	Master's degree				
	Ph.D.				
Nature contact	Up to three times a year	Non-naturalist	268	544	331
	At least once a month				
	Up to three times a month	Naturalist	174	338	196
	At least once a week				
	More than once a week				
	Total		442	882	527
				1851	

[a] Number of participating volunteers in each locality.

Table 2
Questionnaire variables. List of variables in Part 2 of the questionnaires used for project effectiveness assessment, followed by the number of items included for measuring its score and description of the topic each variable was designed to cover. Tourist satisfaction variable was present only in the T_1 questionnaire.

Variable	Number of items	Description
Knowledge	10	Basic coral reef biology and ecology of the maldives/endemic fauna and flora of Madagascar
Attitude	8	Behavioral intentions towards the environment and the project
Customer loyalty	5	Customer loyalty towards the brand hosting the research project
Awareness	9	Personal opinion about actions that may or may not impact the local environment
Tourist satisfaction	11	Tourist evaluation regarding project activities and identification with project goals

customer loyalty), each item could be answered according to a Likert scale (Joshi et al., 2015), ranging from 1 to 5: 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree. Negatively worded items (reverse items) were reverse scored to make the answer consistent with the other items within the same variable.

After all the questionnaires were recorded into a Microsoft Access database, answers were divided according to each variable (knowledge, attitude and awareness, here called sustainability variables) from which, for each tourist, we calculated a sum score for the knowledge variable, and a mean score for the attitude and awareness variables at T_0 and T_1. We then rescaled all sustainability variable scores to a scale of 10.

The set of items pertaining to the tourist satisfaction variable comprised different topics to be evaluated by the tourist, such as appreciation of the project, identification to project goals and willingness to hire the tour operator again in the future. Since the grouping of such items might have resulted in a biased variable analysis, each of the items was analyzed individually. As for the customer loyalty variable, each item regarded different levels of customer loyalty as it relates to the project: 1. Loyalty to the tour operator hosting the project; 2. Loyalty to the presence of a biologist on site; 3. Loyalty to nature-based activities at the touristic facility. Furthermore, each item inquired how much the tourist was willing to spend besides the standard holiday package prices in order to enjoy such accommodations/activities, and so all the items were also analyzed individually.

2.3. Statistical analysis

2.3.1. Reliability analysis

In order to measure the reliability of tourists' answers in terms of internal consistency within the attitude and awareness variables, (i.e., how tourists' answers within a variable are correlated), a Cronbach's alpha (α) correlation (Peterson, 1994) was conducted using IBM SPSS Statistics version 22. In fact, in case of evidence of relationship, a mean score value could be used as representative for the whole variable, instead of the scores for each separate item of that variable.

2.3.2. Sustainability variable analysis

The distribution of variable scores did not meet the assumptions of normality (Kolmogorov-Smirnov test) and equal variance (Levene's test) and differences among factors were thus analyzed using a permutational multivariate analysis of variance (PERMANOVA), which does not require homogeneity of variance or normal distributions (Anderson et al., 2008). We used the R software (R Development Core Team, 2019) to run a preliminary PERMANOVA, so as to assess if the sustainability variable scores (knowledge, attitude and awareness) presented significant differences among the three localities, in which case, they would be analyzed separately.

We performed a PERMANOVA to compare the scores of sustainability variables (knowledge, attitude and awareness) among factor levels. The design considered the factor time (to compare the variable scores at T_0 with those at T_1) and four demographical variables (sex, age, education and nature contact) nested in the factor time. This design assessed possible differences before- vs after-project activities and checked whether demographical factors influenced the sustainability variables scores. Tests were run using Euclidean distance matrixes among samples and 999 permutations in the software Primer v6 – Quest Research Limited (Anderson et al., 2008).

For this study, tourist data were not collected anonymously (name and surname were requested) to guarantee the comparison between the initial environmental education assessment and that after participation in project activities. We have treated the data confidentially, exclusively for institutional purposes (art. 4 of Italian legislation D.R. 271/2009 - single text on privacy and the use of IT systems) and according to art. 12, 13 and 14 of EU Regulation 2016/679 - General Data Protection Regulation (GDPR). Data treatment and reporting took place in aggregate form.

3. Results

From August 2016 to April 2019, 1851 tourists participated in the project and successfully completed both questionnaires (T_0 and T_1), of which 55% were women and 45% were men; the most frequent age group was over 46-year-olds, followed by 31 to 45-year-olds and under 30-year-olds; 60% of participants had completed middle or high school, followed by college graduates; 62% were non-naturalists, while 38% were naturalists (Table 1).

3.1. Reliability analysis

Cronbach's alpha values for both the attitude and awareness variables exceeded a threshold of 0.6 (Table B1 in Appendix B), which is considered acceptable as evidence of a relationship (Branchini et al., 2015b; Goffredo et al., 2010). Accordingly, all items' scores of both variables were substituted by mean score values for both variables and

for each tourist at T_0 and T_1.

3.2. Analysis among localities

PERMANOVA results showed a significant difference in attitude (Pseudo-F = 4.482, P(perm) = 0.001) and awareness (Pseudo-F = 27.227, $P = 0.001$) scores among localities, but no significant differences for knowledge scores (Pseudo-F = 1.228, $P = 0.303$). We then decided, in order to keep a consistency to the statistical analysis, to analyze all three sustainability variables in each locality separately.

3.3. Sustainability variable analysis

3.3.1. Knowledge

PERMANOVA results showed a significant increase in tourist knowledge scores from T_0 to T_1 ($P = 0.001$, Fig. 2, Table 3, Table C1 in Appendix C) at all localities. At Nosy Be, the factor education showed significant differences ($P = 0.03$, Table 3) at T_0 (Table C2 in Appendix C). At Dhiggiri, significant interactions were found between the factors sex and education ($P = 0.038$, Table 3), the factor nature contact showed significant differences ($P = 0.042$, Table 3) at T_0 (Table C3 in Appendix C) and the factor age showed significant differences ($P = 0.003$, Table 3) at T_0 and T_1 (Table C3 in Appendix C). At Maayafushi, significant interactions were found between the factors sex and education ($P = 0.025$, Table 3) and the factor nature contact showed significant differences ($P = 0.008$, Table 1) at T_0 and T_1 (Table C5 in Appendix C). For details on these results, see Appendix C.

3.3.2. Attitude

PERMANOVA results showed a significant increase in tourists' attitude scores from T_0 to T_1 ($P = 0.001$, Fig. 2, Table 4, Table D1 in Appendix D) at all localities. At Nosy Be, significant interactions were found between the factors sex and nature contact ($P = 0.019$, Table 4) at T_0 and T_1 (Table D2 in Appendix D), and the factor age showed significant differences ($P = 0.003$, Table 4) at T_0 and at T_1 (Table D2 in Appendix D). At Dhiggiri, significant interactions were found among the factors sex, age and nature contact ($P = 0.002$, Table 4) at T_0 (Table D4 in Appendix D). At Maayafushi, significant interactions were found among the factors age, education and nature contact ($P = 0.041$, Table 4) at T_0 and T_1 (Table D6 in Appendix D), and the factor sex showed significant differences ($P = 0.001$, Table 4) at T_0 and T_1 (Table D6 in Appendix D). For details on these results, see Appendix D.

3.3.3. Awareness

PERMANOVA results showed a significant increase in tourist awareness scores from T_0 to T_1 ($P = 0.001$, Fig. 2, Table 5, Table E1 in Appendix E) at all localities. At Nosy Be, significant interactions were found between the factors age and education ($P = 0.031$, Table 5) at T_0 and T_1 and the factor nature contact showed significant differences ($P = 0.011$, Table 5) at T_0 and T_1 (Table E2 in Appendix E). At Dhiggiri, the factors age and sex showed significant differences ($P = 0.001$, Table 5) at T_0 and T_1 (Table E4 in Appendix E). At Maayafushi, significant interactions were found between the factors sex and education ($P = 0.039$, Table 5) at T_0 and at T_1 (Table E5 in Appendix E), and the factor age showed significant differences ($P = 0.001$, Table 5) at T_0 and T_1 (Table E5 in Appendix E). For details on these results see Appendix E.

3.3.4. Tourist satisfaction

Across all locations, 92–96% of tourists answered positively ("Agree" or "Strongly agree") to the project meeting their expectations (Appendix F); 94–95% felt their ideas were respected by the Glocal Education project group; 87–88% felt satisfied with having participated in the project's initiative; 64–74% would check for the presence of an environmental education project on their next vacation; 36–46% identified personally with the project; 74–79% considered themselves supporters of the Glocal Education project; 36–38% would choose to go on vacation again with the tour operator that promoted the project in the next year; 61–64% would choose to go on vacation again with the tour operator that promoted the project in the next 3 years; 87–92% were happy to participate in the Glocal Education project; 43% felt that when someone speaks ill of the project, it is as if they did it to them; and 86–91% shared the ideas behind the project.

3.3.5. Customer loyalty

Across all locations, at T_0, 41–67% of the tourists declared to be willing to pay up to 10% more than the standard price to stay in a facility owned by the tour operator promoting the project with a biologist on site who organizes activities in contact with nature (item 1; Table 6, Appendix G); 42–62% would not pay up to 5% more than the standard price to stay in a facility owned by the tour operator promoting the project, but without a biologist (item 2); 35–51% would pay up to 5% more than the standard extra price to stay in a structure of an unknown tour operator, but with the presence of a biologist on site (item 3); 31–58% would pay up to 3% more than the standard price to stay in a structure of an unknown tour operator that proposes an organized activity in contact with nature but does not have a biologist (item 4) and 40–70% would not pay the standard price for any tour operator, without biologist and without activities in contact with nature (item 5). At T_1, the answers changed to 48–71% on item 1; 60–68% on item 2; 42–52% on item 3; 48–54% on item 4 and 67–71% on item 5. Furthermore, from T_0 to T_1, the number of tourists that failed to answer any one of the items in the questionnaire changed from 1.4–36.2% to 2.1–3.6% on item 1, 3.3–38% to 3–5.2% on item 2, 2.2–36.8% to 2.3–4.8% on item 3, 2.7–38.5% to 3.2–5.7% on item 4, 3.3–38.9% to 3.2–5.9% on item 5.

4. Discussion

How people behave regarding a sustainable approach towards the environment hinges on the values underlying people's perspectives on nature and the goals of its sustainable development. In everyday usage, 'values' are portrayed through interests, pleasures or desires. These subjective dimensions are among others mutually formed by knowledge, attitudes and awareness associated with individuals and social and cultural groups (O'Brien and Wolf, 2010). In this regard, results of this study demonstrate that participating in an environmental education project increased all three sustainability variables analyzed: knowledge of biology and ecology concepts (knowledge), willingness to engage in environmentally friendly attitude (attitude) and awareness of tourism impact on natural ecosystems (awareness). This shows that informal environmental education activities can play an important role in promoting sustainable behavioral intentions on tourists on vacation, which is an important step to create interest and sensitivity towards the environment. The analysis conducted using the demographic factors showed that, overall, females presented higher scores than males on all three sustainability variables (knowledge, attitude and awareness), with the exception of Dhiggiri at T_1 (after project activities), where male college graduates were found to have a higher knowledge score than females. This corroborates previous findings obtained on students in schools, where girls outperform boys, exhibiting higher knowledge, more positive attitude and more environmentally aware behavior in school (Olsson and Gericke, 2017). In general, the higher age classes presented higher scores on all three sustainability variables. This is in agreement with previous findings showing that elderly people tend to be more ecologically engaged compared to younger generations as a result of their firsthand experiences of environmental disasters (e.g., Chernobyl, the Exxon Valdez oil spills) (Otto and Kaiser, 2014). At all localities, college graduates showed higher scores than high school graduates on all three sustainability variables, except for Maayafushi, where adult high school graduate naturalists showed a higher attitude score than adult college graduate naturalists both before and after project activities. Several studies report the development of programs regarding

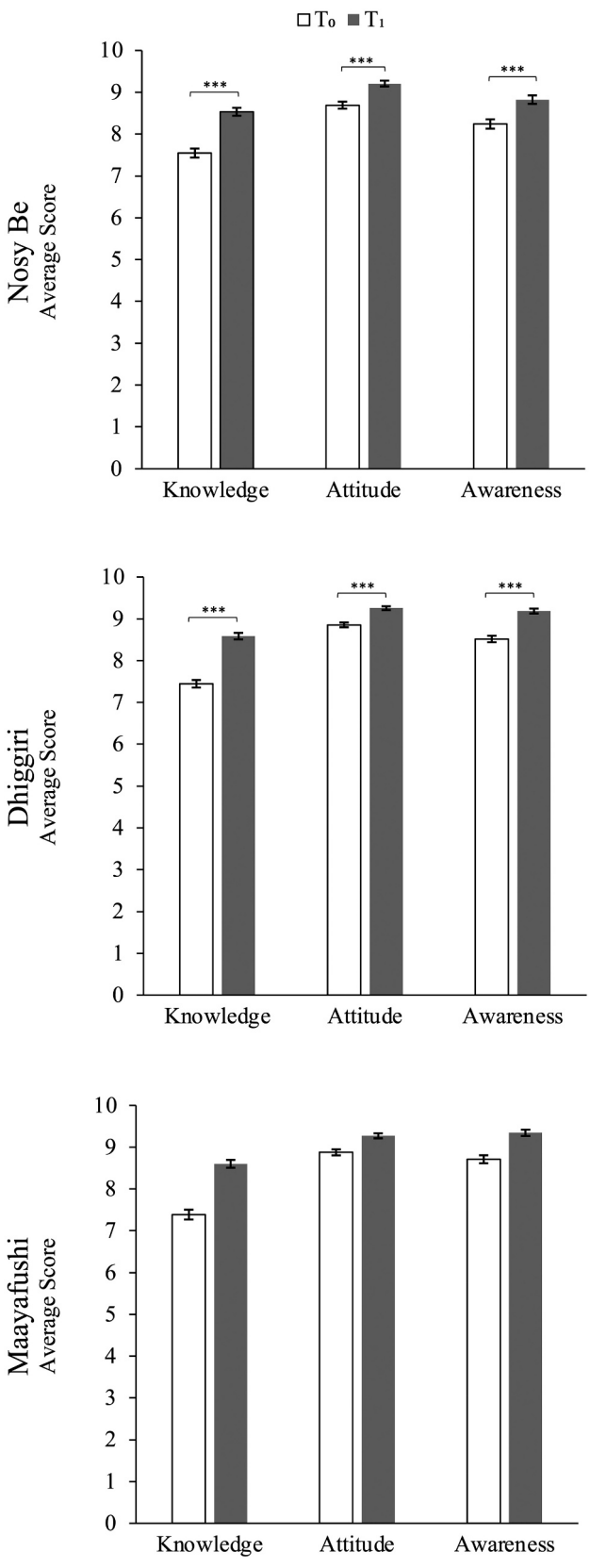

Fig. 2. Before and after scores. Permutational multivariate analysis of variance (PERMANOVA) results for comparisons of knowledge, attitude and awareness scores between T_0 and T_1 (before and after project activities). Error bars represent 95% CI. Significant effects are indicated with asterisks ($p \leq 0.001$).

sustainability issues and environmental learning for higher education institutions (de la Harpe and Thomas, 2009; Felgendreher and Löfgren, 2018; Shephard, 2010), which could help explain our findings. The aforementioned exception could be due to nature contact, rather than education level, which in turn relates to the overall result that naturalists show a higher score on the three sustainability variables (knowledge, attitude, awareness), in comparison to non-naturalists, at all three localities. Differences among factor significances among localities could be due to the fact that each touristic facility targets different demographics. Nosy Be (Madagascar) offers exotic scenarios with close contact with local flora and also targeted packages for teens, families and friends on vacation. Dhiggiri (Maldives) offers relax for adults, as children under 12 are not allowed, with close contact with the local marine ecosystem and targeted packages for couples on honeymoon. Maayafushi (Maldives) encompasses both scenarios, with the proximity of the sea and entertainment that targets from children to elders, with targeted packages for kids and couples on honeymoon. These differences could explain the fact that tourists who choose to visit any of the facilities might have different inclinations and interests towards nature, attempting to actively explore the natural landscape or just enjoying the calm and relaxation such a secluded facility can provide. Overall, tourists showed a high level of satisfaction with project activities and customer loyalty answers reveal willingness to pay extra in order to enjoy touristic facilities with the presence of a biologist and environmental education activities. Moreover, the decrease in the percentage of tourists who chose not to answer the customer loyalty questions in the questionnaire T_0 as opposed to T_1 indicate that even though they were not willing to dispose of extra income in order to participate in environment-related activities before the project, they were much more inclined to do so once they became a part of Glocal Education project. This positive response of the customer could lead to positive sustainability outcomes (Sheth et al., 2011) as the tourist who identifies with the Glocal Education project tends to look for environmentally-related activities when going on vacation, generating a trend for tour operators which could result in bigger profits for the tourism industry. Furthermore, the promotion of environmental education projects in touristic destinations could lead to an initial shift towards the sustainable use of resources, involving thousands of people and increasing environmental awareness, so as to popularize the importance of conservation actions.

4.1. Implications for conservation

Our results corroborate the finding that when informal education activities are proposed in a stress-free environment, participants are more likely to take interest and even retain more information about concrete measures that can be taken in order to alleviate some of the pressure our daily activities put on natural ecosystems (Ballantyne et al., 2011; Branchini et al., 2015a; Meschini et al., 2021; Ballantyne and Packer, 2011). When people discover the consequences of their actions upon the environment, they are able not only to change their own attitude, but also to become advocates in enlightening other people to do the same (Gössling, 2018; Tisdell and Wilson, 2001). People who are made aware of the local and global scale of an environmental problem are found to be more likely to take action in mitigating said problem, supporting conservation efforts (through financial contribution to environmental organizations), as well as acting individually in favor of the environment (like reducing their own carbon footprint) (Rabinovich et al., 2009).

Environmental education projects such as Glocal Education can be developed by the tourism sector in a smaller or larger scale, acting as triggers for advocate behavior in tourists, using informal education activities to create a web of sustainability and action towards the conservation of the environment.

Table 3
Knowledge scores. Permutational multivariate analysis of variance (PERMANOVA) results for comparisons of knowledge scores by Time, sex, age, education (edu) and nature contact (nat), and their interactions. Tests were run using Euclidean distances among samples and 999 permutations in the software Primer. Significant effects (P(perm) < 0.05) are indicated in bold.

Source	Nosy Be			Dhiggiri			Maayafushi		
	df	Pseudo-F	P(perm)	df	Pseudo-F	P(perm)	df	Pseudo-F	P(perm)
Time	1	86.979	**0.001**	1	264.53	**0.001**	1	157.1	**0.001**
Sex	2	0.946	0.411	2	2.203	0.111	2	0.742	0.472
Age	4	1.420	0.231	4	4.472	**0.003**	4	1.339	0.235
Edu	2	3.549	**0.030**	2	12.289	**0.001**	2	5.242	**0.010**
Nat	2	2.562	0.081	2	3.248	**0.042**	2	5.760	**0.008**
Sex x age	4	0.222	0.919	4	0.607	0.650	4	0.667	0.614
Sex x edu	2	0.468	0.664	2	3.296	**0.038**	2	3.420	**0.025**
Sex x nat	2	0.209	0.819	2	0.598	0.540	2	1.042	0.354
Age x edu	4	0.585	0.657	4	0.536	0.729	4	1.825	0.111
Age x nat	4	0.992	0.389	4	1.111	0.365	4	0.376	0.810
Edu x nat	2	0.0313	0.962	2	1.018	0.364	2	0.942	0.392
Sex x age x edu	4	0.643	0.648	4	0.302	0.856	4	1.682	0.141
Sex x age x nat	4	1.908	0.105	4	0.943	0.444	4	0.653	0.616
Sex x edu x nat	2	1.486	0.233	2	0.525	0.566	2	1.759	0.166
Age x edu x nat	4	1.367	0.255	4	0.797	0.527	4	0.345	0.838
Sex x age x edu x nat	4	0.347	0.827	4	0.316	0.874	4	0.525	0.707
Residuals	836			1714			1006		
Total	883			1761			1053		

Table 4
Attitude scores. Permutational multivariate analysis of variance (PERMANOVA) results for comparisons of attitude scores by Time, sex, age, education (edu) and nature contact (nat), and their interactions. Tests were run using Euclidean distances among samples and 999 permutations in the software Primer. Significant effects (P(perm) < 0.05) are indicated in bold.

Source	Nosy Be			Dhiggiri			Maayafushi		
	df	Pseudo-F	P(perm)	df	Pseudo-F	P(perm)	df	Pseudo-F	P(perm)
Time	1	41.868	**0.001**	1	96.206	**0.001**	1	52.307	**0.001**
Sex	2	2.582	0.060	2	17.444	**0.001**	2	13.546	**0.001**
Age	4	4.550	**0.003**	4	15.532	**0.001**	4	10.629	**0.001**
Edu	2	1.106	0.319	2	0.145	0.868	2	2.367	0.106
Nat	2	5.545	**0.004**	2	6.256	**0.004**	2	3.610	**0.032**
Sex x age	4	0.617	0.662	4	2.083	0.089	4	0.511	0.739
Sex x edu	2	1.904	0.153	2	0.783	0.473	2	0.572	0.576
Sex x nat	2	3.882	**0.019**	2	1.987	0.131	2	0.406	0.692
Age x edu	4	1.211	0.300	4	2.243	0.066	4	5.040	**0.001**
Age x nat	4	0.457	0.782	4	1.143	0.317	4	0.719	0.556
Edu x nat	2	1.223	0.299	2	0.400	0.700	2	0.012	0.99
Sex x age x edu	4	0.831	0.489	4	0.732	0.572	4	1.035	0.371
Sex x age x nat	4	0.800	0.541	4	4.251	**0.002**	4	0.799	0.519
Sex x edu x nat	2	0.262	0.770	2	0.240	0.797	2	0.231	0.776
Age x edu x nat	4	1.982	0.092	4	0.653	0.615	4	2.612	**0.041**
Sex x age x edu x nat	4	1.848	0.128	4	0.587	0.658	4	0.823	0.536
Residuals	836			1714			1006		
Total	883			1761			1053		

4.2. Study limitations

Potential limitations of this study lie in the fact that we assessed changes over the period of one week, which did not account for how such increments in all sustainability variables translate to permanent changes in the population, promoting environmentally friendly actions triggered by the same tourists who participated in the project. The next step of this study is to resurvey tourists after one year of participation in the project, to evaluate possible long-term outcomes.

5. Conclusion

Investigating variables such as knowledge, attitude, and awareness could have extensive implications for environmental conservation, described as the management of environmental resources (Budowski, 1976), as peoples' actions have the power to affect biodiversity and sustainability in a positive or negative manner (Newhouse, 1990). Even though demographical factors showed some influence in our results, we conclude that overall, informal environmental education experiences as those provided by the Glocal Education project may increase environmental sensitivity and ultimately promote correct environmental behavior.

Nowadays the word ecotourism is often misused for self-promotion. However, the Glocal Education activities could be a first step towards a trend in environment awareness, providing tourists with the tools and knowledge to critically discern what is and isn't environmentally friendly, not only in terms of products and services, but also when choosing their vacation spots. Correctly educating tourists to what "sustainability" really means could lead tourists to choose tour operators promoting environmentally friendly resorts, ultimately enhancing their economic gain (Fig. 3).

Glocal Education could be an appealing attraction to be added to the plethora of activities that tourists are offered by tour operators while on vacation, as tourists could become more satisfied with the vacation experience. This would provide a "win-win" situation for tourists, tour operators and also - albeit in a smaller proportion and in a longer time-frame - biodiversity conservation. The Glocal Education project could become a best practice for tour operators worldwide, generating not

Table 5
Awareness scores. Permutational multivariate analysis of variance (PERMANOVA) results for comparisons of awareness scores by Time, sex, age, education (edu) and nature contact (nat), and their interactions. Tests were run using Euclidean distances among samples and 999 permutations in the software Primer. Significant effects (P(perm) < 0.05) are indicated in bold.

Source	Nosy Be			Dhiggiri			Maayafushi		
	df	Pseudo-F	P(perm)	df	Pseudo-F	P(perm)	df	Pseudo-F	P(perm)
Time	1	31.618	**0.001**	1	169.520	**0.001**	1	66.893	**0.001**
Sex	2	0.463	0.611	2	24.401	**0.001**	2	16.967	**0.001**
Age	4	2.529	**0.038**	4	13.339	**0.001**	4	8.542	**0.001**
Edu	2	6.776	**0.005**	2	0.336	0.736	2	0.755	0.481
Nat	2	5.008	**0.011**	2	0.846	0.423	2	0.654	0.525
Sex x age	4	0.166	0.955	4	1.474	0.188	4	1.124	0.315
Sex x edu	2	0.085	0.921	2	0.016	0.984	2	3.273	**0.039**
Sex x nat	2	0.678	0.499	2	0.344	0.712	2	0.692	0.492
Age x edu	4	2.632	**0.031**	4	0.174	0.958	4	0.080	0.991
Age x nat	4	1.904	0.104	4	1.143	0.358	4	2.217	0.075
Edu x nat	2	1.109	0.328	2	0.986	0.376	2	0.252	0.772
Sex x age x edu	4	0.872	0.462	4	0.593	0.682	4	0.372	0.832
Sex x age x nat	4	0.785	0.516	4	0.648	0.644	4	0.905	0.448
Sex x edu x nat	2	0.145	0.867	2	0.338	0.732	2	1.452	0.239
Age x edu x nat	4	0.777	0.512	4	0.589	0.683	4	1.107	0.341
Sex x age x edu x nat	4	0.441	0.769	4	0.132	0.968	4	1.552	0.183
Residuals	836			1714			1006		
Total	883			1761			1053		

Table 6
Customer loyalty values. Customer loyalty answers for questionnaires T_0 and T_1 at all three localities.

		Item									
		1[a]		2[b]		3[c]		4[d]		5[e]	
		T0	T1	T0	T1	T0	T1	T0	T1	T0	T1
Nosy-Be	% no answer[f]	4.3	3.6	5.9	5.2	5.9	4.8	6.8	5.7	6.8	5.9
	% negative answer[g]	11.8	12.7	9.0	11.5	22.6	19.5	18.1	15.8	4.5	4.1
	% neutral answer[h]	16.5	13.1	23.3	23.3	24.0	23.3	26.9	27.6	21.3	20.6
	% positive answer[i]	67.4	70.6	61.8	60.0	47.5	52.5	48.2	50.9	67.4	69.5
Dhiggiri	% no answer[f]	1.4	2.3	3.3	3.2	2.2	2.3	2.7	3.2	3.3	3.2
	% negative answer[g]	14.1	15.9	9.1	10.2	21.9	23.1	18.8	13.7	5.4	3.7
	% neutral answer[h]	19.4	22.9	20.9	21.5	25.1	30.7	26.4	29.5	21.4	22.1
	% positive answer[i]	65.2	59.0	66.8	65.1	50.9	43.9	52.0	53.6	69.8	71.0
Maayafushi	% no answer[f]	36.2	2.1	38.0	3.0	36.8	3.4	38.5	3.2	38.9	3.6
	% negative answer[g]	10.4	23.1	7.8	9.1	12.3	21.6	14.6	18.6	4.6	3.8
	% neutral answer[h]	12.3	26.6	12.0	20.3	16.1	33.0	15.9	30.2	16.9	25.8
	% positive answer[i]	41.0	48.2	42.3	67.6	34.7	41.9	30.9	48.0	39.7	66.8

[a] Customer willing to pay up to 10% more than the standard price to stay in a Francorosso facility with nature-related activities and a biologist on site;
[b] Customer willing to pay up to 5% more than the standard price to stay in a Francorosso facility, without a biologist;
[c] Customer willing to pay up to 5% more than the standard price to stay in another tour operator facility with a biologist on site;
[d] Customer willing to pay up to 3% more than the standard price to stay in another tour operator facility with nature-related activities but no biologist on site;
[e] Customer willing to pay standard price for any tour operator, with neither nature-related activities nor a biologist on site.
[f] Percentage of tourists who didn't answer each of the items at both times.
[g] Percentage of tourists who answered "disagree" or "strongly disagree" to each of the items at both times.
[h] Percentage of tourists who answered "neutral" to each of the items at both times.
[i] Percentage of tourists who answered "agree" or "strongly agree" to each of the items at both times.

only further environmental awareness within tourists, but also higher profits for the entrepreneurs that host the project. Furthermore, such activities could possibly be extended to other informal contexts beyond the touristic environment (e.g., museums, zoos, parks). In order to assess how this environmental knowledge, attitude and awareness can translate into actual behavioral change, further (follow-up after at least one year) studies are required, by including also psychological variables to assess how personal response to the project might influence long-term retention of the studied variables (knowledge, attitude and awareness).

Appendixes A-G. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2021.109122.

CRediT authorship contribution statement

Marta Meschini: Data curation, Writing - Review & Editing. **Mariana Machado Toffolo:** Investigation, Data curation, Writing – Original Draft, Writing - Review & Editing, Visualization. **Erik Caroselli:** Writing - Review & Editing, Visualization. **Silvia Franzellitti:** Writing - Review & Editing, Visualization. **Chiara Marchini:** Funding acquisition, project administration, Writing - Review & Editing, Visualization. **Fiorella Prada:** Writing - Review & Editing, Visualization. **Alessio Boattini:** Formal Analysis. **Viviana Brambilla:** Methodology. **Grit Martinez:** Writing - Review & Editing. **Francesca Prati:** Methodology. **Ginevra Simoncini:** Investigation. **Marco Visentin:** Writing - Review & Editing. **Valentina Airi:** Methodology. **Simone Branchini:** Methodology. **Stefano Goffredo:** Conceptualization, Supervision, Funding acquisition.

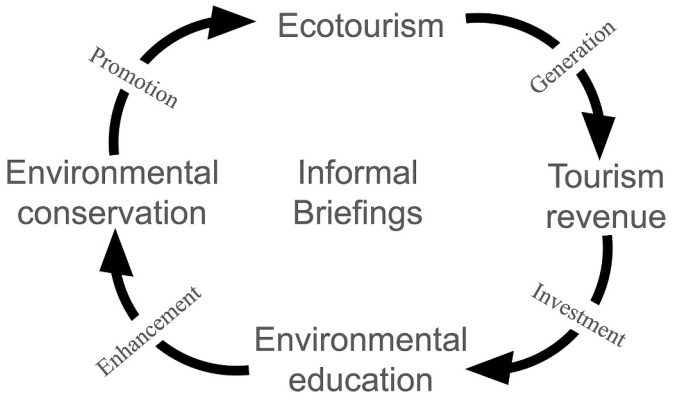

Fig. 3. Schematic diagram of Glocal Education's contribution to tourism sustainability. The diagram illustrates how environmental education informal briefings can have meaningful implications for environmental conservation, while helping advertise ecotourism, bringing revenue to the tourism industry, who ultimately can reinvest in environmental education projects, creating a network of sustainability that bolsters environment conservation and economic growth (based on Ramadoss and Moli, 2010).

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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CHAPTER 6.

LONG TERM EFFECTS OF AN INFORMAL EDUCATION PROGRAM ON TOURIST ENVIRONMENTAL PERCEPTION

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Long term effects of an informal education program on tourist environmental perception

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Author contribution statement

M.M.T and G.S. have contributed equally to this work and share first authorship.
M.M.T and G.S. collected data during the study; M.M.T. and G.S. analyzed the data; M.M.T., G.S., M.M., C.M., E.C., F.P., S.F., and S.G., wrote and reviewed the manuscript; C.M managed the project; S.G. supervised the research. All authors discussed the results and participated to the scientific discussion.

Keywords

Environmental Education, knowledge, Attitude, Awareness, tourism, informal learning, Cognitive Dissonance

Abstract

Word count: 284

Tourism is one of the most important economic sectors worldwide, with significant overarching impact on the environment, including negative effects caused by tourist inappropriate behavior while on vacation. By providing informal educational activities, tourism also has an educative role that leads to positive learning outcomes and beneficial environmental effects. Here we present the short- and long-term outcomes of a project for environmental education (Glocal Education) carried out in three travel destinations, aimed at promoting sustainability variables (knowledge, attitude, and awareness) in participating tourists. Since psychological components can affect learning outcomes, we also considered tourist satisfaction in participating in the project and identification with its values, as well as the intention to travel with the hosting tour operator again in the future. Tourists were asked to complete evaluation questionnaires three times: before Glocal Education activities, right after activities (i.e., while still on vacation), and after at least one year from initial project participation. Short- and long-term learning outcomes were tested, and possible relations between these variables and psychological components (satisfaction, identification, and intention) of the learning experience were verified. Overall, knowledge, attitude and awareness increased in the short term, while in the long term, knowledge and attitude decreased, and awareness remained constant. In most cases, psychological components showed positive relation with sustainability variables, which suggested their important role in structuring and carrying out environmental education activities. This study suggests that informal environmental education activities can be advantageous for tourism stakeholders in terms of customer loyalty. Such activities can contribute to enhance environment literacy, by allowing tourists to observe the environmental impact caused by human activity, and understand how their day-to-day actions, even if small, might help address some of the current concerns for environmental conservation.

Contribution to the field

This manuscript describes the outcomes of an educational model implemented in touristic facilities, directly targeting tourists, with the aim of testing the effectiveness of environmental education activities on tourist environmental perception. It is an important addition to the scientific literature because we have analyzed long term retention of tourist environmental perception after participating in informal environmental education activities. Our findings showed a short-term increase in knowledge, attitude, and awareness (sustainability variables), suggesting immediate positive outcomes, which could lead to reduced environmental impact. Although knowledge and attitude decrease in the long term, the increase in awareness is maintained. We also found that social aspects (psychological variables) of learning have a role in facilitating the pursuit of positive educational outcomes. Thus, knowing the short- and long-term outcomes of an informal environmental education project on tourist perception, our research can serve as a starting point for better tailoring such informal activities to promote higher long-term retention in tourist environmental perception.

Ethics statements

Studies involving animal subjects

Generated Statement: No animal studies are presented in this manuscript.

Studies involving human subjects

Generated Statement: The studies involving human participants were reviewed and approved by Bioethics Committee of the University of Bologna (Prot. 118055). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Inclusion of identifiable human data

Generated Statement: No potentially identifiable human images or data is presented in this study.

Data availability statement

Generated Statement: The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: 10.6084/m9.figshare.15143130..

Long term effects of an informal education program on tourist environmental perception

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Keywords: Environmental education, knowledge, attitude, awareness, tourism, informal learning, cognitive dissonance.

Word count: 5595
Number of figures: 5
Number of tables: 5

Abstract

Tourism is one of the most important economic sectors worldwide, with significant overarching impact on the environment, including negative effects caused by tourist inappropriate behavior while on vacation. By providing informal educational activities, tourism also has an educative role that leads to positive learning outcomes and beneficial environmental effects. Here we present the short- and long-term outcomes of a project for environmental education (Glocal Education) carried out in three travel destinations, aimed at promoting sustainability variables (knowledge, attitude, and awareness) in participating tourists. Since psychological components can affect learning outcomes, we also considered tourist satisfaction in participating in the project and identification with its values, as well as the intention to travel with the hosting tour operator again in the future. Tourists were asked to complete evaluation questionnaires three times: before Glocal Education activities, right after activities (i.e., while still on vacation), and after at least one year from initial project participation. Short- and long-term learning outcomes were tested, and possible relations between these variables and psychological components (satisfaction, identification, and intention) of the learning experience were verified. Overall, knowledge, attitude and awareness increased in the short term, while in the long term, knowledge and attitude decreased, and awareness remained constant. In most cases, psychological components showed positive relation with sustainability variables, which suggested their important role in structuring and carrying out environmental education activities. This study suggests that informal environmental education activities can be advantageous for tourism stakeholders in terms of customer loyalty. Such activities can contribute to enhance environment literacy, by allowing tourists to observe the environmental impact caused by human activity, and understand how their day-to-day actions, even if small, might help address some of the current concerns for environmental conservation.

1 Introduction

Tourism, currently one of the largest industries in the world, is an example of human activity with an overarching impact on the environment, contributing to global pollution, infrastructure development, and land use (Gössling, 2002; United Nations World Tourism Organization, (UNWTO), 2017). Although the modernization of transportation has helped promote global connectivity and affordable air travel (Cohen, 2012), the previous trend that predicted 1.8 billion international tourist arrivals by 2030 (UNWTO and ITF, 2019) has been severely impacted by the coronavirus (COVID-19) pandemic, leading to a decline of more than 50% in international tourist arrivals for the year 2020 (UNWTO, 2020). Hence, predicting long-term touristic global trends is currently problematic (Gössling et al., 2020; UNWTO, 2020).

Many popular travel destinations are often locations known for their appealing natural environments, such as tropical locations, characterized by unique ecosystems and biodiversity (e.g., coral reefs and tropical forests). In addition to the aforementioned social impacts, tourists can significantly impact the environment through inappropriate behavior (Gössling, 2002; Davenport and Davenport, 2006; Pickering and Hill, 2007). For example, trampling by tourists can lead to disturbance of local vegetation and damage in coastal environments (sand dunes and intertidal areas), and also underwater, damaging coral reefs. (Davenport and Davenport, 2006; Pickering and Hill, 2007; Defeo et al., 2009). Moreover, visitors can leave their debris along the beach causing problems to marine organisms through tangling and ingestion (Beeharry et al., 2017), and they contribute to sunscreen pollution that cause a cascade of impacts to the ecological structure(Koh and Fakfare, 2020; Downs et al., 2022). Tourists interested in observing nocturnal fauna are responsible for light pollution which can cause changes in orientation, disorientation, or misorientation, and attraction or repulsion from the altered light environment, which in turn may affect foraging, reproduction, migration, and communication (Longcore and Rich, 2004). Further issues include harvesting of natural components or their acquisition as souvenirs, such as local and sometimes endangered plant and animal species, seashells, coral fragments, and sand(Gössling, 2002; Pickering and Hill, 2007; Defeo et al., 2009; Kowalewski et al., 2014), and also interactions with wildlife: touching and feeding animals create disturbance for wildlife and can lead to behavioral and reproductive modifications, increased human dependency or aggression (Orams, 2002; Green and Giese, 2004).

Short-term effects derived from inappropriate and unaware tourist behavior can cumulatively develop into long-term impacts on populations and ecosystems (Green and Giese, 2004; Pickering and Hill, 2007; Kowalewski et al., 2014). Thus, it is important to address these issues, by acting on a small, local scale, to reduce overall environmental impact (Green and Giese, 2004; Defeo et al., 2009). Reducing such effects benefits the environment and the tourism stakeholders, both public and private, as natural ecosystem integrity guarantees the lasting appeal of travel destinations and continuous economic influx from tourism (Gössling, 2002).

For these reasons, The UN Conference on Sustainable Development Rio+20, in 2012, reported the need to support sustainable tourism activities and the promotion of environmental awareness, with governments, tourists, local communities, and stakeholders all having interest in promoting sustainable tourism development (United Nations, 2012, 2015). Furthermore, recent initiatives such as the UN Decade of Ocean Science (Ryabinin et al., 2019) and the EU Green Deal and Horizon Europe (Eckert and Kovalevska, 2021) provide additional support for compliance with the sustainable development goals of the Agenda 2030.

Environmental education can contribute to achieving more sustainable tourism (United Nations, 1993, 2015; Tilbury, 1995). Education shapes not only knowledge and

understanding, but also emotions, awareness, and personal development, which in turn can influence behavior (Gössling, 2018). Knowledge (cognition, understanding topics, and issues), attitude (concern and active improvement and protection), and awareness (consciousness, sensitivity to issues) are among the objectives that environmental education should address (UNESCO, 1977; Pooley and O'Connor, 2000; Cheng and Wu, 2015). Even though knowledge is not the only factor that might contribute to environmentally-friendly behavior, with factors such as group behavior, previous beliefs and even income playing an important role on how much people are willing to contribute to conservation overall (Gustafson and Rice, 2016), several studies indicate that when individuals have higher levels of environmental knowledge, they are more concerned about the environment (Hines et al., 1987; Lyons and Breakwell, 1994; Sh, 2009). Moreover, Cheng and Wu (2015) found that when tourists feel attached to the destination they are visiting, they tend to feel protective towards such a destination, showing intention to actively prevent negative impacts to that given place.

Knowledge, awareness, and attitude are not the only variables contributing to environmental perception, possible behavioral changes and increased sustainable actions (Grob, 1995; Gössling, 2018). Other important variables in the path of environmental education are the so-called "empowerment variables" (hereafter, psychological variables) (Hungerford and Volk, 1990). These variables, affective attributes that contribute to empathy towards the environment (Chawla, 1998), are the cornerstone in environmental education and include: identification with the environmental cause, intention to act in favor of the environment, and personal satisfaction in being an active participant to environment protection (Hungerford and Volk, 1990; Bamberg and Möser, 2007). In creating sensitivity, combined with a sense of power and responsibility, people can choose to contribute to a mass effort in the conservation and protection of the environment (Hungerford and Volk, 1990).

Although there is a plethora of touristic targets (gastronomic, historical, cultural, wildlife, and so on), we focused our study on mass tourism resorts located in naturalistic tropical destinations. Such resorts are popular touristic destinations, raising concerns about possible social, economic, and environmental consequences across the local area (Richins, 2009; Cowburn et al., 2018; Grilli et al., 2021). Nevertheless, these touristic destinations can be profitably employed to put environmental education into practice and, in the long-term, select the best educational model prompting novel, conservation-oriented, public attitudes toward vulnerable ecosystems.

This study aimed to assess the short-term and long-term effects of recreational activities offered to tourists. Specifically, these activities were provided within the Glocal Education project, an environmental education project carried out as a pilot study at three different tropical resort facilities located in Madagascar and the Maldives. The study considered variables related to sustainability and environmental perception (environmental knowledge, attitude, and awareness) and psychology (satisfaction, identification, intention), and the possible relation between them.

2 Materials and methods

2.1 Ethics statement

The Glocal Education project and its consent acquisition procedure have received the approval of the Bioethics Committee of the University of Bologna (Prot. 118055). For this study, participants (or parents/guardians in case of minors) gave their consent by signing a declaration inserted in the questionnaires., and their personal data (name and surname) were

collected to guarantee the comparison between the initial environmental education assessment and that after participation in project activities. We have treated the data confidentially, exclusively for institutional purposes (art. 4 of Italian legislation D.R. 271/2009 - single text on privacy and the use of IT systems) and according to art. 12, 13, and 14 of EU Regulation 2016/679 - General Data Protection Regulation (GDPR). Data treatment and reporting took place in aggregate form.

2.2 Field activities

The activities were carried out in three travel destinations as part of the environmental education project "Glocal Education". These locations were Nosy Be island (Madagascar), Dhiggiri island and Maayafushi island (Maldives) (Figure 1) (see Meschini et al., 2021).

Tourists were asked upon arrival to take part in the Glocal Education project. In case of positive response, they filled the first questionnaire (T_0) before the first scheduled project activity with the biologist onsite, in order to assess their environmental background. The Glocal Education biologists were BSc or MSc students in biological or natural sciences at the University of Bologna, selected based on their interest and experience in both environmental education and touristic facilities, and previously trained on project activities.

Tourists could then take part in any of the project weekly activities, which consisted of 1) two one-hour introductory lessons, the first on focused on island geology, coral reef formation and coral biology, and the second one on the identification and general biology of local organisms (marine invertebrates, fish, marine reptiles, and mammals in the Maldives, and both terrestrial and tropical plant species in Madagascar); 2) an "around-the-island" interactive walk, with explanations on local fauna and flora; 3) participation in field excursions accompanied by the Glocal Education biologist and local guides - snorkeling excursions were organized at the Maldives facilities, and excursions through the primary forest at the facility in Madagascar.

After conclusion of the last proposed activity, eligible tourists were asked to fill the second questionnaire, here referred to as questionnaire T_1. Tourist eligibility required participation in at least one Glocal Education activity.

To test for long-term effects of the Glocal Education project (GE-LT), tourists who agreed to leave their email address were re-contacted after approximately 12-16 months from initial participation, to fill out a third evaluation questionnaire (T_2), using the Qualtrics online survey platform (Qualtrics, Provo, UT, USA. https://www.qualtrics.com).

2.3 Environmental education evaluation questionnaire

The questionnaire, previously developed to detect short-term effects (see Meschini et al., 2021) was repeated after one year of tourist participation in the project. The evaluation questionnaire (Supplementary Figure 1-7) was developed by the Department of Psychology of the University of Bologna and was divided into sections as follows:

- Section A: Participant personal data. Name and email were used to pair questionnaires filled by the same participant over time, to have repeated measures for every participant, while sex, age, education and nature contact (frequency of activities carried out in nature regularly) were asked to evaluate if these factors could affect initial levels of environmental education and their variation in time.
- Section B: Knowledge variable. 10 items (number 1 to 10) regarding knowledge in basic biology and ecology topics covered during Glocal Education activities. Some items were customized accordingly to the ecosystem of each location.

- Section C: Attitude variable. 8 items (number 11 to 18) regarding the intention to carry out pro-environmental and sustainable actions, therefore a positive behavior towards the environment.
- Section D: Awareness variable. 9 items (number 19 to 27) regarding the emotional component of individual awareness towards environmental issues.
- Section E: Satisfaction variable. 4 items (number 28 to 31) regarding the personal impression of the quality of the proposed project activities.
- Section F: Identification variable. 4 items (number 32 to 35) regarding participants' sense of affinity to the project and its values.
- Section G: Intention variable. 4 items (number 36 to 38) regarding the intention to travel with the same tour operator who hosted the environmental education activities again in the future.

For sections B-G, scores were calculated according to Meschini et al., 2021. We defined sustainability variables, the variables of knowledge, attitude, and awareness which represented overall environmental perception before participation in Glocal Education activities (T_0), in the short term (T_1) and long term (T_2) after project participation. We defined psychological variables, related to participating in the Glocal Education project, the variables of satisfaction, identification, and intention, measured in the short term (T_1) and long term (T_2).

2.4 Statistical analysis

For each variable measured with the Likert scale (attitude, awareness, satisfaction, identification, intention), reverse formulated items were recalculated accordingly (Paulhus, 1991), and reliability analysis using Cronbach's alpha (α) was conducted to test the internal consistency of items for each repeated measure of the variables at T_0, T_1, and T_2. When Alpha values resulted in below acceptable scores ($\alpha < 0.50$), items were removed to reach acceptable internal consistency. Reliable items for each section were used to calculate mean scores as representative of the measure of each variable, for all individuals (Supplementary Table 1). All scores for all variables for every participant were re-scaled from 1 to 10.

Levene's test was used to test homogeneity of variance and Kolmogorov-Smirnov's test was used to test the normality of variance, for sustainability and psychological variables; these analyses were performed using IBM SPSS Statistics v. 22.

Using PRIMER-e v.6 – Quest Research Limited and PERMANOVA+ (Anderson et al., 2008), a first permutational multivariate analysis of variance (PERMANOVA) was carried out with two factors ("location" with 3 levels: Nosy Be, Dhiggiri, Maayafushi; and "time" with 3 levels: T_0, T_1, T_2) based on Euclidean distance and 999 permutations to test the effect of the factor "location" on sustainability variables. A second PERMANOVA with five factors ("time" with 3 levels: T_0, T_1, T_2; "sex" with 2 levels: male, female; "age" with 2 levels: under 40, 40 and over; "education" with 2 levels: high school diploma, college degree; "nature contact" with 2 levels: naturalist, non-naturalist), based on Euclidean distance and 999 permutations, was carried out to test the effect of participants demographic factors on sustainability variables. The levels of age, education and nature contact were determined based on the sample number; we chose to group further levels into 2 for all the factors due to the fact that when we employed more levels (e. g., <30, 31-45 and 46> years for age), there were level combinations in which the sample number was equal to zero (i.e., there were no participants that fit that particular subset of levels to allow us to analyze factor interaction on PERMANOVA). Pairwise comparisons were subsequently carried out to investigate the main effects of factor time on sustainability variables.

For interpretation of all PERMANOVA analyses and pairwise comparisons, a threshold value for the average scores of sustainability variables was set to identify statistical significance that also indicated an actual difference in overall environmental education from participation in the Glocal Education project. The threshold for the difference in average scores was set at 0.5, which indicated that at least half of total participants (n = 97) answered at least one additional question correctly, corresponding to a variation of at least +1 in a variable score, in T_1 relatively to T_0 and in T_2 to T_1.

Assumptions for parametric statistics were not met, so Wilcoxon signed-rank test was carried out (IBM SPSS Statistics v. 22) to compare repeated measures of psychological variables for participants in time (T_1, T_2). To test for relations between sustainability variables and psychological variables, Spearman's rank correlation analyses were performed using IBM SPSS Statistics v. 22. Variation for each sustainability variable in time, from T_1 to T_2, was calculated for every participant:

$$\Delta variable = \left(\frac{T_2\ average - T_1\ average}{T_1\ average}\right) \times 100$$

and tested for correlation with psychological variables as described above.

3 Results

From August 2016 to April 2019, 1851 tourists participated in Glocal Education – Short term study. Of these, a subset of 1192 tourists expressed availability to be re-contacted in the future and were invited to compile the long-term evaluation questionnaire between May 2018 to November 2019. 223 individual responses were received (19% response rate). Incomplete questionnaires were removed, resulting in 194 valid questionnaires for Glocal Education – Long term (GE-LT) analysis, each questionnaire having been compiled by one single participant. The present study focused on the 194 tourists who participated in GE-LT by compiling three valid sequential environmental education questionnaires (T_0, T_1, T_2). Participation was slightly higher among females (n = 111, 57%) compared to males (n = 83, 43%) (Table 1). The overall average age was 43 years old, with the slightly underrepresented age category of under 40 (n = 84, 43%) relatively to 40 and over (n = 110, 57%) (Table 1). The level of education was divided quite equally between participants having up to a high school diploma (n = 100, 52%) and those with a graduate degree or higher (n = 94, 48%) (Table 1). Most participants carried out activities in contact with nature up to once a month (n = 124, 64%) and the minority more than once a month (n = 70, 36%) (Table 1).

3.1 Effects on sustainability variables in time

PERMANOVA analyses to test for the effects of factors location and time on sustainability variables showed no interaction between factors ($p > 0.05$; Table 2) while there was a significant effect for the factor time on all sustainability variables ($p < 0.01$; Table 2). For the factor location, there was no effect on variables knowledge and attitude ($p > 0.05$; Table 2), but a significant effect for variable awareness ($p < 0.01$; Table 2).

Pairwise comparisons (Table 3) showed that awareness scores for Maayafushi (Avg = 9.3, 95% CI = 9.2-9.4) were significantly different from Nosy Be (Avg = 8.9, 95% CI = 8.7-9.1) and Dhiggiri (Avg = 9.0, 95% CI = 8.9-9.1). However, the difference in average scores was below the threshold of 0.5, thus they were not considered meaningful in educational terms. Data from sustainability variables from all locations were aggregated for all following analyses.

Pairwise comparisons showed that all sustainability variables were significantly different ($p < 0.01$) for levels of factor time (T_0, T_1, T_2), except for the variable awareness that showed no significant difference between T_1 and T_2 (Table 4).
Knowledge average scores increased from T_0 (Avg = 7.6; 95% CI = 7.4-7.9) to T_1 (Avg = 8.7; 95% CI = 8.6-8.8) and decreased from T_1 to T_2 (Avg = 8; 95% CI = 7.8-8.2), with T_2 scores higher than T_0 scores (Figure 1). Attitude average scores increased from T_0 (Avg = 8.9; 95% CI = 8.8-9.0) to T_1 (Avg = 9.4; 95% CI = 9.3-9.5) and decreased from T_1 to T_2 (Avg = 8.1; 95% CI = 8-8.2), with T2 scores lower than T_0 scores (Figure 1). Awareness average scores increased from T_0 (Avg = 8.8; 95% CI = 8.7-8.9) to T_1 (Avg = 9.3; 95% CI = 9.2-9.4) and were not significantly different from T_1 to T_2 (Avg = 9.2; 95% CI = 9.1-9.3) (Figure 1).

The PERMANOVA analysis to test for the effects of demographic factors on sustainability variables showed no interaction between time and any of the demographic factors ($p > 0.05$; Table 5). The full analysis of demographic factor effects did not provide clear patterns of interpretation (see Supplementary Tables S2-S8). Since the effects of factor time were independent of participants' demographics, data from all demographic groups were aggregated.

3.2 Relation between sustainability and psychological variables

Wilcoxon signed rank test showed that all psychological variables were significantly different between T_1 and T_2 (Satisfaction $p < 0.001$; Identification $p < 0.001$: Intention $p < 0.001$; Supplementary Table 9).

We then performed Spearman's correlation analyses among sustainability and psychological variables T_1 and T_2 (Figures 3-5, Supplementary Table 10, Supplementary Figures 8 and 9), which showed that Within T_1 and T_2, knowledge showed no correlation with any psychological variables ($p > 0.05$; Figures 3 and 4). Attitude showed positive correlation with all psychological variables ($p < 0.001$ for satisfaction; $p < 0.001$ for identification; $p < 0.001$ for intention; Figures 3 and 4). Awareness showed positive correlation with satisfaction and identification ($p < 0.01$; Figures 3 and 4).

Knowledge, attitude and awareness scores at T_2 showed positive correlation with satisfaction measured at T_1 ($p < 0.05$, $p < 0.001$ and $p < 0.01$, respectively; Figure 5). Attitude and awareness variables also showed positive correlation with identification at T_1 ($p < 0.001$ and $p < 0.05$ respectively; Figure 5).

The variation of knowledge scores between T_1 and T_2 positively correlated with satisfaction at T_1 ($p < 0.05$; Supplementary Figure 8) and the variation of attitude positively correlated with satisfaction, identification and intention scores at T_2 ($p < 0.01$, $p < 0.001$ and $p < 0.01$ respectively; Supplementary Figure 9).

4 Discussion

The Glocal Education project may contribute to investigating potential outcomes of environmental education activities as learning opportunities in tourism when mediated by an educator figure and inserted within the informal context of a leisure vacation. Previous studies show that positive learning outcomes can derive from participation in tourist activities such as wildlife safaris, whale watching experiences, citizen science projects and aquarium/zoo visits (Ballantyne and Packer, 2011; Higginbottom et al., 2011; Hughes et al., 2011; Branchini et al., 2015). The aim of this study was not to bring tourism impact to a zero, as that would not be possible, but rather create food for thought and sensitize tourists. The translation of reported outcomes into actual sustainable and environmentally friendly behavior is still a

convoluted aspect to analyze and report accurately (Huddart et al., 2009; Hadjichambis et al., 2015; Chen and Tsai, 2016). A potential follow-up study focusing on this interaction would be required to verify in what manner these variables contribute to individual change in behavior.

4.1 Sustainability variables

Sustainability variable scores (knowledge, attitude, awareness) were the same in the three travel destinations (one in Madagascar and two in the Maldives). This suggested that the same project can be carried out in different locations leading to the same result. A possible bias to this outcome could be that all localities were within tropical ecosystems, and therefore similar amongst them. To address this issue, future studies should test the Glocal Education project in a wider range of locations, such as in the Mediterranean Sea and possibly other temperate environments.

Subsequently, we verified that effects of project participation were equal amongst different demographic groups. Informal education experiences can vary significantly among them, and contrasting information exists regarding learning outcomes for different demographic groups: in some cases, demographics have a significative effect, and in some cases they do not (Rodari, 2009). In the case of Glocal Education, all participants expressed similar learning outcomes, regardless of previous education, gender, age, or nature contact. Although age range was somewhat broad (under 40 and over 40, with no ranges in between), these results imply that everyone can benefit equally from the learning experience provided by Glocal Education and that possible outcomes on environmental perception can be achieved equally by all participants. Further analysis focusing on the age factor can be performed in order to ascertain whether age is a significant influencer on the learning experience proposed by the Glocal Education project.

4.2 Short-term vs. Long-term effects

When evaluating learning experiences, time passed after participation is to be considered, as educational outcomes may show up at different times (Rodari, 2009; Falk et al., 2012). Short-term outcomes are the most reported as they are easier to verify, but there are also long-term outcomes that can appear much later or that can have important long-lasting effects (Rodari, 2009). Long-term outcomes are the most difficult to record as they require tracking of individuals over time. However, they are necessary to assess the influence of education over time (Rodari, 2009). In order to verify the long-lasting effects of the Glocal Education project, all sustainability and psychological variables were tested in participants after one year of taking part in Glocal Education activities.

In the short term, knowledge, attitude, and awareness increased compared to pre-participation scores. From learning about the surrounding environment and how one can behave in order to minimize impact, all while being able to see firsthand the beauty and diversity of such environment (through snorkeling or hiking, for example), tourists knew and were more aware of environmental issues. Tourists reported to be more careful to avoid direct harmful and damaging behavior towards the environment and showed a positive attitude in promoting such behaviors with others in the short-term. From an environmental point of view, this positive result highlights the importance of implementing informal education projects in travel destinations. If our proposed project were to be implemented in resorts globally, the positive short-term outcomes seen for each individual would be multiplied by engaging a large number of participants simultaneously.

In the long term, knowledge scores decreased to intermediate values compared to pre-project participation and short-term outcomes. In this case, it is probable that acquired concepts about tropical reefs and exotic ecosystems, while being of interest to tourists on vacation, were forgotten in the long run, being of minor relevance in individuals' daily lives and likely not repeated often once returned home. Long term attitude scores decreased compared to both short-term outcomes and pre-project participation. On the other hand, awareness scores remain stable in time after the increase registered in the short-term indicating that positive outcomes achieved from project participation tied to the emotional components of environmental education are maintained even after one year. Long-term outcomes of the Glocal Education project indicate that having knowledge and being aware of environmental issues does not always translate into a more sustainable attitude towards the environment and sustainable actions. This result is in line with social psychology studies indicating that there is a gap between environmental perception and actual pro-environmental behavior (Hines et al., 1987; Kollmuss and Agyeman, 2002; Liu et al., 2020) and highlights how some educational outcomes, such as attitude, may be subject to complex social/emotional factors beyond simple knowledge of environmental facts (Bamberg and Möser, 2007). Behavioral intentions (here, attitude), which in turn shape actions, can be influenced by economic constraints, social pressures and constructs, moral norms, and the opportunity to choose different actions (Hines et al., 1987; Bamberg and Möser, 2007; Steg and Vlek, 2009). The resulting pro-environmental behavior is therefore a mixture of self-interest and pro-social motives, with attitude being one of the many components (Kollmuss and Agyeman, 2002; Bamberg and Möser, 2007; Steg and Vlek, 2009). The resulting higher attitude scores right after participating in the educational activities and lower scores in the long term, can be explained by a few theories, such as: social desirability: tourists might answer in a manner that is considered socially acceptable, rather than their own actions and points of view, giving biased answers instead of true ones (White et al., 2018; Vesely and Klöckner, 2020; Vilar et al., 2020); cognitive dissonance: this social-psychological theory is based on the knowledge that people tend to act consistently with personal beliefs to avoid discomfort (Festinger, 1962; Thøgersen, 2004) and the psychological distancing perspective: whenever people feel positive (in this case, seeing in person and learning about the biodiversity of a tropical paradise), they tend to "draw plans" on how to achieve a certain goal (in this case, the conservation of ecosystems) (Labroo and Patrick, 2009).The Glocal Education project participation occurred while the tourist was enthusiastic, immersed in a compelling natural environment, and in the presence of the educator figure. Such factors could have influenced individuals to answer the questionnaire according to what they think is the most appropriate answer, as opposed to what they would actually do in that particular situation (Thøgersen, 2004). Furthermore, after one year or more from the vacation, individual initial enthusiasm may have worn off. This reasoning can also be applied to the difference recorded in psychological variables, with higher scores registered in the short term also attributed to direct emotional involvement with the Glocal Education project on location. Additionally, information received over a short period of time tends to be stored in more "shallow" levels, allowing the receiver to forget more easily (Craik and Lockhart, 1972). In the case study of Glocal Education, tourists were fully immersed in an exotic location, which coupled with participation in Glocal Education activities led to an overall boost in reported environmentally friendly behavior intention on vacation. However, once returned home, individuals tended to revert to behaviors and habits determined by other external factors such as routine or social constructs, which led to knowledge and attitude declining in long term even when high awareness scores were maintained (Festinger, 1962; Kollmuss and Agyeman, 2002). Furthermore, because of the lack of reinforcement of the positive outcomes acquired on vacation via subsequent similar learning experiences, immediate effects dissipated in the long term, as has been observed in

the case of free-choice education activities (Ballantyne and Packer, 2011). For this reason, if activities like those proposed by the Glocal Education project were to be consistently implemented in a greater number of touristic resorts worldwide, tourists would benefit from further reinforcement of previous learning experiences and educational achievements in future vacations.

4.3 Sustainability and Psychological variable correlation

As indicated in the correlation analysis, there was no significant relationship between knowledge and psychological variables. Attitude and awareness showed a positive relationship with both satisfaction and identification in all tested cases (6 out of 6; Supplementary Table 10). The more participants were satisfied in having taken part in the Glocal Education project, and the more they identified with project values, the higher was their awareness and attitude scores. This goes in line with previous findings (Meschini et al., 2021), indicating that psychological components of educational activities can contribute to greater learning outcomes. In most cases (2 out of 3; Supplementary Table 10) attitude also correlated with the intention to travel with the same tour operator again. From an economic perspective, individuals with higher attitude scores expressed higher intention to travel with the same tour operator again, a strong indication of customer loyalty towards the host who provided the educational program. For these reasons, we propose the implementation of the Glocal Education project to be carried out by the main stakeholder organizations that represent commercial, touristic, and service businesses, travel agents, and tour operators, in mass tourist resorts, since we believe that it could be beneficial from an environmental, social, and economic perspective.

In the case of Glocal Education, these positive correlations found with the psychological components of participating in activities demonstrate the importance of valuing social and emotional aspects of environmental education projects in tourism. Furthermore, participants with higher psychological scores in the long term showed a higher value in attitude after one year. To reinforce positive attitudes to behave sustainably, satisfaction and identification of individuals are therefore important features to consider (Thøgersen, 2004). Since the study analyzed a reduced sample size (194 out of 1851 who initially participated in the project), the observed results could be corroborated by further studies with a larger sample size, achieved through higher engagement of participants on the follow up analysis. Higher tourist engagement can be achieved not only through the development of a user-friendly app, rendering the activities easier and more interactive, but also with the employment of "vacation coupons", discount coupons to be raffled among project participants. GE activities could also be adapted to other contexts such as zoos, parks, etc. according to the target audience (children, schools, other touristic facilities), to render the project accessible and efficient in different scenarios.

4.4 Tourism impacts

The tourism industry is a complex and interconnected system, where socioeconomic and environmental interactions and impacts take place over distances (Liu et al., 2020). Hence, a useful tool to analyze the industry as a whole would be through telecoupling, an integrated framework suited to understand the interconnected world and help map possible pathways towards the United Nations' Sustainable Development Goals(United Nations, 2015) and other global challenges. Nonetheless, our study had a more limited scope, focusing on educational activities within touristic facilities. Such activities, applied over a larger range of touristic facilities and involving a larger number of participants to mitigate volunteer bias,

could in the future present useful to the tourism industry, at which point they could be added to the telecoupling framework. As this is a pilot study, further analyses are required.

It is un-neglectable that global tourism is leaving its ecological and social footprint, and that global actions should be undertaken to promote awareness, educate people, and achieve a meaningful behavioral change towards more environmentally parsimonious ways of life. The rationale behind the Glocal Education project is to provide individuals with an enhanced perception of the environment and related issues to enhance their intention of positive behaviors while on vacation. The ultimate goal is to improve a localized action that, together with other initiatives, may help contribute to mitigating the global problem of mass tourism impacts on biodiversity and natural landscapes. The present study reported the first outcomes for the Glocal Education project on a limited number of tourist resorts. Thus, the reported data do not allow to discuss or make societal impact projections on a broad spatial scale. In this context, the informal educational activities described here could be applied to different locations and could have a wide outreach, involving a significant number of participants.

5 Conclusion

Informal education activities are in line with the UN Sustainable Development Agenda, particularly Goals 8 - devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products (United Nations, 2015) -; and 12 - Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products (United Nations, 2015), and can aid the tourism sector in pursuing this goal on multiple fronts. There is social and educative importance focused on the direct involvement of tourists who gain knowledge, awareness, and positive attitudes while on vacation. There is a financial interest for stakeholders, such as tour operators, who can benefit from increased competitiveness by hosting environmentally friendly programs and becoming more appealing to customers. In addition, maintaining ecosystem integrity by reducing impact guarantees continuous natural appeal in the long term for tourists, and therefore a continuous economic return for the tourism sector.

Overall, the educational model we present addresses the importance of implementing informal learning projects in tourism, specifically on location within tourist resorts and other popular travel destinations. The tourism industry has the potential and the responsibility to act as a key player in implementing such strategies, which can be immediate actions contributing to sustainability that do not require strategic policymaking. In this context, the recreational and informal educational activities as described here be applied to different locations and can have a wide outreach involving a significant number of participants. By providing individuals with an understanding of the environment and related issues, the aim is to reduce the direct environmental impact caused by tourists while on vacation.

Finally, the outcomes of our study indicate that on the fine scale of local and individual intention of action, by tailoring Glocal Education to the reality of touristic facilities, tourists may help address environmental and biodiversity issues.

6 Conflict of Interest statement

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.

7 Author Contributions statement

M.M.T and G.S. collected data during the study; M.M.T. and G.S. analyzed the data; M.M.T., G.S., M.M., C.M., E.C., F.P., S.F., and S.G., wrote and reviewed the manuscript; C.M managed the project; S.G. supervised the research. All authors discussed the results and participated to the scientific discussion.

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Data Availability Statement

The dataset analyzed for this study can be found on FigShare, available at: 10.6084/m9.figshare.15143130.

766 # Tables

767

Table 1. Tourist participation in the Glocal Education project. Tourists were classified according to 4 factors: Age, Sex, Education level and frequency of contact with nature.

Factors		N	%
Sex	Male	83	42,78
	Female	111	57,22
Age	Under 40	84	43,30
	40 and over	110	56,70
Education	High School	100	51,55
	College	94	48,45
Nature contact	Non-Naturalist	124	63,40
	Naturalist	70	36,60
	Total	194	

Table 2. PERMANOVA[a,b] analyses testing the effect of factors location and time on sustainability variables (knowledge, attitude, awareness).

	Knowledge		Attitude		Awareness	
Factor	Pseudo-F	p	Pseudo-F	p	Pseudo-F	p
Location	0.352	0.706	19425	0.142	82376	0.002
Time	33975	0.001	97472	0.001	14158	0.001
Location x Time	24354	0.051	14763	0.198	0.894	0.460

a. Tests were run using Euclidean distances among samples and 999 permutations.
b. Significative effects ($p < 0.05$).

Table 3. Pairwise comparison[a] among locations for the variable awareness.

768

Variable	Pairwise-comparison	t	p
Awareness	Nosy Be vs Dhiggiri	0.67998	0.492
	Nosy Be vs Maayafushi	3243	0.001
	Dhiggiri vs Maayafushi	35976	0.001

a. Significative comparisons ($p < 0.05$) are indicated in bold.

Table 4. Pairwise comparison[a] among times (T_0: before GE activities; T_1: short term after GE activities; T_2: long term after GE activities) for all sustainability variables (knowledge, attitude, awareness).

Variable	Pairwise-comparison	t	p
Knowledge	T_0 vs T_1	83218	0.001
	T_0 vs T_2	3022	0.003
	T_1 vs T_2	51729	0.001
Attitude	T_0 vs T_1	4673	0.001
	T_0 vs T_2	86764	0.001
	T_1 vs T_2	13584	0.001
Awareness	T_0 vs T_1	46358	0.001
	T_0 vs T_2	42616	0.001
	T_1 vs T_2	0.4	0.705

a. Significative comparisons ($p < 0.05$) are indicated in bold.

769 **Table 5.** PERMANOVA test for demographic factors and factor time. Tests were run using Euclidean distances
770 among samples and 999 permutations in the software Primer+PERMANOVA. Significative effects ($p<0.05$) are
771 indicated in bold.
772

	Knowledge		Attitude		Awareness	
Factor	Pseudo-F	p	Pseudo-F	p	Pseudo-F	p
Time	35766	**0.001**	87837	**0.001**	16703	**0.001**
Sex	62087	**0.012**	0.29328	0.602	23068	0.121
Age	25468	0.135	96361	**0.004**	58306	**0.011**
Education	15901	**0.001**	0.85084	0.337	0.38406	0.536
Nature contact	0.14363	0.675	0.13823	0.696	40326	**0.039**
Time x Sex	1369	0.251	0.32893	0.725	0.71503	0.468
Time x Age	0.30922	0.745	0.22683	0.792	15881	0.218
Time x Education	15499	0.221	17446	0.16	0.21271	0.8
Time x Nature contact	0.46255	0.636	0.25739	0.792	0.28467	0.766
Sex x Age	25371	0.104	27207	0.123	11794	0.277
Sex x Education	10148	0.313	0.50348	0.459	0.31044	0.59
Sex x Nature contact	16935	0.194	0.55182	0.442	0.6251	0.434
Age x Education	0.53916	0.502	17654	0.166	0.24543	0.643
Age x Nature contact	7.48	**0.008**	0.30379	0.581	107.38	0.93
Education x Nature contact	0.11778	0.733	0.19976	0.648	724.89	0.801
Time x Sex x Age	558.97	0.952	0.12892	0.885	0.16881	0.825
Time x Sex x Education	0.19867	0.815	0.16121	0.86	15106	0.229
Time x Sex x Nature contact	0.12759	0.887	0.5919	0.537	0.40413	0.674
Time x Age x Education	0.23891	0.777	0.77832	0.465	11687	0.265
Time x Age x Nature contact	0.22737	0.796	0,77011	0.455	588.55	0.944
Time x Education x Nature contact	11948	0.287	14537	0.214	0.36744	0.698
Sex x Age x Education	203.96	0.884	24399	0.12	21227	0.151
Sex x Age x Nature contact	942.16	0.743	27264	0.101	0.59801	0.42
Sex x Education x Nature contact	63028	**0.011**	34643	0.065	45173	**0.031**
Age x Education x Nature contact	0.13425	0.714	0.41963	0.519	89.05	0.77
Time x Sex x Age x Education	0.26343	0.779	0.32579	0.724	0.91012	0.417
Time x Sex x Age x Nature contact	0.10286	0.904	19094	0.148	0.7476	0.505
Time x Sex x Education x Nature contact	0.82229	0.444	0.22631	0.809	0.46871	0.627
Time x Age x Education x Nature contact	0.10138	0.902	587.35	0.932	0.39267	0.656
Sex x Age x Education x Nature contact	0.15291	0.665	386.91	0.857	40949	**0.039**
Time x Sex x Age x Education x Nature contact	0.38767	0.7	0.68597	0.508	12407	0.307

773

Figure captions

Figure 1. Locations where the Glocal Education project was performed: Nosy Be island, in Madagascar, and Dhiggiri and Maayafushi islands, Maldives.

Figure 2. Average scores of sustainability variables (knowledge, attitude, awareness) in time (T_0, T_1, T_2). Brackets with asterisks indicate significant differences between two groups: *** ($p < 0.001$). The box indicates the 25th and 75th percentiles, the line within the box marks the median, and the cross is the average. Whisker length is equal to 1.5 × interquartile range. N = 194.

Figure 3. Correlation plots between sustainability variables (knowledge, attitude, awareness) and psychological variables (satisfaction, identification, intention) at T_1. Only significant ($p<0.05$) regressions are drawn. n: number of participants; Rho: Spearman's rank correlation coefficient; p: p-value.

Figure 4. Correlation plots between sustainability variables (knowledge, attitude, awareness) and psychological variables (satisfaction, identification, intention) at T_2. Only significant ($p<0.05$) regressions are drawn. n: number of participants; Rho: Spearman's rank correlation coefficient; p: p-value.

Figure 5. Correlation plots between sustainability variables (knowledge, attitude, awareness) at T_2 and psychological variables (satisfaction, identification, intention) at T_1. Only significant ($p<0.05$) regressions are drawn. n: number of participants; Rho: Spearman's rank correlation coefficient; p: p-value.

Figure 1.JPEG

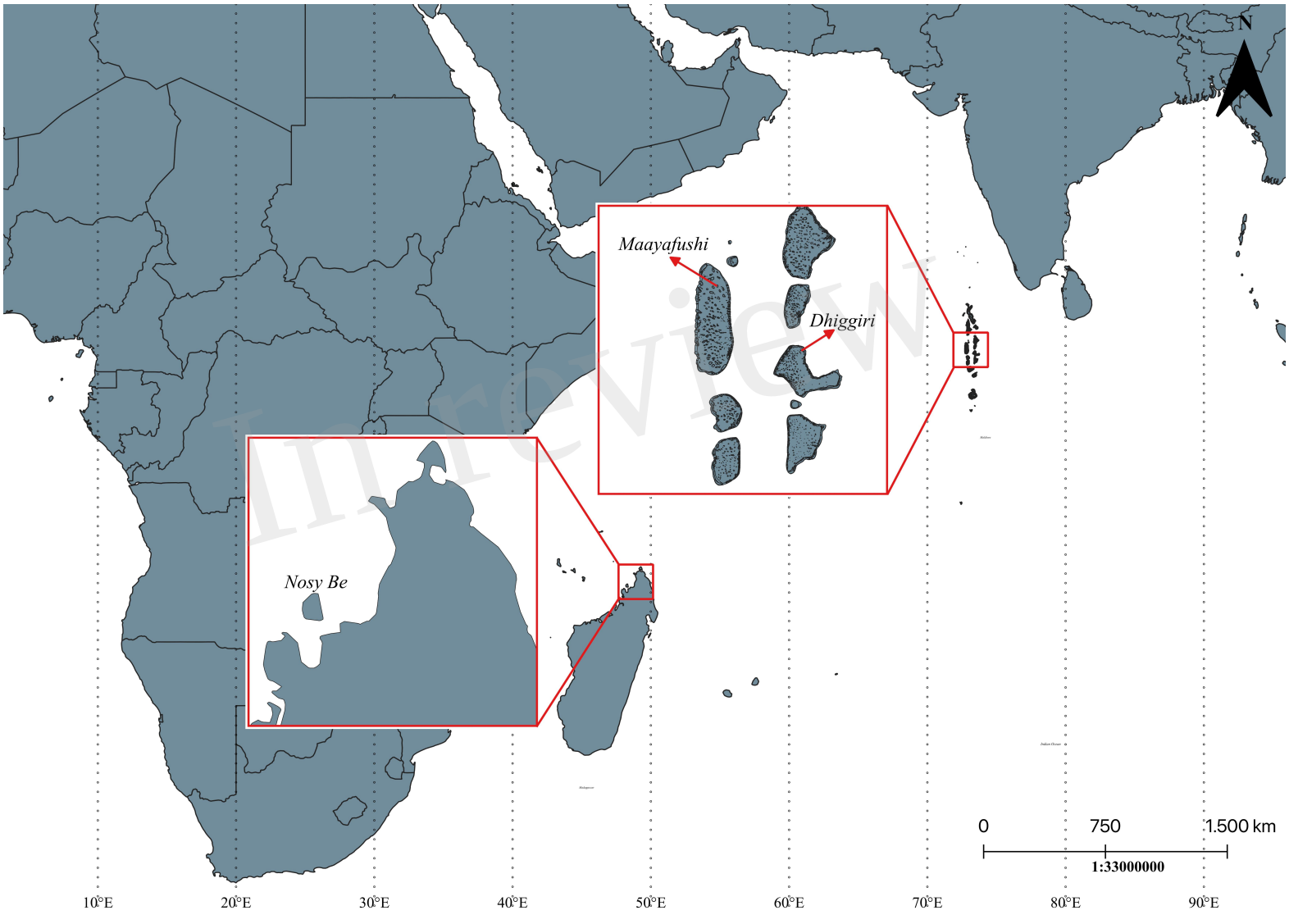
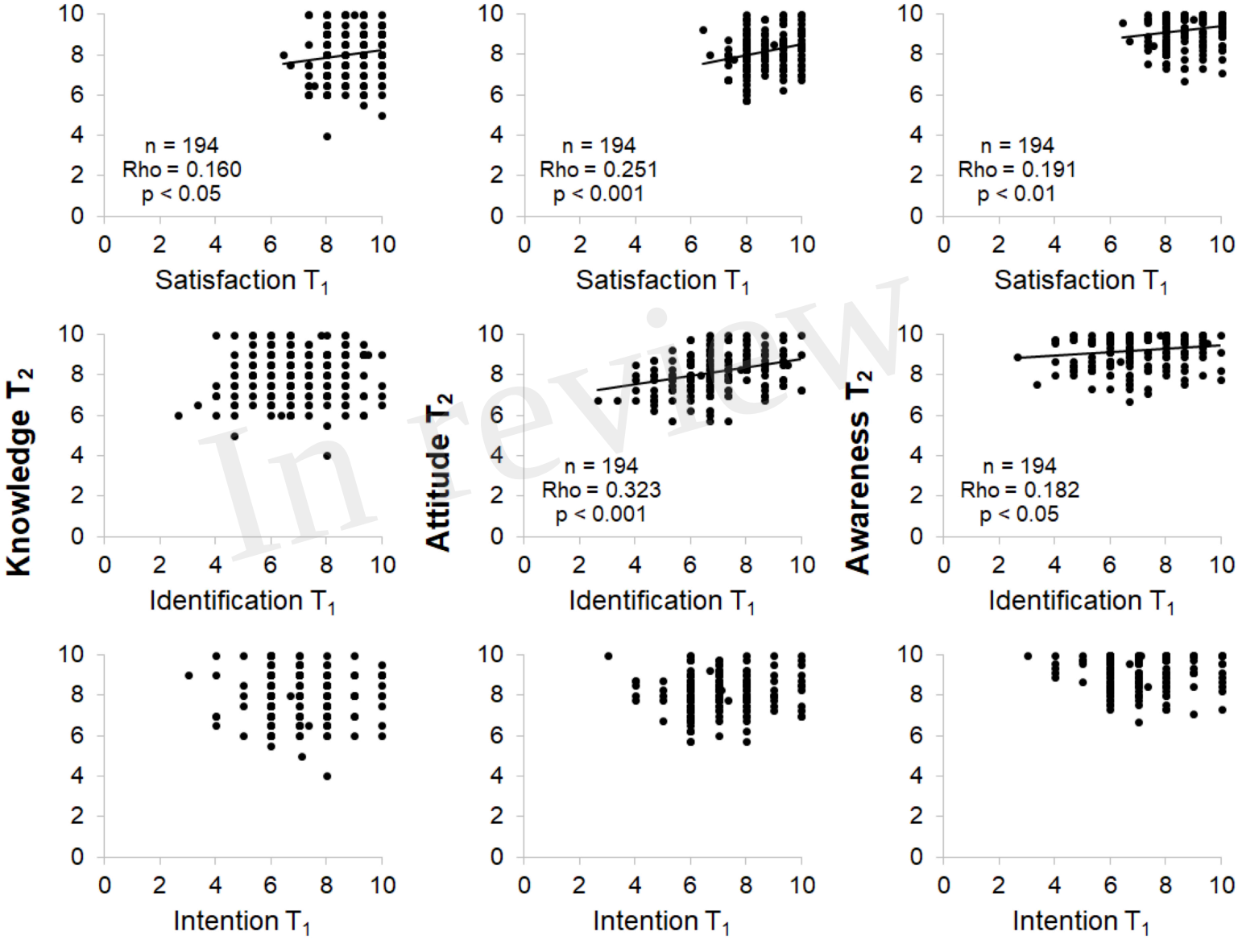


Figure 2.JPEG



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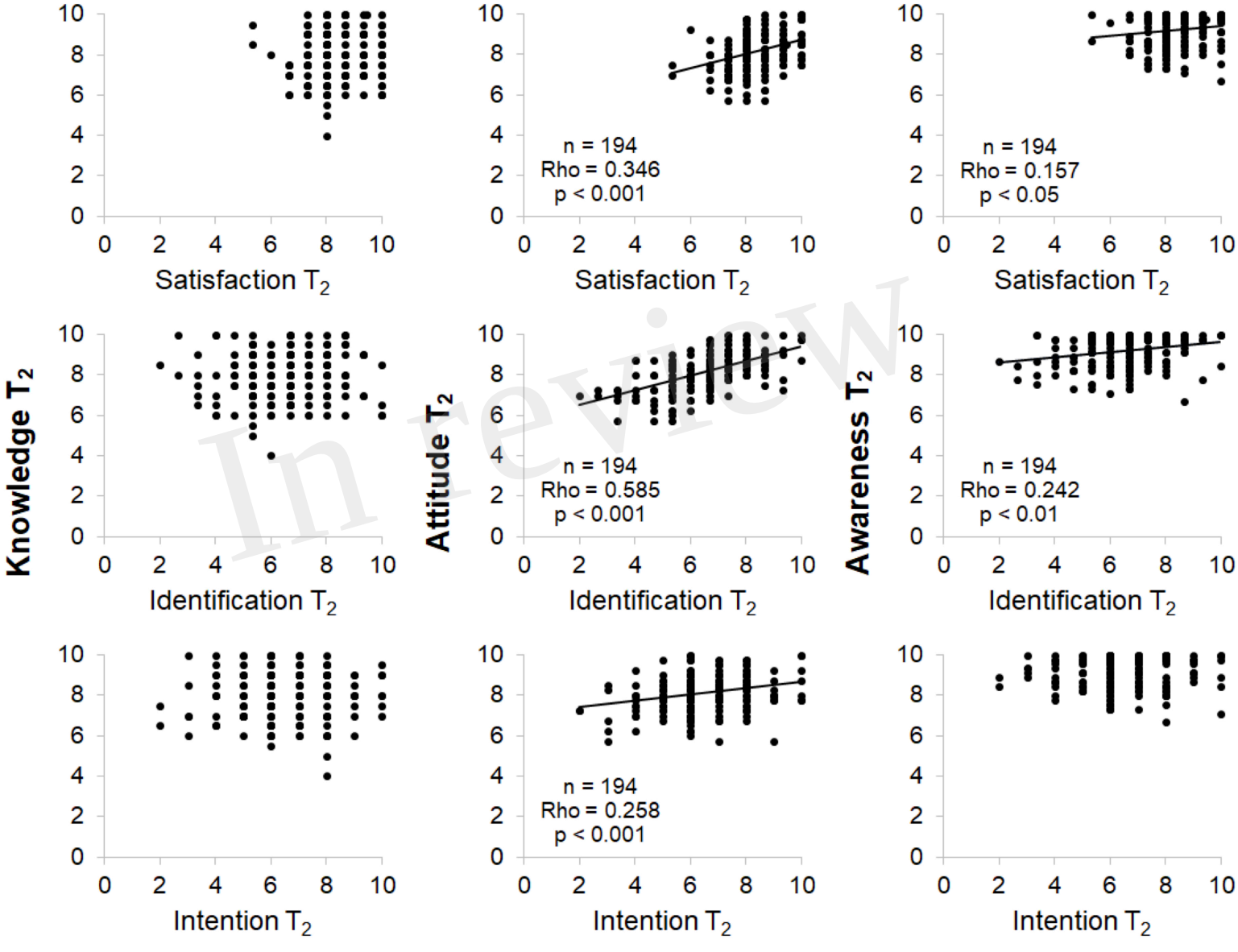


Figure 4.JPEG

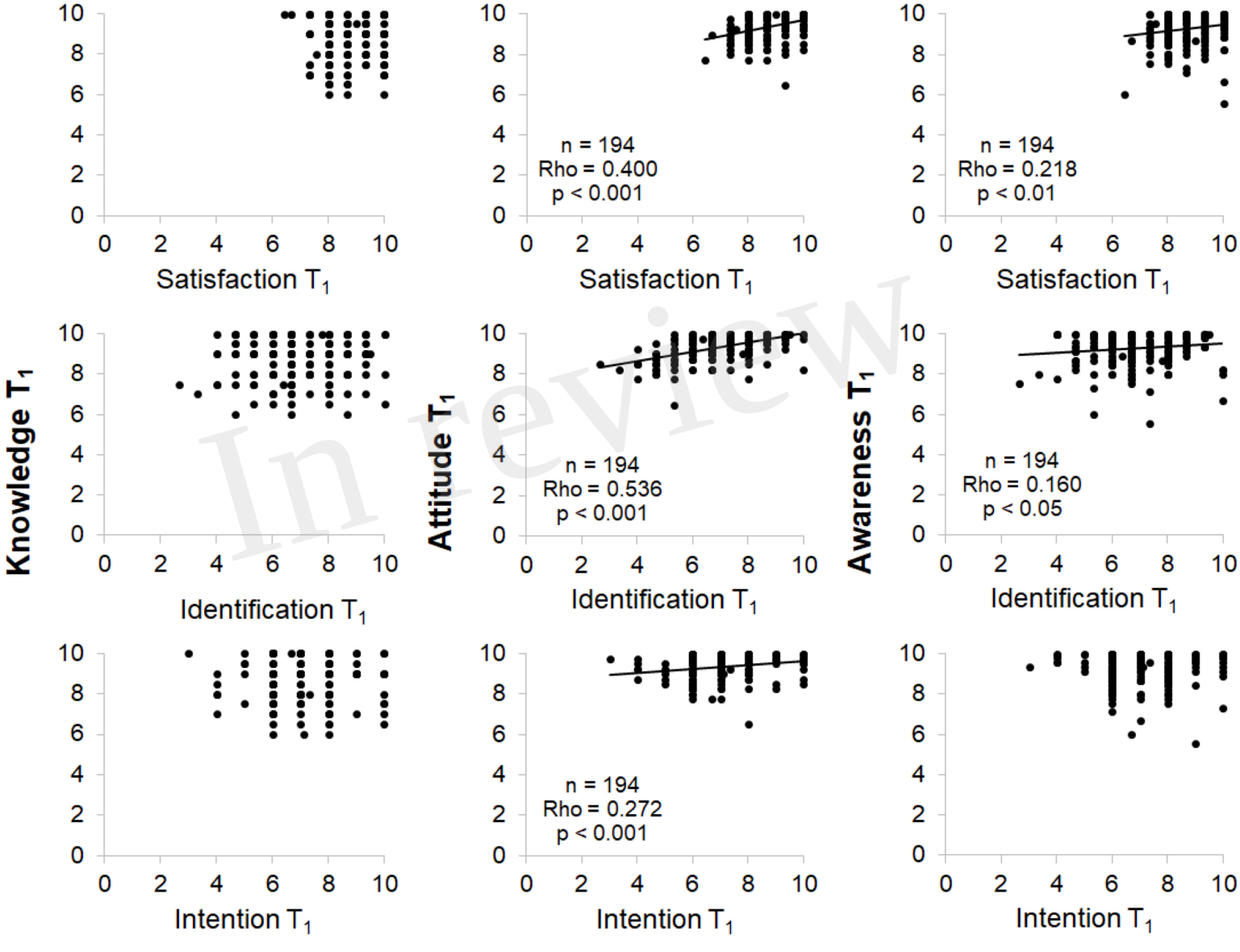
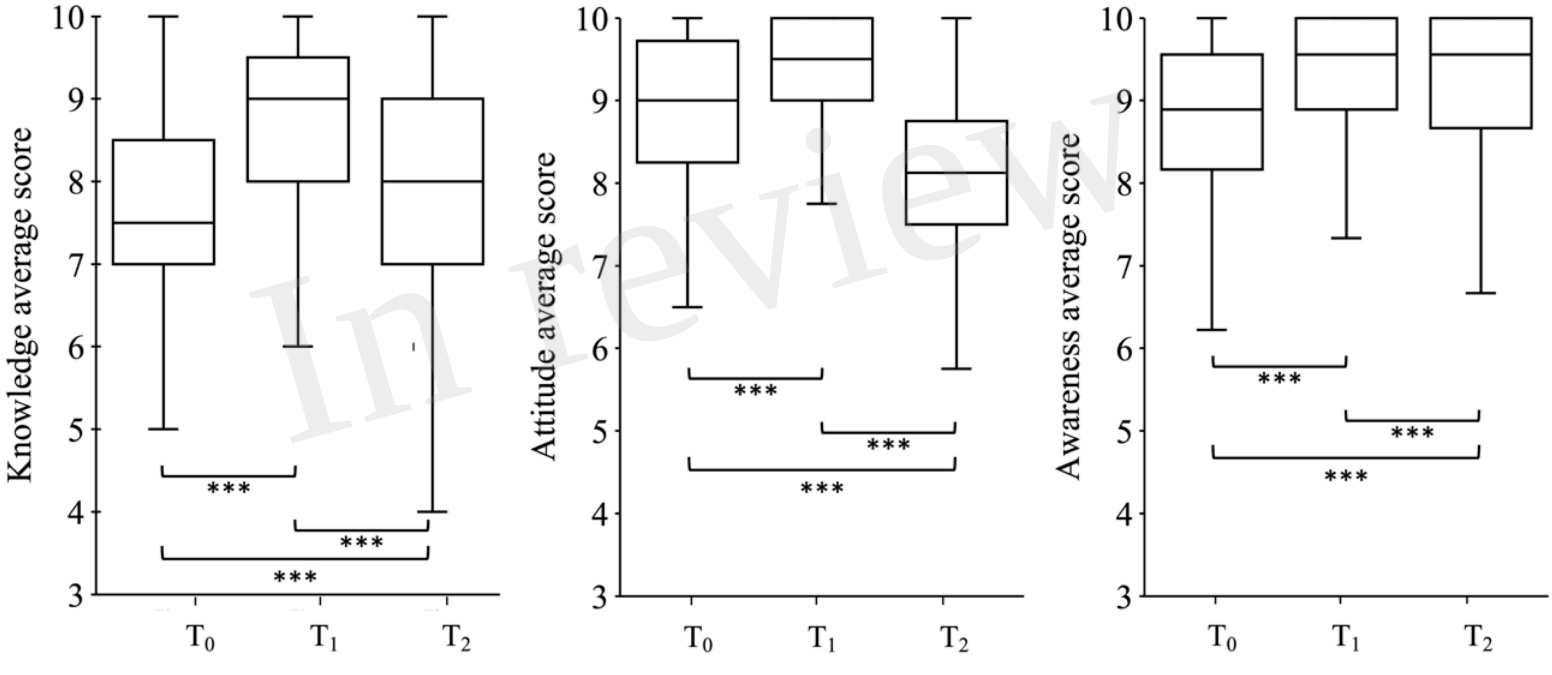


Figure 5.JPEG



Supplementary Material

Date_____

ENVIRONMENTAL EDUCATION EVALUATION QUESTIONNAIRE

SECTION A - The personal data collected through the questionnaire is to be used only for scientific research purposes and will be treated anonymously.

FULL NAME: _____ GENDER: M ☐ F ☐

BIRTH YEAR: _____ NATIONALITY: _____

ADDRESS:_____

E-MAIL: _____

EDUCATION: ☐ Elementary School Diploma ☐ High School Diploma
☐ Undergraduate Degree ☐ Master's Degree
☐ PhD

HAVE YOU EVER VISITED THIS DESTINATION BEFORE? ☐ Yes ☐ No

HOW OFTEN DO YOU TAKE PART IN NATURE-RELATED ACTIVITIES?

☐ Up to 3 times a year ☐ At least once a month ☐ Up to 3 times a month
☐ At least once a week ☐ More than once a week

Supplementary Figure 1. Demographical data section, present in questionnaire T_0.

SECTION B - For each of the following sentences choose "true" (T), "false" (F) or "I don't know" (DK)

	T	F	DK
1. Corals are animals			
2. Whale sharks are mammals (DH, MY) / Chameleons change color according to temperature, light, and their mood (NB)			
3. Freshwater use needs to be limited in the Maldives (DH, MY) / in Madagascar (NB)			
4. Even when wild animals seem harmless and friendly, it is best to avoid touching them			
5. Sea turtles are amphibians (DH, MY) / Madagascar's flora and fauna are threatened by long periods of drought (NB)			
6. The purchase of souvenirs or direct harvesting of coral reef organisms (such as shells, sea stars, etc.) is harmful to the coral reef			
7. Coral reefs are threatened by sea tides and marine predators (DH, MY) / The flowers of the vanilla orchid wilt after one day if not pollinated (NB)			
8. Despite being an herbivore, the parrot fish is one of the biggest contributors to sand formation (DH, MY) / Lemurs are considered at risk of extinction (NB)			
9. Feeding animals can help them survive			
10. My touristic activity impacts the environment only through direct contact with the nature that surrounds the destination I am visiting			

Supplementary Figure 2. Knowledge section of questionnaires T_0, T_1 and T_2 for the localities of Dhiggiri (DH), Maayafushi (MY), the Maldives, and Nosy Be (NB), Madagascar.

SECTION C – For each of the following statements, please indicate to what degree you would be willing to:

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
11. Attend nature-related lectures					
12. Touch wildlife during excursions					
13. Advise others to dispose of waste responsibly					
14. Advise my close ones to not waste water					
15. Participate in excursions with the Glocal Education biologists					
16. Take home souvenirs made from natural resources					
17. Advertise the Glocal Education initiative to others					
18. Get to know the ecosystems on the destinations I visit					

Supplementary Figure 3. Attitude section of questionnaires T_0, T_1 and T_2 for all 3 localities.

SECTION D - For each of the following sentences, please indicate the answer best corresponding to your opinion. During excursions:

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
19. I feel guilty in touching the animals					
20. I feel I act responsibly by not taking sand home as a souvenir					
21. I feel comfortable feeding the animals					
22. I feel I act responsibly by not feeding the animals					
23. I feel guilty in taking sand home as a souvenir					
24. I feel comfortable touching the animals					
25. I feel guilty in feeding the animals					
26. I feel I act responsibly by not touching the animals					
27. I feel comfortable in taking sand home as a souvenir					

Supplementary Figure 4. Awareness section of questionnaires T_0, T_1 and T_2 for all 3 localities.

SECTION E - Please indicate in what measure you agree with the following statements:

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
28. The Glocal Education activities have met my expectations					
29. I feel my ideas are respected by the Glocal Education project group					
30. I feel satisfied with having participated in the Glocal Education initiative					
31. I'm happy to be a participant in the Glocal Education project					

Supplementary Figure 5. Satisfaction section of questionnaires T_1 and T_2 for all 3 localities.

SECTION F - Please indicate in what measure you agree with the following statements:

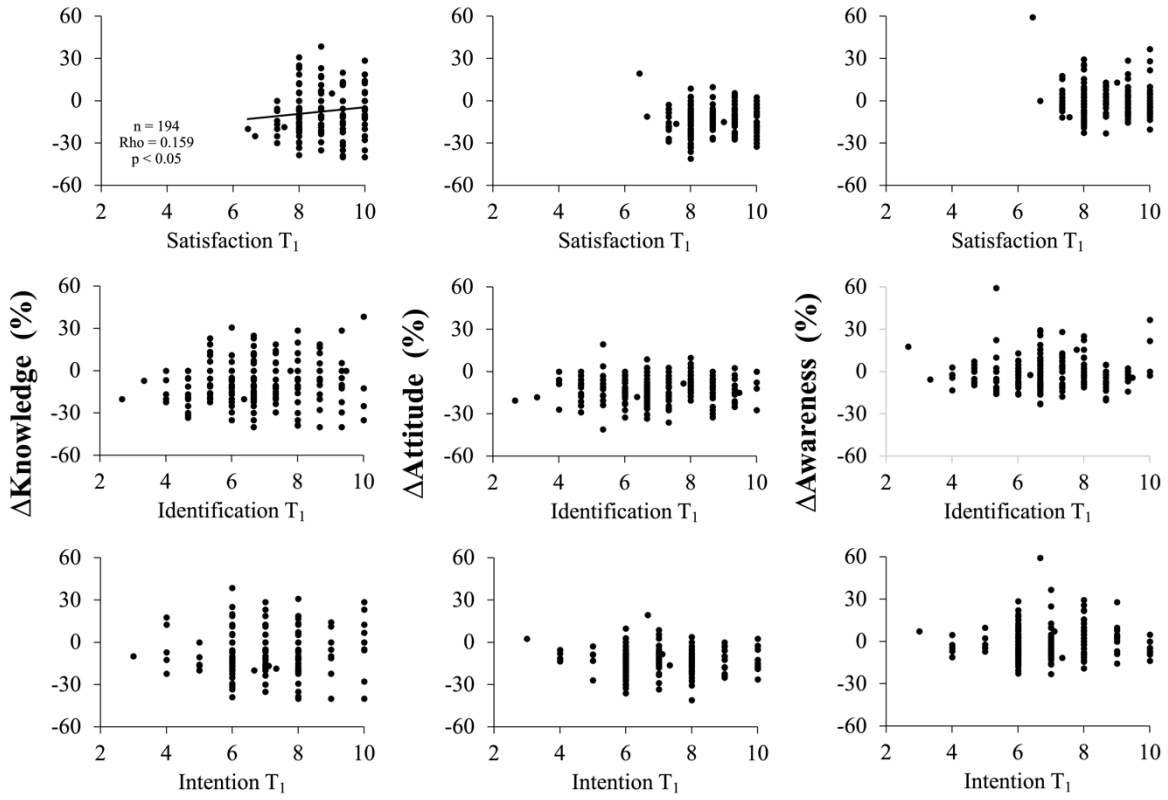
	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
32. When I talk about the ideas of the Glocal Education project, I use "us" and not "them"					
33. I am proud to consider myself a supporter of the Glocal Education project					
34. When someone speaks ill of the Glocal Education or similar project, it is as if they did it to me					
35. I share the ideas behind the Glocal Education project					

Supplementary Figure 6. Identification section of questionnaires T_1 and T_2 for all 3 localities.

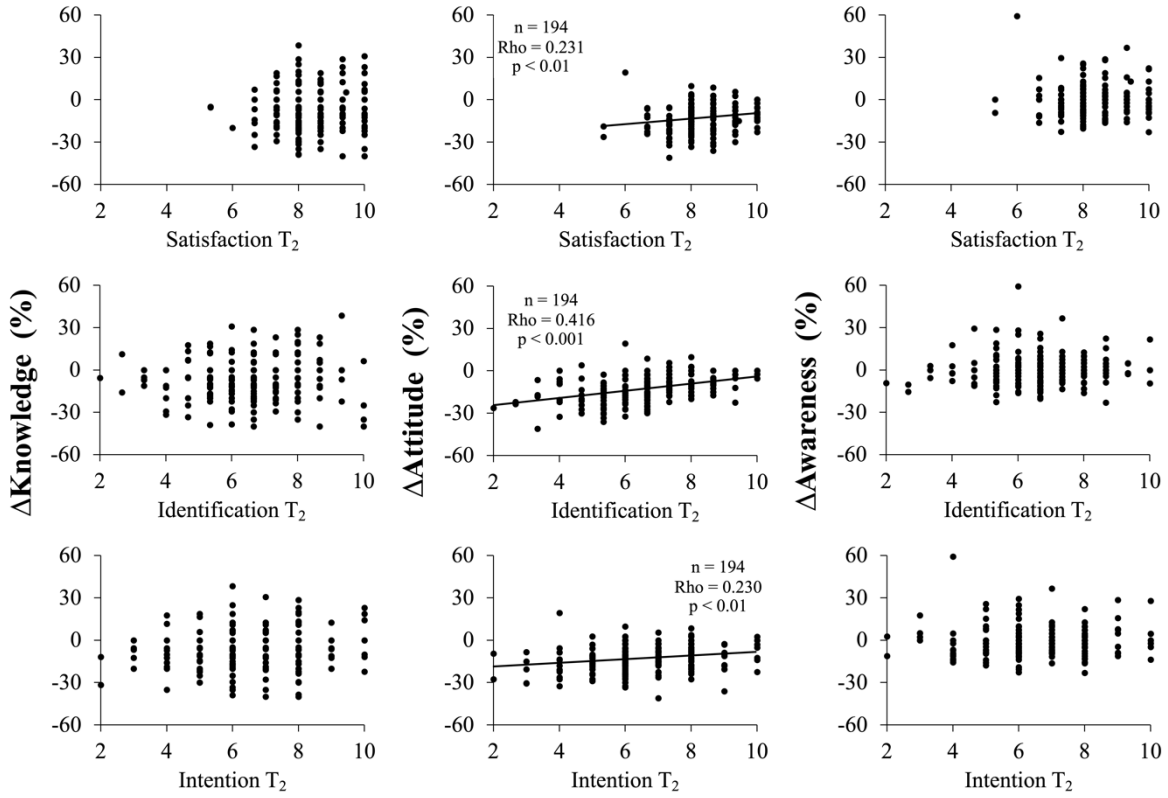
SECTION G - Please indicate in what measure you agree with the following statements:

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
36. When choosing the tour operator for my next vacation, I will check for the presence of an environmental education project					
37. I will go on vacation with Francorosso again next year					
38. I will go on vacation with Francorosso again over the next 3 years					

Supplementary Figure 7. Intention section of questionnaires T_1 and T_2 for all 3 localities.



Supplementary Figure 8. Correlation plots between percent variation (Δvariable %) of sustainability variables (knowledge, attitude, awareness), calculated as in paragraph 2.3, and psychological variables (satisfaction, identification, intention) at T1. Only significant ($p<0.05$) regressions are drawn. n: number of participants; Rho: Spearman's rank correlation coefficient; p: p-value.



Supplementary Figure 9. Correlation plots between percent variation (Δvariable %) of sustainability variables (knowledge, attitude, awareness), calculated as in paragraph 2.3, and psychological variables (satisfaction, identification, intention) at T_2. Only significant ($p<0.05$) regressions are drawn. n: number of participants; Rho: Spearman's rank correlation coefficient; p: p-value.

Supplementary Table 1. List of items from the environmental education evaluation questionnaire with corresponding values of Cronbach's α for each measure of the variable in time.

Variable	Item number	Item	Reliable items	Cronbach's α[c]		
				T_0	T_1	T_2
Attitude	11	Attend nature-related lectures	x[a]	0.534	0.688	0.567
	12	Touch wildlife during excursions	(r)[b]			
	13	Advise others to dispose of waste responsibly	x[a]			
	14	Advise my close ones to not waste water	x[a]			
	15	Participate in the excursions with the Glocal Education	x[a]			
	16	Take home souvenirs made from natural resources	(r)[b]			
	17	Advertise the Glocal Education initiative to others	x[a]			
	18	Get to know the ecosystems on the destinations I visit	x[a]			
Awareness	19	I feel guilty in touching the animals	x[a]	0.740	0.743	0.722
	20	I feel I act responsibly by not taking sand home as a	x[a]			
	21	I feel comfortable feeding the animals	(r)[b]			
	22	I feel I act responsibly by not feeding the animals	x[a]			
	23	I feel guilty in taking sand home as a souvenir	x[a]			
	24	I feel comfortable touching the animals	(r)[b]			
	25	I feel guilty in feeding the animals	x[a]			
	26	I feel I act responsibly by not touching the animals	x[a]			
	27	I feel comfortable in taking sand home as a souvenir	(r)[b]			
Satisfaction	28	The Glocal Education activities have met my expectations	x	NA	0.701	0.706
	29	I feel my ideas are respected by the Glocal Education	x[a]			
	30	I do not feel satisfied with having participated in the	(r)[b]			
	31	I'm happy to be a participant in the Glocal Education	x[a]			
Identification	32	When I talk about the ideas of the Glocal Education	x[a]	NA	0.694	0.675
	33	I am proud to consider myself a supporter of the Glocal	x[a]			
	34	When someone speaks ill of the Glocal Education or	x[a]			
	35	I do not share the ideas behind the Glocal Education	(r)[b]			
Intention	36	When choosing the tour operator for my next vacation, I		NA	0.658	0.679
	37	I will go on vacation with Francorosso again next year	x[a]			
	38	I will go on vacation with Francorosso again over the next	x[a]			

a. Reliable items.
b. Reverse items, formulated in negative phrasing, reversed scored for analysis.
c. Acceptable scores: Cronbach $\alpha > 0.50$.

PERMANOVA analysis to test for the effects of demographic factors and factor time on sustainability variables showed no interaction between time and any of the demographic factors ($p > 0.05$) for all tested variables (Table 2), therefore the effect of factor time on all variables was independent from demographic categories. Significant interaction terms were found amongst demographic factors. Pairwise comparisons were conducted on significant interactions in the case of knowledge and awareness, and for the single demographic factor age in the case of attitude. Average scores were compared to interpret results.

For the variable knowledge, significant demographic effects were found for the interacting terms Sex x Education x Nature contact ($p < 0.05$, Table 2) and Age x Nature contact ($p < 0.001$, Table 2).

Pairwise comparisons (Supplementary Table 4 & 5) and respective comparisons of average scores (Supplementary Table 6 & 7) revealed that 7 out of 12 cases were non-significative ($p > 0.05$), and amongst significative cases (5 out of 12, $p < 0.05$) there were no clear patterns among demographic groups.

Supplementary Table 2. Pairwise comparisons[a] of knowledge scores for interacting factors Sex x Education x Nature contact.

Pairwise Comparison	t	p	Unique permutations
Male vs Female	Within College, Non naturalists		
	2989	0.001	993
	Within College, Naturalists		
	0.89828	0.361	993
	Within High school, Non naturalists		
	13664	0.171	999
	Within High school, Naturalist		
	25148	0.016	987
High school vs College	Within Males, Non naturalists		
	40692	0.001	996
	Within Males, Naturalists		
	10831	0.287	996
	Within Females, Non naturalists		
	820	0.928	996
	Within Females, Naturalists		
	29722	0.005	996
Non Naturalist vs Naturalist	Within Males, College		
	0.22924	0.814	998
	Within Males, High school		
	16724	0.102	996
	Within Females, College		
	10503	0.304	997
	Within Females, High school		
	22881	0.018	994

a. Significant comparisons ($p < 0.05$) are indicated in bold.

Supplementary Table 3. Pairwise comparisons[a] of knowledge scores for interacting factors Age x Nature contact.

Pairwise Comparison	t	p	Unique permutations
Under 40 vs Over 40	Within Non naturalists		
	0.98094	0.341	998
	Within Naturalists		
	26467	0.009	994
Non naturalist vs Naturalist	Within Over 40		
	24318	0.019	996
	Within Under 40		
	16368	0.107	998

a. Significant comparisons ($p < 0.05$) are indicated in bold.

Supplementary Table 4. Knowledge average score divided by levels of the interacting factors Sex x Education x Nature contact with the 95% Confidence Interval (CI).

Demographic group	N	Average	95% CI
Male, College, Non naturalist	78	8.5	8.3-8.7
Male, College, Naturalist	36	8.6	8.2-9.0
Male, High School, Non naturalist	81	7.7	7.4-8.1
Male, High School, Naturalist	54	8.3	8.0-8.6
Female, College, Non naturalist	111	8.0	7.8-8.3
Female, College, Naturalist	57	8.3	8.0-8.6
Female, High School, Non naturalist	102	8.1	7.8-8.3
Female, High School, Naturalist	63	7.7	7.4-8.1

Supplementary Table 5. Knowledge average score divided by levels of the interacting factors Age x Nature contact with the 95% Confidence Interval (CI).

Demographic group	N	Average	95% CI
40 and Over, Non naturalist	189	8.0	7.8-8.2
40 and Over, Naturalist	141	8.3	8.1-8.5
Under 40, Non naturalist	183	8.1	8.0-8.3
Under 40, Naturalist	69	7.8	7.6-8.1

For the variable attitude, the effect of factor Age ($p < 0.01$, Table 2) was analyzed by comparing average scores amongst demographic groups (Supplementary Table 8). While the factor age was statistically significant, difference in average scores was below the set threshold (0.5), therefore there was no actual educational effect.

Supplementary Table 6. Attitude average scores divided by levels of the factor age with the 95% Confidence Interval (CI).

Demographic group	N	Average	95% CI
Under 40	252	8.7	8.6-8.8
40 and Over	330	8.9	8.8-9.0

For the variable awareness, significant demographic effects were found in the interacting terms Sex x Age x Education x Nature contact ($p < 0.05$, Table 2) and therefore were analyzed within pairwise comparison (Supplementary Table 9) and comparison of average scores (Supplementary Table 10). 28 out of 32 cases were non-significative ($p > 0.05$) and among significant cases (4 out of 32, $p < 0.05$) there were no clear patterns for demographic effects on the variable awareness.

Supplementary Table 7. Pairwise-comparisons[a] of awareness scores for interacting factors Sex x Age x Education x Nature contact.

Pairwise Comparison	t	p	Unique permutations
Male vs Female	Within Over 40, College, Non naturalists		
	0.4851	0.646	986
	Within Over 40, College, Naturalists		
	0.88471	0.367	989
	Within Over 40, High school, Non naturalists		
	19.935	0.045	981
	Within Over 40, High school, Naturalists		
	1.565	0.127	977
	Within Under 40, College, Non naturalists		
	7.05E+01	0.924	976
	Within Under 40, College, Naturalists		
	12.437	0.231	960
	Within Under 40, High school, Non naturalists		
	1.469	0.151	987
	Within Under 40, High school, Non naturalists		
	18.347	0.07	968
Under 40 vs Over 40	Within Males, College, Non naturalists		
	0.58347	0.545	996
	Within Males, College, Naturalists		
	12.993	0.211	938
	Within Males, High school, Non naturalists		
	0.93964	0.36	954
	Within Males, High school, Non naturalists		
	10.354	0.275	977
	Within Females, College, Non naturalists		
	14.479	0.143	964
	Within Female, College, Naturalists		
	0.78517	0.444	971
	Within Female, High school, Non naturalists		
	0.89913	0.369	989
	Within Female, High school, Non naturalists		
	27.001	0.015	980
	0.87074	0.422	991
	Within Males, Under 40, Naturalists		
	10.826	0.302	972
	Within Females, Over 40, Non naturalists		
	0.18963	0.838	963

a. Significant comparisons ($p < 0.05$) are indicated in bold.

Supplementary Table 7 (Continued). Pairwise comparisons[a] of awareness scores for interacting factors Sex x Age x Education x Nature contact.

a.

Pairwise Comparison	t	p	Unique permutations
High school (or lower) vs College	Within Males, Over 40, Non naturalists		
	0.63195	0.493	988
	Within Males, Over 40, Naturalists		
	10.342	0.323	990
	Within Males, Under 40, Non naturalists		
	0.87074	0.422	991
	Within Males, Under 40, Naturalists		
	10.826	0.302	972
	Within Females, Over 40, Non naturalists		
	0.18963	0.838	963
	Within Females, Over 40, Naturalists		
	0.43989	0.646	988
	Within Females, Under 40, Non naturalists		
	0.99123	0.317	986
	Within Females, Under 40, Naturalists		
	21.637	0.038	979
Non naturalist vs Naturalist	Within Males, Over 40, College		
	0.88559	0.347	982
	Within Males, Over 40, High school		
	0.76272	0.457	978
	Within Males, Under 40, College		
	0.17822	0.868	990
	Within Males, Under 40, High school		
	20.209	0.052	977
	Within Females, Over 40, College		
	10.531	0.304	988
	Within Females, Over 40, High school		
	0.77979	0.462	990
	Within Females, Under 40, College		
	21.294	0.043	959
	Within Females, Under 40, High school		
	12.393	0.229	986

Significant comparisons ($p < 0.05$) are indicated in bold.

Supplementary Table 8. Attitude average scores divided by levels of the interacting factors Sex x Age x Education x Nature contact

Demographic group	N	Average	95% CI
Male, Over 40, College, Non naturalist	45	9.1	8.7-9.4
Male, Over 40, College, Naturalist	27	9.3	9.0-9.5
Male, Over 40, High School, Non naturalist	54	8.9	8.7-9.2
Male, Over 40, High School, Naturalist	42	9.1	8.8-9.3
Male, Under 40, College, Non naturalist	33	8.9	8.6-9.2
Male, Under 40, College, Naturalist	9	8.9	8.0-9.7
Male, Under 40, High School, Non naturalist	27	8.7	8.4-9.1
Male, Under 40, High School, Naturalist	12	9.4	8.9-9.9
Female, Over 40, College, Non naturalist	24	9.2	8.8-9.6
Female, Over 40, College, Naturalist	30	9.4	9.2-9.6
Female, Over 40, High School, Non naturalist	66	9.2	9.0-9.4
Female, Over 40, High School, Naturalist	42	9.4	9.1-9.6
Female, Under 40, College, Non naturalist	87	8.9	8.7-9.1
Female, Under 40, College, Naturalist	27	9.3	9.0-9.6
Female, Under 40, High School, Non naturalist	36	9.1	8.8-9.4
Female, Under 40, High School, Naturalist	21	8.8	8.4-9.2

Supplementary Table 9. Average scores calculated for psychological variables (satisfaction, identification, intention) with the 95% Confidence Interval (CI) in each time (T_1, T_2), followed by Wilcoxon's test statistics[a] (Z).

Variable	Time	N	Average score	95% CI	Z	p
Satisfaction	T_1	194	8.7	8.6-8.8	-4.541	0.000
	T_2	194	8.3	8.2-8.5		
Identification	T_1	194	7.0	6.8-7.2	-3.563	0.000
	T_2	194	6.6	6.3-6.8		
Intention	T_1	194	7.0	6.8-7.2	-4.324	0.000
	T_2	194	6.5	6.3-6.7		

a. Significant comparisons ($p < 0.05$) are indicated in bold.

Supplementary Table 10. Spearman's rank correlation[a,b] analysis between sustainability variables (knowledge; attitude; awareness) and psychological variables (satisfaction; identification; intention).

Sustainability variables	n	Psychological variables					
		Satisfaction T_1		Identification T_1		Intention T_1	
		Rho	p value	Rho	p value	Rho	p value
Knowledge T_1	194	0.002	0.973	-0.011	0.877	-0.059	0.414
Attitude T_1	194	0.400	0.000	0.536	0.000	0.272	0.000
Awareness T_1	194	0.218	0.002	0.160	0.026	-0.006	0.933
		Satisfaction T_2		Identification T_2		Intention T_2	
		Rho	p value	Rho	p value	Rho	p value
Knowledge T_2	194	0.058	0.421	0.110	0.125	0.042	0.565
Attitude T_2	194	0.346	0.000	0.585	0.000	0.258	0.000
Awareness T_2	194	0.157	0.028	0.242	0.001	0.114	0.113
		Satisfaction T_1		Identification T_1		Intention T_1	
		Rho	p value	Rho	p value	Rho	p value
Knowledge T_2	194	0.160	0.026	0.096	0.185	0.005	0.947
Attitude T_2	194	0.251	0.000	0.323	0.000	0.097	0.180
Awareness T_2	194	0.191	0.008	0.182	0.011	0.042	0.562
		Satisfaction T_1		Identification T_1		Intention T_1	
		Rho	p value	Rho	p value	Rho	p value
ΔKnowledge (%)	194	0.159	0.027	0.098	0.174	0.081	0.261
ΔAttitude (%)	194	0.062	0.389	0.019	0.787	-0.051	0.482
ΔAwareness (%)	194	0.024	0.740	0.022	0.757	0.018	0.803
		Satisfaction T_2		Identification T_2		Intention T_2	
		Rho	p value	Rho	p value	Rho	p value
ΔKnowledge (%)	194	0.008	0.917	0.068	0.348	0.106	0.141
ΔAttitude (%)	194	0.231	0.001	0.416	0.000	0.230	0.001
ΔAwareness (%)	194	0.046	0.521	0.073	0.312	0.080	0.269

a. Variation of sustainability variables (Δvariable %) calculated as in paragraph 2.3.
b. Statistically significant correlations ($p < 0.05$) in bold.

CHAPTER 7.

TRENDS IN MEDITERRANEAN SEA ORGANISMS' DISTRIBUTION THROUGH DATA COLLECTED BY CITIZEN SCIENTISTS OVER A PERIOD OF 20 YEARS

Preliminary results

Trends in Mediterranean Sea organisms' distribution through data collected by citizen scientists over a period of 20 years

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Abstract

The Mediterranean Sea has an incredible diversity of ecosystems and species. Nowadays, it is threatened by a variety of stressors related to the ever-growing coastal population, urbanisation, agriculture, industry, shipping and fishing, leading to habitat degradation and loss, pollution, eutrophication and dumping of rubbish and waste. The biodiversity of the Mediterranean is changing and more research is needed to better understand how human activities will affect Mediterranean food webs, ecosystem functioning and ecosystem services. The Sea Sentinels - Divers United for the Environment project (DUE project) is a citizen science project that has been running since 2017 across the Mediterranean, with a particular focus on the Italian coasts, and aims to monitor marine biodiversity through the involvement of volunteers in data collection. This project is a continuation of the previous citizen science project 'Mediterranean Underwater Biodiversity Project' (SPA project) (2002-2005). Recreational divers were asked to complete a questionnaire recording the presence of animal and plant taxa and litter. From 2002 to 2005 (SPA project) and from 2017 to 2020 (DUE project), a total of 25,852 valid questionnaires were completed. About 68% of the stations (184 out of 271) were in a 'medium' environmental quality status.

Introduction

Despite its small size (0.82% of the surface area of the world's oceans and 0.32% of the volume), the Mediterranean Sea has an incredible diversity of ecosystems and species. It is considered a hotspot of marine biodiversity, with > 17,000 reported species, representing 7% of the world's biodiversity, of which between 25% and 30% are endemic Mediterranean species found nowhere else in the world[13] (Coll et al., 2010). The Mediterranean Sea is one of the most densely populated and highly

[13] https://www.rac-spa.org/biodiversity

urbanized coastal areas, with more than 450 million people living along its coasts[14]. In addition, it provides goods and services of fundamental importance to populations, such as: recreational activities, thus supporting the tourism industry; coastal protection; commercial and recreational fishing; and the well-being associated with different natural ecosystems (Liquete et al., 2016). However, the Mediterranean Sea is threatened by a variety of stressors related to the ever-growing coastal population, urbanisation, agriculture, industry, shipping and fishing, leading to habitat degradation and loss, pollution, eutrophication and dumping of waste and rubbish (Halpern et al., 2019; Danovaro et al., 2020). In interaction with climate change, these stress factors can act synergistically and influence the dynamics and possibly also the resilience of sensitive ecosystems (Danovaro et al., 2020). Mediterranean biodiversity is changing and more research is needed to better understand how human activities will affect Mediterranean food webs, ecosystem functioning and ecosystem services (Katsanevakis et al., 2014). In ecology, the term "biodiversity" is defined as the number of plant and animal species present in a place, region or ecosystem. A natural and unaltered habitat has a high degree of biodiversity because many species of plants and animals live there in ecological balance. In contrast, an unnatural or altered environment has a low degree of biodiversity because it is home to only a few species. Therefore, the level of biological diversity is an indication of the state of the environment. Monitoring is essential to understand the state of the environment and is therefore a prerequisite for the management and conservation of natural resources. Comprehensive conservation measures and large temporal and spatial-scale monitoring are necessary to obtain the data needed for effective management to prevent biodiversity loss due to human impacts and climate change (West and Salm, 2003). Government agencies and research institutions are often underfunded, but in some cases, Citizen Science can overcome the economic limitations of data collection by engaging citizens in monitoring programs while increasing their active participation in scientific research and environmental awareness (Goffredo et al., 2010; Branchini et al., 2015b, 2015a). If citizens are made aware and involved, they can participate in monitoring activities and thus contribute to the protection of these habitats.

Methods

“Sea Sentinels – Divers United for the Environment” (DUE project) is a citizen science project taking place throughout the Mediterranean Sea since 2017, with a particular focus on Italian coasts, aiming

[14] https://www.grida.no/resources/5900

to monitor marine biodiversity through volunteers' involvement in data collection. This project is a follow-up of the previous 'Mediterranean Underwater Biodiversity Project' (SPA project) [15] (2002-2005) citizen science project, with the objective to collecting and evaluating a long-time series of marine biodiversity data to compare the current biodiversity status with the results of the previous project. The methodology used here is the same of the SPA project to allow results comparisons. Please refer to Goffredo et al., (2010) for the full methodology description. This work presents some preliminary results of the DUE project that is still going on.

Questionnaire

Recreational divers were asked to complete a questionnaire that recorded the presence of animal and plant taxa, as well as litter. The questionnaire had three sections: i) one with photographs to identify the taxa surveyed, ii) one with a form to record the data (61 taxa were recorded: four plant and 57 animal), and iii) one with two infographics about some of the consequences caused by plastic litter on the marine ecosystem, to increase volunteers' awareness about the topic (this was added for the DUE project). As in previous work, the data required were general information about the investigator, the level of diving qualification, the diving agency that issued the diving license, technical information about the dive (location, date, time of day, depth, duration), the type of habitat studied (rocky bottom, sandy bottom or another habitat) and an estimate of the abundance of the organisms studied. For each taxon, we defined the level of abundance as "rare," "frequent," or "abundant" based on the frequency with which the taxon is normally encountered. Simple random sampling was used (i.e. volunteer divers conducted survey dives when and where it suited them, without specific project requirements). The profile of the dive (dive depth, time, route and safe diving practices) was also not changed for the surveys: divers conducted the dive as they normally do for recreational diving. During the survey dive, each diver was responsible for observing plants, invertebrates and fish, as well as litter. Shortly after the dive, each participant completed a data collection questionnaire. Completion of the questionnaires shortly after the dive and assistance from trained professional divers during data collection were key elements of the data quality control survey protocol. The divemasters and other instructors working with the volunteers had all attended the professional diver training courses.

Questionnaires were aggregated depending on the habitat type explored, and data from sandy and other seabed were not analised since the rocky seabed was the habitat recorded in the highest number

[15] Goffredo, S., Pensa, F., Neri, P., Orlandi, A., Gagliardi, M. S., Velardi, A., ... & Zaccanti, F. (2010). Unite research with what citizens do for fun: "Recreational monitoring" of marine biodiversity. Ecological Applications, 20(8), 2170-2187.

of questionnaires, enabling spatiotemporal comparison. The questionnaires from rocky seabed were aggregated by the dive site.

To measure each survey station's environmental quality, the parameters calculated for each station were compared to those calculated for the Standard Reference Station (please refer to Goffredo et al., 2010 for full description of Standard Reference Station calculation).

Survey stations' parameter values calculated from data aggregated in 2002-2020 (SPA + DUE) were compared to the Reference Station's values. The Volunteers Marine Biodiversity Quality Index (V.MBQI) has five classes of environmental quality (please refer to Goffredo et al., 2010 for full description of V.MBQI calculation):

- very good (values from 0 to 0.125);
- good (from 0.126 to 0.375);
- mediocre (from 0.376 to 0.625);
- low (from 0.626 to 0.875);
- very low (from 0.876 to 1).

Statistical analysis and validation trials

To present the result of the analysis as a general aggregated value and ensure that aggregated values were representative of single years, V.MBQI was calculated for each year of the two research projects and compared with the ones of the aggregated analysis (2002-2020). The tests used were:

- Cronbach's alpha (α) correlation, where values above 0.6 were considered a level of adequate reliability (Flynn et al., 1994), and values above 0.7 are more definitive (Peterson 1994);
- Spearman's rank correlation coefficient (ρs).

Preliminary Results

From 2002 to 2005 (SPA project) and from 2017 to 2020 (DUE project), a total of 25,852 valid questionnaires, of which 82.4 % were collected from the rocky environment and led to the identification of 271 survey stations (Table 1). Most of the data collected came from the Italian coast, but also from Croatia, France, Greece, Malta, Slovenia, Spain and Turkey (Fig. 1). About 68% of the stations (184 out of 271) were found to be in the 'mediocre' environmental quality status, 15,1 % (41

stations) in the 'low' status, 12,2 % (33 stations) in the 'good' status, 4,8 % (13 stations) in the 'very low' status, and no stations were found to be in the 'very good' status (Fig. 2).

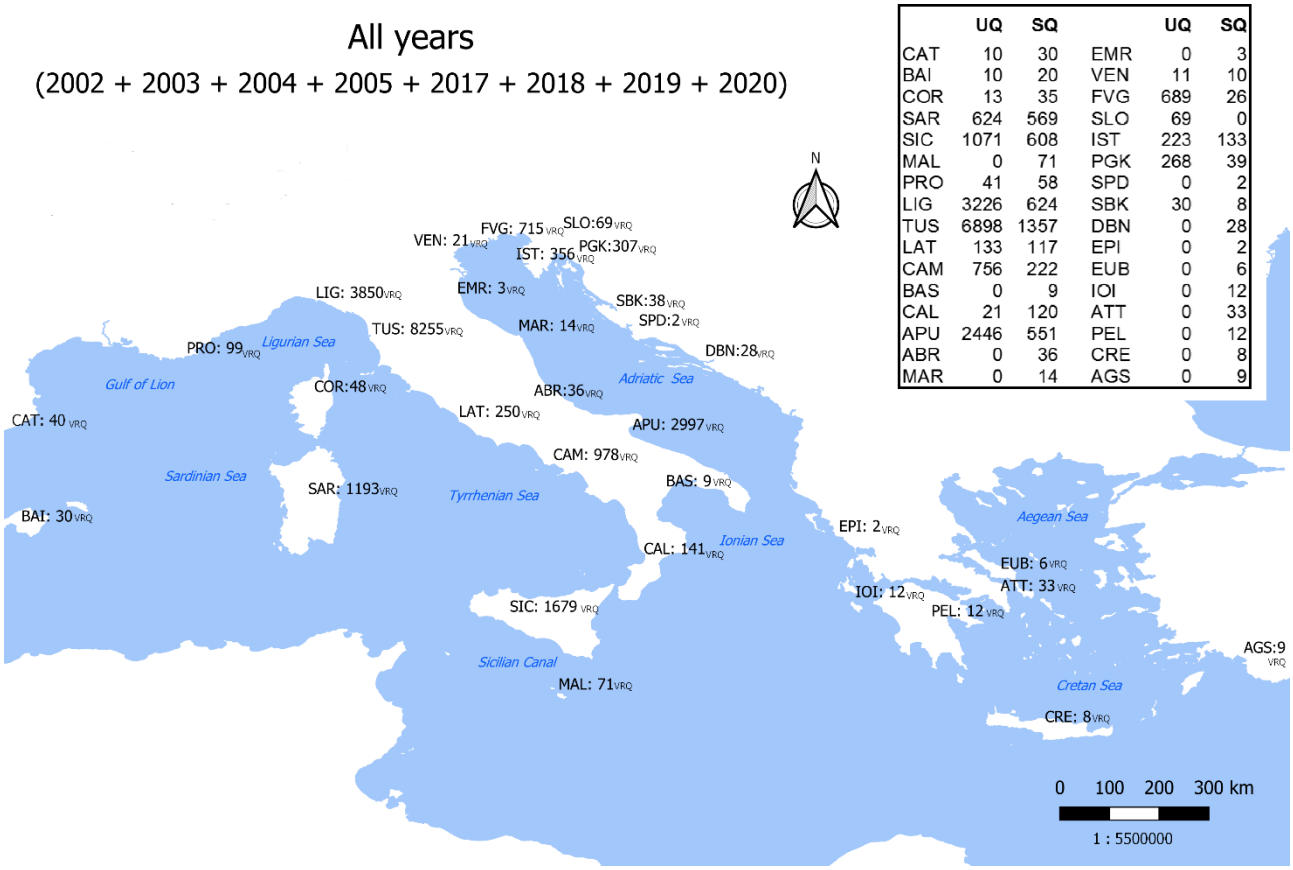
The results of the two correlation tests showed no significant differences between different year (Table 2), a part for the 2020 that reported a non-significant Spearman correlation with the aggregated scores.

Table 1. Distribution of survey effort performed by volunteer recreational divers in the eight years of research; only rocky bottom questionnaires were analised.

Year	N volunteer divers	Total valid questionnaires	Rocky bottom questionnaires	Sandy bottom questionnaires	Other habitat questionnaires
2002	936	3342	2847	387	108
2003	1615	6230	5544	428	258
2004	1214	5313	4699	452	162
2005	803	3872	3443	352	77
2017	686	1385	1215	108	62
2018	883	2521	1655	725	141
2019	937	2522	1589	800	133
2020	142	667	311	306	50
Total		25852	21303	3558	991
%			82.4	13.8	3.8

Table 2. Results of the two correlation tests performed to verify the representativeness of the aggregated data for each year of the two projects SPA and DUE. Cronbach's alpha > 0.6 represents effective representativeness. Spearman's rho is significant with P < 0.05*, P < 0.01**, P < 0.001***.

Year	Cronbach (α)	Spearman (ρ_S)
2002	0.757	0.531***
2003	0.928	0.806***
2004	0.839	0.658***
2005	0.816	0.668***
2017	0.714	0.511*
2018	0.837	0.455**
2019	0.665	0.494**
2020	0.708	0.544



	UQ	SQ		UQ	SQ
CAT	10	30	EMR	0	3
BAI	10	20	VEN	11	10
COR	13	35	FVG	689	26
SAR	624	569	SLO	69	0
SIC	1071	608	IST	223	133
MAL	0	71	PGK	268	39
PRO	41	58	SPD	0	2
LIG	3226	624	SBK	30	8
TUS	6898	1357	DBN	0	28
LAT	133	117	EPI	0	2
CAM	756	222	EUB	0	6
BAS	0	9	IOI	0	12
CAL	21	120	ATT	0	33
APU	2446	551	PEL	0	12
ABR	0	36	CRE	0	8
MAR	0	14	AGS	0	9

Figure 1. Geographic distribution of the survey effort performed on rocky bottom habitats over the eight years of research (2002–2005 + 2017-2020). The total number of valid recorded questionnaires (VRQ) was divided into useful questionnaires (UQ), those coming from survey stations, and sparse questionnaires (SQ), those coming from diving sites that failed to reach an annual quorum of 10 recorded questionnaires. Key to site abbreviations: APU, Apulia; ATT, Attica; BAI, Balearic Islands; BAS, Basilicata; CAL, Calabria; CAM, Campania; CAT, Catalonia; COR, Corsica; CRE, Crete; DAL, Dalmatia; EMR, Emilia-Romagna; EPI, Epirus; EUB, Euboea; FVG, Friuli-Venezia Giulia; IOI, Ionian Islands; IST, Istria; LAT, Latium; LIG, Liguria; MAL, Malta; MAR, Marches; PEL, Peloponnesus; PRO, Provence; SAR, Sardinia; SIC, Sicily; TUS, Tuscany; VEN, Veneto.

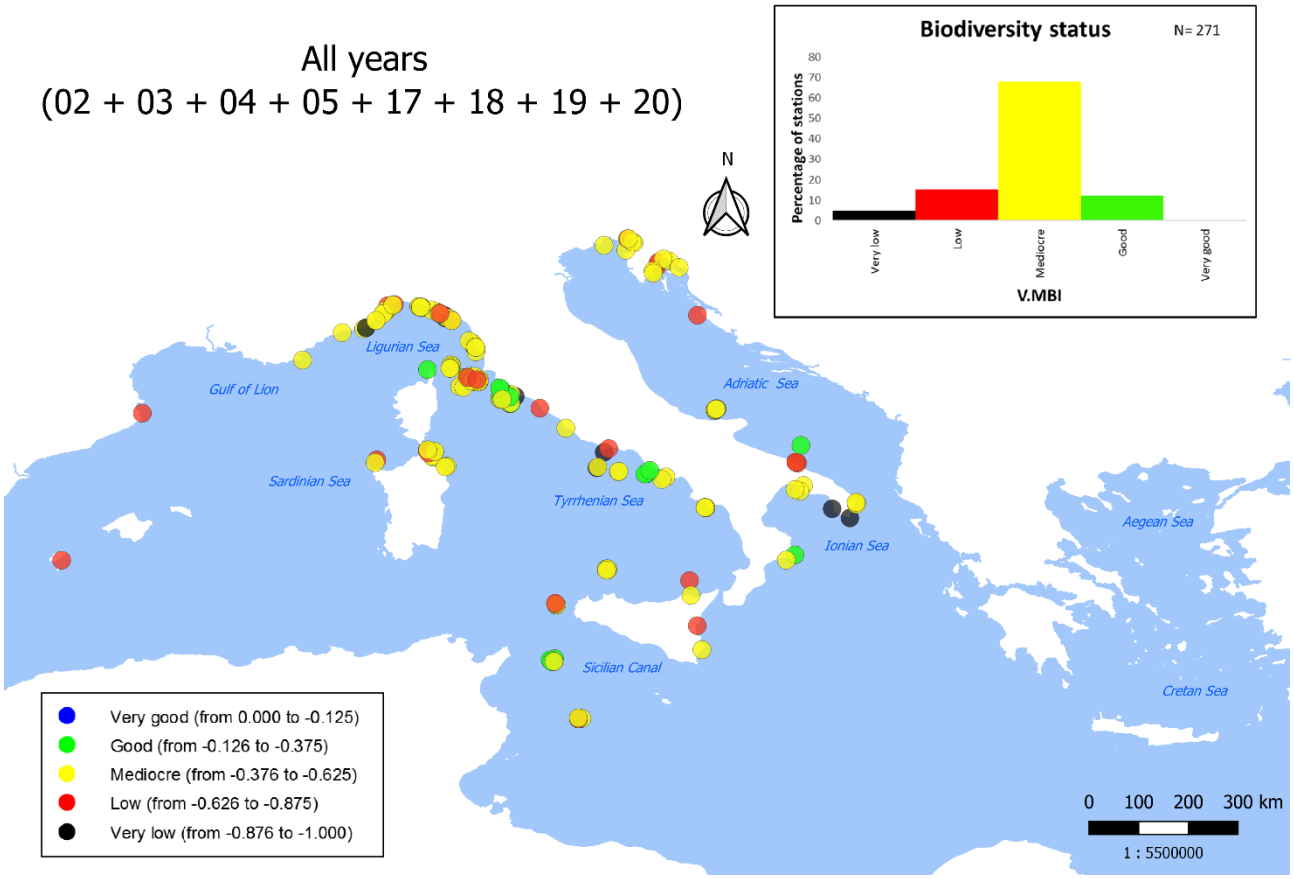


Figure 2. Marine biodiversity index (V.MBI) in the 271 stations surveyed in the eight years of research (2002–2005 + 2017-2020).

Discussion

Even if the DUE project collected far fewer questionnaires compared to the SPA project, the methodology used for both projects seem to be still appealing for volunteers. Most of the questionnaires collected in the SPA and DUE projects came from rocky bottoms, as they are often considered more interesting by divers and snorkelers, due to the better visibility and the higher number of species present compared to sandy bottoms and, unlike other types of bottoms (such as wrecks), more accessible also to less experienced divers (Goffredo et al., 2004, 2010; Branchini et al., 2015b). In 2020, we saw a significant reduction in the number of questionnaires collected (-73.5% compared to 2019), probably due to the impact that the COVID-19 epidemiological emergency also had on tourism.

In both the DUE project and the two SPA+DUE projects, most of the survey stations showed a "mediocre" status of the studied sites (similar to the results obtained in Goffredo et al., 2010), few stations were found to belong to the "very low" class and none to the "very good" class.

Here we presented the aggregated results of SPA + DUE projects (2002-2020) because the statistical analysis showed that the aggregated score is representative of the individual project years, apart from Spearman's rho for 2020 probably due to the low number of survey stations (only 9). Another hypothesis could be that in 2020 the pandemic brought to the abrupt interruption of almost all human activities (and maritime), and this have had an impact on the amount of data collected. These aspects will be further investigated on a project-specific basis in the coming months with a species-specific analysis of the distribution at SPA and DUE.

Conclusions

This work reinforces the importance of citizen science projects as a fundamental tool for environmental monitoring and management activities. This method could be applied in several countries by local governments and marine managers to implement large-scale, long-term conservation and management actions necessary in a rapidly changing world where climate change and anthropogenic uses of natural resources are causing environmental changes worldwide at an unprecedented rate.

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CHAPTER 8.

PEOPLE'S PERCEPTIONS OF NATURAL SITES, IMPLICATIONS FOR CONSERVATION PLANS

Manuscript in preparation

Peoples' perceptions of natural sites before and during COVID-19 pandemic for a more inclusive natural management

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Abstract

Nowadays, 55% of the world's population lives in urban areas. This has led to an extraordinary disconnect between people and the natural environment. Many people spend less than 10% of the day outdoors. Previous studies showed that frequent contact or recreational play in nature in childhood increases the sense of emotional connection with nature and influences interest in natural environments and outdoor activities in adulthood. The changes we have made to ecosystems over the last 70 years have led to the degradation of many ecosystems and are causing ever-increasing costs. Intensive human activities and land use changes have degraded ecosystem services and unwittingly created new pathways for the spread of disease (e.g. COVID -19). Protecting the environment, its biodiversity and ecosystem services means protecting our species. The aim of environmental policy and management should be to incorporate local people's relationships with nature into their strategies and to think about how people can be involved to reduce the negative impacts of their lifestyles on ecosystems and participate in positive change for the benefit of the environment. In this study, we wanted to explore how people perceive natural areas and what attributes are important to them in order to develop a broader understanding of what should be prioritised in managing and improving access, connectedness and enjoyment of natural areas. Another aim of this study was to determine whether perceptions of natural areas had changed as a result of the pandemic COVID -19. Ninety-seven Italian participants completed the project questionnaire between February 2020 and August 2020. The results showed that the frequency of visiting natural areas did not change in most cases before and during the COVID -19 pandemic, while it correlated with the frequency of visiting natural

areas in childhood. More than 60% of respondents said that the global COVID -19 pandemic had not changed their perception of the natural environment.

Introduction

In recent decades, the huge shift from people living mainly in rural areas to those living mainly in cities has resulted in more than 55% of the world's population living in urban areas. In 1950, 751 million people lived in cities, while the urban population in 2018 was 4.2 billion[16]. By 2050, the world population living in urban areas is expected to increase to 68%. While this massive 'westernisation' has doubled human life expectancy, it has led to an extraordinary disconnect between people and the natural environment (Maller et al., 2006). To describe this loss of engagement with nature and alienation from nature, nearly 30 years ago, Robert M Pyle termed it as the ‘extinction of experience’ (Soga and Gaston, 2016). For many people in industrialised nations and financially prosperous countries, less than 10% of the day is spent outdoors, participation in nature-based recreational activities is also declining being replaced by virtual alternatives (Capaldi et al., 2015; Soga and Gaston, 2016). Nowadays, children spend a lot of time in front of screens and less outdoors. A study conducted among American youth (aged 8-18) found that the average total media use (e.g. TV content, music/audio, computer, video games) was 7.38 hours per day in 2009 (Rideout et al., 2010). Frequent contact or recreational play in natural areas during childhood increases feelings of emotional connection with nature, influencing interest in natural environments and outdoor activities during adulthood. Indeed, was also found that the frequency of use of urban green spaces depends more on people's emotional attachment to nature than on the degree of green space coverage in the neighbourhood (Soga and Gaston, 2016).

The extinction of experience in nature is not only seen as a public-health issue, but also one of the fundamental obstacles to reversing global environmental degradation (Soga and Gaston, 2016). In fact, a reconnection between humans and nature is needed to mitigate current environmental problems (e.g. climate change) (Capaldi et al., 2015). There is growing evidence to support the age-old belief that connecting with nature promotes well-being and mental health. Indeed, without regular contact with nature, people miss out on some of these psychological benefits (Capaldi et al., 2015). The

[16] https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

disengagement with nature and too much artificial stimulation and living in a purely human environment can lead to exhaustion and a loss of vitality and health (Maller et al., 2006; Katcher and Beck, 2015). Human being seems to be totally dependent on nature not only for his material needs (e.g. food, water, shelter, etc.) but also for his psychological, emotional and spiritual needs (Frumkin, 2001; Maller et al., 2006). For these reasons, the natural environment or 'nature' as it is perceived, appreciated and used has increasingly become a relevant issue. There is a growing interest in understanding the multiple benefits of the natural environment for human health and well-being (Hoyle et al., 2019). Human well-being has several key components, including: i) basic material requirements for a good life (e.g. a secure and adequate livelihood, sufficient food at all times); ii) health (such as feeling well and having a healthy physical environment, clean air and access to clean water); iii) good social relations (e.g. social cohesion, mutual respect); iv) personal security (e.g. safe access to natural and other resources, personal safety); and v) freedom of choice and action (e.g. the opportunity to achieve what the individual values to do and be)[17].

Most of these components are closely linked to nature and the state of ecosystems. Capaldi et al., (2015) have put forward three important theories to explain the connection between nature and human well-being: biophilia, attention restoration and stress reduction. The first theory is based on the fact that humans have always lived in and been connected to the natural environment, so the need to connect with nature may remain an innate part of the human being. This also suggests that satisfying this need increase wellbeing. The attention restoration theory supports that after contact with nature there are improvements in concentration, attention and emotional functioning. The third theory is about the role of nature in stress-reduction, and it maintains that exposure to natural environments can decrease perceived stress levels and promote psychophysiological stress recovery. Maller et al., (2006) examined the potential use of human contact with nature as a health promotion intervention due to the worldwide increase of diseases and depression. Their findings suggest that nature plays an important role in human health and well-being and that parks and nature reserves play an important role in providing people with access to nature. Suggesting that contact with nature could be an effective population-wide strategy for preventing mental illness.

While the link between nature and human wellbeing could be easily visible and tangible, how the state of ecosystems relates to human wellbeing could result as a more cryptic concept. All the benefits that humans obtain from ecosystems, known as ecosystem services[18], are at the basis of human life

[17] https://millenniumassessment.org/documents/document.301.aspx.pdf

on the earth (Millennium Ecosystem Assessment, 2005). Ecosystem services affect human well-being and all its components cited above. The changes we have made to ecosystems in the last 70 years, due to increasing demands for food, fresh water, fuel, fiber and timber have substantially enhanced human well-being and economic development. However, this uncontrolled growth has also led to the degradation of many ecosystem services with growing costs. Two thirds of the ecosystem services examined by the Millennium Ecosystem Assessment are being degraded or used unsustainably (Millennium Ecosystem Assessment, 2005). Human intense activities and land use changes have degraded ecosystem services unwittingly creating new pathways of spread of diseases. The EcoHealth Alliance (2019)[19] estimates that changing land use is linked to 31% of outbreaks of emerging infectious diseases. UNEP (2016)[20] identified a global increase in zoonotic epidemics (diseases that pass from animals to human), including 75% of emerging human infectious diseases, whose origins are closely linked to environmental changes and which occur at a rate of one new human infectious disease every four months on average (Everard et al., 2020). An example of this is zoonotic disease is the SARS-CoV-2 virus causing the global COVID-19 pandemic. COVID-19 pandemic, spread worldwide in December 2019, has forced governments to take exceptional measures to face this emergency and to manage public health systems. The severity of the measures implemented varied from country to country: some examples of strict lockdowns where people were only allowed to leave their homes for vital activities were used in China, Italy or Spain, while in the Scandinavian countries restrictions on movement were recommendations rather than binding rules (Pouso et al., 2021). Estimates indicate that lockdowns and physical distancing between February 2020 and May 2020 have saved more than 3 million lives only in 11 European countries (Flaxman et al., 2020; Pouso et al., 2021). However, depending on severity of lockdown measures, people's mental health has been affected by social isolation. Spending time in blue-green spaces (e.g. urban parks, forests, rivers and the coast) has a number of potential benefits for mental health and well-being and contact with nature helped people to cope with COVID-19, especially for those under strict lockdown (Pouso et al., 2021). As found by Modi et al., (2021), Italy was the first European country to start a national lockdown and one of the hardest hit countries in the initial phase of the COVID-19 pandemic, with > 400,000 confirmed cases and > 36,000 COVID -attributed deaths by mid-October 2020.

[19] https://www.ecohealthalliance.org/wp-content/uploads/2019/09/IDEEAL_report_final.pdf

[20] https://wesr.unep.org/media/docs/assessments/UNEP_Frontiers_2016_report_emerging_issues_of_environmental_concern.pdf

Protect the environment, its biodiversity and ecosystem services mean to protect our species (Balmford et al., 2002; Assessment, 2005). Conservation strategies need to focus not only on biological/environmental loss, but on the entire social-ecological systems (Burgos-Ayala et al., 2020). Although there is not a unique definition for the social-ecological systems, for the scope of this paper we will use the definition by Harrington et al., (2010): 'A system that includes societal (human) and ecological (biophysical) subsystems in mutual interactions (Gallopin 1991) and thus captures interactions between ecosystems, biodiversity and people'. The objective of environmental policy and management should be to integrate local people's relationships with nature in their strategies, thinking of the ways that people could be engaged to lessen the negative effects of their lifestyles on ecosystems and be part of positive pro-environment change (Chan et al., 2016). Conservation should be seen through a collaborative approach with communities instead of an imposition by outsiders (Chan et al., 2016). The possibility to reconnect societies with nature has become clear when the Millennium Ecosystem Assessment shared the value of including the Ecosystem Services in the conservation debate and the development of environmental policies, bringing the worldwide policymakers attention on this topic (Burgos-Ayala et al., 2020). To mitigate results of anthropogenic pressure on the environment, such as climate change, a drastic change of human behaviour is needed (Jans, 2021). A significant increase in social awareness and engagement will facilitate the implementation of this new conservation paradigm. Although nature is experienced subjectively (Hartig et al., 2014), environmental education programmes can increase public awareness about environmental challenges, promoting a pro-environmental behaviour and a change of attitude towards the environment (Wynes and Nicholas, 2017; Meschini et al., 2021b, 2021a). Therefore, communication, education, and participatory actions (CEPA) are key tools and strategies for this change of conservation paradigm (Jiménez et al., 2015; Wali et al., 2017; Burgos-Ayala et al., 2020). It is thought that adaptive, participatory and transdisciplinary approaches will allow the achievement of sustainable development and biodiversity conservation (Agnoletti et al., 2015). This new vision is based on the need for participatory approaches that bridge science and society while actively involving policy makers and stakeholders (Peano et al., 2021).

In this study we aimed to investigate peoples' perceptions of natural sites and characteristics they give importance to, in order to have a more inclusive understanding of what might need to be prioritised in considering management and improving access, attachment and enjoyment of natural sites. Another goal for this study was to evaluate if the perception of natural sites has changed due to the COVID-19 pandemic. Although the word 'nature' often refers to all physical features and

processes of non-human origin (Hartig et al., 2014), here we consider that natural sites could be wild places in which nature regulates itself, or sites in which the natural environment is managed by the state or by conservation charities (e.g., National Trust).

Methods

Data collection

Data were collected during one month between 26th of July and 26th of August 2021 from Italian participants living in Italy using an online anonymous questionnaire, run through the Survey Monkey platform. The questionnaire was composed of 26 questions, lasting on average 10 minutes (Supplementary Materials (SM) Questionnaire). The questionnaire was spread through social media (Facebook, Instagram, Twitter, LinkedIn) and sent to friends and colleagues of researchers involved in the project. Participants could withdraw from the study at any point without explanation. The project received the approval of the Bioethics Committee of the University of Liverpool and the University of Bologna.

Questions (Q hereafter) 1-4 of the questionnaire were dedicated to participant information data and participant consent; Qs 5-9 asked participants some general information about their habits regarding contact with nature and communication channels they use to find information about natural places. Qs 10-11 asked respondents to express their agreement or disagreement with statements using 5-point Likert-Type questions with the addition of an "I don't know" option. These questions were about practical issues that respondents notice most when visiting a natural site (e.g., the presence of children's play area(s)). Q 12 was about personal interest in taking part in some proposed activities (e.g., clean-up events); Qs 13-14 were open questions to understand what people would invest money on in natural sites and which characteristics they consider beautiful in natural sites. Qs 15-16 were about the COVID-19 pandemic effects on respondents' perception of nature and Q15 also had an open answer section to investigate how the pandemic had changed peoples' perception of natural sites. For COVID-19 related question we used the term 'before' to indicate the period before the spread of the virus in Italy (February/March 2020) and the term 'during' to indicate the period after March 2020 since August 2021. Qs 17-21 were demographic questions, and from Qs 22 -25 the respondents were asked about some habits (e.g., whether they recycle waste) and experiences from

childhood (between the end of infancy and the onset of puberty 2-10/12 years old[21]). The last question, Q 26, was about the communication channel from which they heard about the survey. For the Likert-Type questions, respondents could choose only one answer for each item; depending on the questions they were asked to express their level of agreement or disagreement with each item, or to indicate the frequency of some activities. These Likert-Type questions were ranked from 1 to 5: 1: Strongly disagree/Never, 2: Disagree/Rarely, 3: Neither disagree or agree/Sometimes, 4: Agree/Often, 5: Strongly agree/Very often (Sullivan and Artino, 2013; Harpe, 2015) (SM Questionnaire).

Data analysis

Once survey responses had been collected the distribution of scores were explored. As they did not meet the assumption of normality, so differences in responses between variables and items were tested using nonparametric statistical tests (Kolmogorov-Smirnov test). Median scores were explored for central tendency, frequencies for analysis of variability, Kendal tau B for association analyses and the Kruskal Wallis test to explore differences in response distributions. All the statistical analyses were performed using IBM SPSS Statistics version 22. Open ended questions were divided into categories and then the frequency and percentage of single terms was explored. For these questions, word clouds were also created to visualize results using an online word generator (https://www.freewordcloudgenerator.com/).

Results

A total of 115 Italian participants filled in the project questionnaire between July and August 2021, 18 (15.6%) of those were discarded due to incomplete answers. Within the 97 valid questionnaires, most respondents were female, nearly 50% were aged between 25 and 34, the majority lived in an urban area and more than 80% had an undergraduate university degree, equivalent or higher (Table 1). The most common way that this survey was disseminated was through friends (~ 65%) and from colleagues (22%).

[21] https://dictionary.apa.org/childhood

Table 1. Demographic characteristics of the 97 respondents for this study.

Factors	Categories	%	N of respondents
Gender	Female	62.9	61
	Male	35.1	34
	Prefer not to say	2.1	2
Age class	18-24	5.2	5
	25-34	49.5	48
	35-44	12.4	12
	45-54	10.3	10
	55-64	13.4	13
	65	8.2	8
	Prefer not to say	1	1
Living location	Urban area	53.6	52
	Suburban area	8.2	8
	Rural areas/countryside	38.1	37
Education level	Undergraduate university degree, equivalent (e.g., UGAdvDip or UGAD) or higher	80.4	78
	Any post 16 qualifications (e.g., A-levels, diplomas, Highers, Btec, apprenticeship, or equivalent)	3.1	16
	Any pre-16 qualifications (e.g., GCSEs, O-Levels, equivalents)	0	0
	Prefer not to say	16.5	3
Total		**100%**	**97**

Visiting natural sites

Both during and before the COVID-19 pandemic, most respondents visited natural sites 1-3 times per month, although during the pandemic a lower number of respondents selected 'more than 12' for visits (-17.5 %) and a higher number of respondents selected 1-3 times per month during the pandemic (+10.8) (Figure 1, SM Table 1). More than 50% of respondents visited natural places often or very often with parents or caregivers in their childhood, with less than 20% of respondents stating they never or rarely visited natural places in childhood (SM Figure 1). The frequency of visits to natural places during childhood was correlated with both before (T_B=0.189, $p<0.05$) and during (T_B=0.247, $p<0.01$) COVID-19 visits. The most visited type of natural site was the seaside, with around 56% of respondents visiting beaches and other coastlines often or very often, followed by woodland or forests (~47%), urban green space (e.g., parks) (~45%), and river, lake or canal sites (~42%) (SM Table 2). The frequency of visits to urban green space was the only parameter related to where the respondents live (T_B=-0.210, $p<0.05$). The most frequently used channel to collect information about natural sites to visit was websites, with more than 80% of respondents using them often or very often. Other communication channels, such as Facebook, Instagram, Tik Tok and Twitter, seemed to be used less frequently by this demographic for this purpose (SM Figure 3).

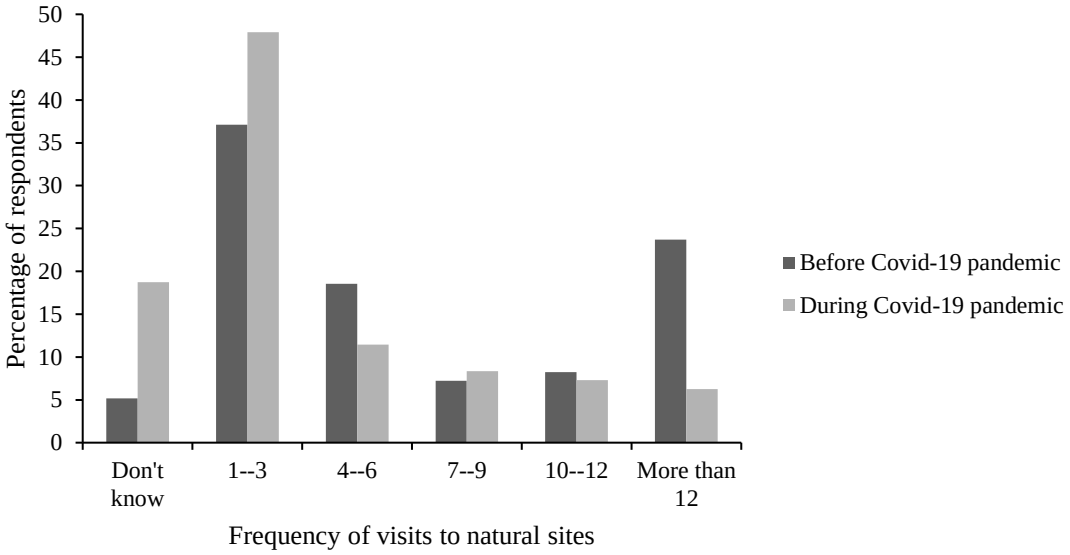

Figure 1. Frequency of visits to natural sites before and during the COVID-19 pandemic of the 97 respondents for this study

Characteristics of Natural Sites

Results showed that, within the main practical issues, respondents of this survey did not give importance to the presence of children's play areas or the possibility of taking their dog, while they agreed with all the other statements, showing that access to the sites and facilities therein were important (Table 2). The environmental characteristic that the respondents noticed most in natural sites, was the beauty of the place, with around 80% strongly agreeing this was something they noticed (and 99% of respondents agreeing or strongly agreeing with this statement). The other two main environmental characteristics agreed or strongly agreed were the presence of litter (e.g., plastic bottles) (96.9%) and how wild an environment is (94.8%) (Table 2). When people were asked to define the concept of beauty, the four most used categories were: no-litter, wild, biodiversity and low human impact (Figure 3), whilst a smaller fraction of respondents (7.3%) used categories such as wild, authentic, or no human impact in combination with accessible or well-managed.

Table 2. Percentage of level of agreement or disagreement with the items for the practical issues and environmental characteristics expressed by the 97 respondents. Here reported the questions and items. **Practical issues question**: Which are the main practical issues you look at when you choose a natural site to visit? **Items**: **PI1** The presence of children's play area(s); **PI2** The presence of pedestrian routes inside the site; **PI3** Whether or not I can take my dog(s); **PI4** The presence of services and facilities (e.g., toilets, café, visitor centre); **PI5** The ease of reaching the site on foot or by bike; **PI6** The ease of reaching the site by public transport; PI7 The easy of reaching the site by car. **Environmental characteristics question**: Which environmental characteristics do you notice when you visit sites? **Items "In natural sites I give particular attention to"**: **EC1** the presence of litter (e.g., plastic bottles, cigarette butts, etc); **EC2** the presence of buildings and their environmental impact; **EC3** how wild an environment is; **EC4** the state of maintenance; **EC5** site information, panels and signage; **EC6** the beauty of the place.

	Items	Don't know	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Practical issues	PI1	6.2	32	18.6	30.9	7.2	5.2
	PI2	2.1	2.1	6.2	11.3	50.5	27.8
	PI3	5.2	22.7	11.3	24.7	23.7	12.4
	PI4	0	8.3	11.5	21.9	45.8	12.5
	PI5	3.1	2.1	3.1	14.4	51.5	25.8
	PI6	0	7.2	7.2	19.6	44.3	21.6
	PI7	1	3.1	2.1	20.6	54.6	18.6
Environmental issues	EI1	0	1	0	2.1	33	63.9
	EI2	0	2.1	1	8.2	41.2	47.4
	EI3	0	1	1	3.1	41.2	53.6
	EI4	0	0	1	10.3	46.4	42.3
	EI5	0	0	3.1	13.4	44.3	39.2
	EI6	0	0	0	1.0	19.6	79.4

Figure 3. Word cloud where all the answers of the 97 respondents on their perceptions of beauty in natural places are included. The bigger and bolder the word appears, the more often it was mentioned by respondents.

Participatory approach

Around 56% of respondents were interested in participating often or very often in activities where they gained insights about the natural environment (e.g., hiking talks). Less than 40% of participants were interested in taking part in policy making discussions about management of natural areas often or very often, in all the other cases respondents were interested in the activities and few answered never or rarely. For all the proposed activities, most of respondents were only interested in undertaking them sometimes (Table 3). Results also showed that in most cases the interest for participatory actions was correlated with the membership or volunteering item (SM table 3) showing that people engaged with an environmental organization (23.7% of the respondents) were more interested in a participatory approach. Eighty-one people answered the open question in which participants were asked to indicate up to three things they would invest in if they had the opportunity to choose how money is used in a natural site. Maintenance (42%) and cleaning/keep clean natural sites (35.8%) were the two things respondents would invest in if they had the opportunity to choose how money is used in a natural site (Figure 4).

Table 3. Percentage of level of interest regarding the items for the participatory approach (PA) question expressed by the 97 respondents. Here reported the questions and items. **Question**: Given the chance, would you like to join any of the below-mentioned initiatives in natural sites? **Items**: **PA1** Insights about the natural environment (e.g., hiking talks, picnic talks); **PA2** Monitoring of natural sites (e.g., checking that paths are in good condition, mapping areas with more litter); **PA3** Clean-up site events (e.g., beach clean-up days); **PA4** Participate in policy making discussions about management of natural areas; **PA5** Participate in long-term project to co-design the conservation strategy of natural areas.

Items	Don't know	Never	Rarely	Sometimes	Often	Very often
PA1	2.1	1.0	9.3	30.9	29.9	26.8
PA2	4.1	4.1	12.4	38.1	22.7	18.6
PA3	2.1	1.0	12.4	42.3	21.6	20.6
PA4	3.1	6.2	22.7	32.0	17.5	18.6
PA5	5.2	8.2	17.5	26.8	22.7	19.6

Figure 4. Word cloud where all the answers of the 97 respondents on how they would have invested money in a natural site. The bigger and bolder the word appears, the more often it was mentioned by respondents.

COVID-19 pandemic impact

For around 61% of respondents the COVID-19 pandemic has not changed their perception of nature (Table 4). Within the features that would help people to feel safer during their visits to natural sites after COVID-19, the most appreciated was to limit the number of people visiting the place, with 72% agreeing or strongly agreeing with this statement. Nearly 50% of respondents would like to have the possibility of booking their visits in advance, but less than 20% would prefer an audio guide to a real guide (Table 4). Out of the 37 people that said COVID-19 had changed their perceptions of natural sites, 31 answered an open question asking in which way the pandemic had changed their perceptions, with answers covering three main areas: i) an increased attention toward nature (~35%); (ii) an increased need to be in nature (~32%); and (iii) a greater appreciation of nature and activities in nature (~32% of the 31 respondents).

Gender effect

When analysing the role of gender within the items, some trends were found. For respondents who were interested in participating often or very often in activities where they gained insights into the natural environment (e.g., hiking talks), the results showed significant differences (T_B =0.226, $p < 0.05$), indicating that women were more interested than men. It was also found that women were more likely to agree that COVID -19 changed their perception of nature (T_B=-0.248, $p < 0.05$). Following this result, a correlation was found between gender and the item on COVID -19 actions "Limited access to sites to control numbers of people visiting at any one time' (T_B=0.213, $p < 0.05$), where women agreed more than men.

Table 4. COVID-19 pandemic related questions in the questionnaire used for this study. For COVID-19 related question we used the term 'before' to indicate the period before the spread of the virus in Italy (February/March 2020) and the term 'during/after' to indicate the period after February/March 2020 since August 2021.

Questions	Items	Answers	%	N of respondents
Do you agree that the COVID-19 emergency has changed your perception of nature?		Yes	38.5	37
		No	61.5	59
Looking at different ways natural places have changed after COVID-19, which features would help you to feel safer during your visit?	Possibility to book in advance visits to a natural site	Don't know	3.1	3
		Strongly disagree	7.2	7
		Disagree	14.4	14
		Neither agree or disagree	27.8	27
		Agree	40.2	39
		Strongly agree	7.2	7
	Possibility to have an audio guide instead of a guide	Don't know	2.1	2
		Strongly disagree	15.5	15
		Disagree	32	31
		Neither agree or disagree	30.9	30
		Agree	12.4	12
		Strongly agree	7.2	7
	Limited access to sites to control numbers of people visiting at any one time	Don't know	3.1	3
		Strongly disagree	6.2	6
		Disagree	4.1	4
		Neither agree or disagree	14.4	14
		Agree	54.6	53
		Strongly agree	17.5	17

Discussion

Results showed that the frequency of visiting natural sites did not change in most cases before and during the COVID -19 pandemic, while it was correlated with the frequency of visiting natural sites in childhood. This seems to confirm the existing literature and the important role of childhood nature experiences in connecting with nature in adulthood (Thompson et al., 2008; Hosaka et al., 2017).

Although social media are becoming more and more used in everyday life (Xiang and Gretzel, 2010), our study suggested that for planning/researching visits to natural sites the most used channels to reach information were websites. In fact, more than 80% of the respondents, who were mainly between 25 and 34 years old, preferred to use the websites to gather information about natural sites rather than other social media (e.g. Instagram, Facebook, etc.). This aspect could be of interest for future communication plans of natural sites. We also found relevant the definitions that respondents gave about the concept of beauty of a natural site. While most respondents used similar categories of terms such as "no litter", "wild," "biodiverse," and "low human impact," 7.3% of respondents described a natural site as beautiful that was wild, authentic, or without human impact, along with terms such as "accessible" and "well-managed." It would be interesting to explore this further in future studies with in-depth interviews to understand if the concept of beauty of a natural place is related to human management. This interpretation is also supported by respondents' agreement with the statement about the presence of services and facilities in natural places. The results also indicated that membership or volunteering in an environmental education association could be a predictor of people interest in more participatory approaches to nature management. Indeed, a higher level of participation requires more effort from participants. While more than 50% of respondents were interested in insights about the natural environment, only 36.1% were interested in policy making discussions. Activities that require less effort from participants could effectively engage a greater number of people. More than 60% of respondents indicated that the global COVID -19 pandemic had not changed their perceptions of the natural environment. While people would continue to use real guides instead of audio guides despite the pandemic, most of them would limit the number of visitors to natural sites and would have the option to book their visit in advance. People whose perception of nature has changed as a result of the COVID -19 pandemic have an increasing attention toward nature, an increased need to be in nature, and a greater appreciation for nature and activities in nature.

Limitations

In this study, the major limitation was the unbalanced sample in terms of demographic characteristics, as the majority of the respondents were between 25 and 34 years old and 80% of them had a university degree (e.g. UGAdvDip or UGAD) or higher. One possible explanation for these results is that the survey was most effectively disseminated through friends and colleagues, so it reached people of similar age and background.

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Supplementary materials

SM Questionnaire. Survey questionnaire used for this study and completed by 97 respondents. See the 'methods' section for the single questions information. In brackets and bold font the score for each item.

1. I confirm that I have read and have understood the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

Yes No

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my rights being affected.

Yes No

3. I understand that, under the Data Protection Act, I can withdraw only before the submission of my answers, because data are collected in an anonymous way and it will not be possible to link answers to a particular person at a later date.

Yes No

4. I confirm that I am over 18 and agree to take part in the study.

Yes No

For the following questions, please think about natural sites in general, rather than a specific place.

5. Between 2018-2020, on average, how many times <u>per month</u> do you think you visited natural sites?

1-3	4-6	7-9	10-12	More than 12	Don't know

6. During the COVID-19 pandemic, on average, how many times <u>per month</u> do you think you visited natural sites?

1-3	4-6	7-9	10-12	More than 12	Don't know

7. In your leisure time which of the following type of natural sites do you visit?

	Never	Rarely	Sometimes	Often	Very often	Don't know
Urban green space (such as a park, field or playground)						
Grounds of a historic property or country park						
Woodland or forest						
River, lake or canal						
Hill, mountain or moorland						
Beach / other coastline / sea						
Nature / wildlife reserve						
Fields / farmland / countryside						
Another green and natural space (please specify)						

8. Thinking about most natural sites that you have visited by yourself, with your family or friends, did you have to pay for an entrance ticket or membership fee?

Never	Rarely	Sometimes	Often	Very often	Don't know

9. Which kind of communication channels do you usually use to find information about natural sites?

	Never	Rarely	Sometimes	Often	Very often	Don't know
Websites						
Facebook						
Instagram						
Tik tok						
Twitter						
Others (please specify)						

How strongly do you agree or disagree with the following statements?

10. Which are the main practical issues you look at when you choose a natural site to visit?

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	Don't know
The presence of children's play area(s)						

The presence of pedestrian routes inside the site						
Whether or not I can take my dog(s)						
The presence of services and facilities (e.g., toilets, café, visitor centre)						
The ease of reaching the site on foot or by bike						
The ease of reaching the site by public transport						
The easy of reaching the site by car						
Others (please specify)						

11. Which environmental characteristics do you notice when you visit sites?

	Strongly disagree	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**	**Don't know**
In natural sites I give particular attention to the presence of litter (e.g., plastic bottles, cigarette butts, etc)						
In natural sites I give particular attention to the presence of buildings and their environmental impact						
In natural sites I give particular attention to how wild an environment is						
In natural sites I give particular attention to the state of maintenance						
In natural sites I give particular attention to site information, panels and signage						
In natural sites I give particular attention to the beauty of the place						

12. Given the chance, would you like to join any of the below-mentioned initiatives in natural sites?

	Never	Rarely	Sometimes	Often	Very often	Don't know
Insights about the natural environment (e.g., hiking talks, picnic talks)						
Monitoring of natural sites (e.g., checking that paths are in good condition, mapping areas with more litter)						
Clean-up site events (e.g., beach clean-up days)						
Participate in policy making discussions about management of natural areas						
Participate in long-term project to co-design the conservation strategy of natural areas						

13. If you had the opportunity to choose how money is used in a natural site, what would you invest in? (list up to 3 things that could be invested in)

_____

_____

_____

14. In your opinion, which characteristics should a natural site have to be considered beautiful?

_____

_____

15. Do you agree that the COVID-19 emergency has changed your perception of nature?

Yes

No

If yes, could you please write below in which way?

_____

_____

_____

16. Looking at different ways natural places have changed after COVID-19, which features would help you to feel safer during your visit?

	Strongly disagree	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**	**Don't know**
Possibility to book in advance visits to a natural site						
Possibility to have an audio guide instead of a guide						
Limited access to sites to control numbers of people visiting at any one time						
Others (please specify)						

17. What is your age?

18-24

25-34

35-44

45-54

55-64

65 or older

Prefer not to say

18. Which is your highest level of qualification?

Undergraduate university degree, equivalent (e.g., UGAdvDip or UGAD) or higher

Any post 16 qualifications (e.g., A-levels, diplomas, Highers, Btec, apprenticeship, or equivalent)

Any pre-16 qualifications (e.g., GCSEs, O-Levels, equivalents)

Prefer not to say

19. What is your gender?

Female

Male

Other (please specify)

Prefer not to say

20. Which is your nationality?

_____

21. Thinking about the location of your house, chose one of the below-mentioned locations

Urban area

Suburban area

Rural areas/ Countryside

22. Do you normally recycle your waste from home?

Yes No

23. Are you a member or volunteer of an environmental organization? If yes, please write below which one

_____

24. Thinking about your childhood, did your parents or caregivers take you to visit natural sites?

Never	Rarely	Sometimes	Often	Very often	Don't know

25. Do you work at a natural site? If so, please specify your role in the line below

Yes

No

Role (please specify here)

26. How did you heard about the survey?

Facebook

Instagram

Twitter

Linkedin

Friends

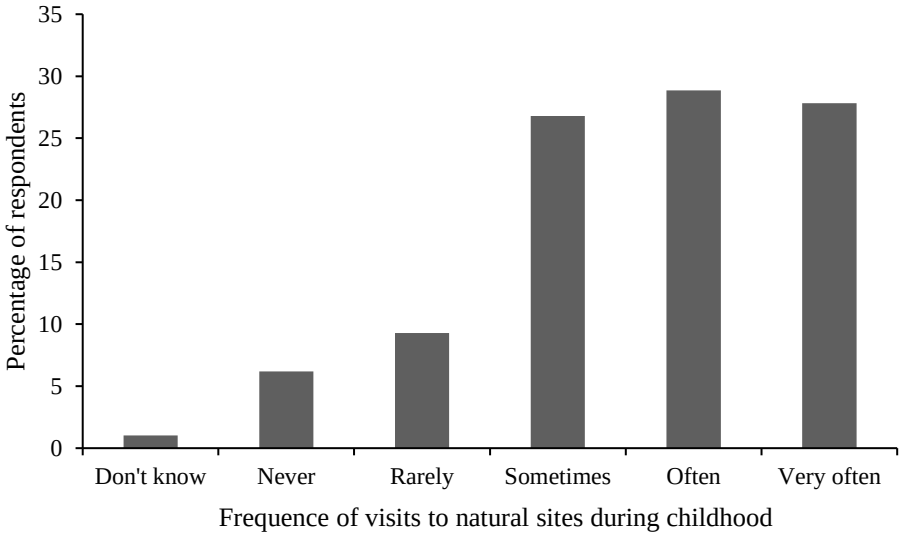
Colleagues

Charities (please specify which one)

Others (please specify)

SM Table 1. Frequency of visits to natural sites before and during COVID-19 pandemic, expressed by the 97 participants. Last column indicates the percantage difference of visits to natural sites between before and during COVID-19.

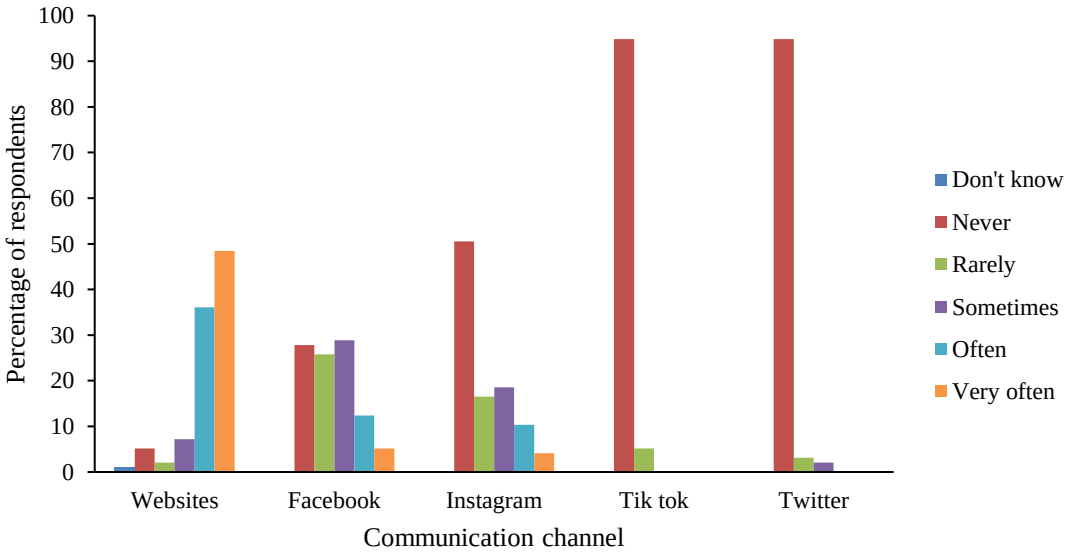
	Before COVID-19	During COVID-19	percentage difference
Don't know	5.2	18.8	13.6
1-3	37.1	47.9	10.8
4-6	18.6	11.5	-7.1
7-9	7.2	8.3	1.1
10-12	8.2	7.3	-1.0
More than 12	23.7	6.3	-17.5



SM Figure 1. Frequency of visits to natural sites during childhood of the 97 respondents for this study.

SM Table 2. Frequency of visits to natural sites divided by the chosen environment, expressed by the 97 participants.

	Don't know	Never	Rarely	Sometimes	Often	Very often
Urban green space (such as a park, field or playground)	0	4.2	20.8	30.2	27.1	17.7
Grounds of a historic property or country park	0	2.1	29.9	42.3	22.7	3.1
Woodland or forest	0	2.1	24.7	25.8	33	14.4
River, lake or canal	0	4.1	27.8	25.8	28.9	13.4
Hill, mountain or moorland	0	0	24.7	36.1	24.7	14.4
Beach / other coastline / sea	1	2.1	12.4	28.9	34	21.6
Nature / wildlife reserve	1	8.2	28.9	34	18.6	9.3
Fields / farmland / countryside	1	4.1	23.7	39.2	23.7	8.2



SM Figure 3. Communication channels used by respondents to search information about natural sites to visit.

Table 3. Correlation between Participatory Approaches (PA) questions and Membership. Here reported the questions and items. **Question Participatory Approaches**: Given the chance, would you like to join any of the below-mentioned initiatives in natural sites? **Items**: **PA1** Insights about the natural environment (e.g., hiking talks, picnic talks); **PA2** Monitoring of natural sites (e.g., checking that paths are in good condition, mapping areas with more litter); **PA3** Clean-up site events (e.g., beach clean-up days); **PA4** Participate in policy making discussions about management of natural areas; **PA5** Participate in long-term project to co-design the conservation strategy of natural areas. **Question Membership**: Are you a member or volunteer of an environmental organization?. Reported number are Kendall's tau_b (T_B) values, significance of correlation is indicated as * = $p < 0.05$.

Participatory Aprproaches	Membership
PA1	-0,127
PA2	-0,220*
PA3	-0,217*
PA4	-0,209*
PA5	-0,180*

CHAPTER 9.

CONCLUSIONS

Following the scopes of my research, that were:

i) analyze the reliability of data collected by volunteers during the STE (2007-2015) and SPA (2002-2005) + DUE (2017-2020) projects;
ii) evaluate the long-term impact of environmental education activities performed during the STE project following the study of Branchini et al., (2015);
iii) evaluate the short and long-term impact of Glocal Education project (2016-2019);
iv) coordinate DUE project activities and data collection (2017-2020) to monitoring the biodiversity status of studied sites for a follow up study of SPA project (2002-2005);
v) develop a questionnaire to investigate people's perceptions of natural sites and characteristics they give importance to, in order to have a more inclusive understanding of what might need to be prioritised in considering management of natural sites;

I will summarize the main outcomes for each performed study.

i) analyze the reliability of data collected by volunteers during the STE (2007-2015) and SPA (2002-2005) + DUE (2017-2020) projects

The evaluation of the reliability of data collected by volunteers showed that they can be sufficiently accurate in most studied parameters. Interestingly, the parameter that achieved the lowest mean score was the Consistency one. For this analysis the reference diver (a researcher from the MSG taken as reference for comparing data collected by volunteers) is not involved, in fact, this parameter analyzes the similarity of data collected by separate volunteers during the same dive. This result is probably related to the different personal interests of the volunteers, which led them to focus on different species. For this reason, it is essential in this type of project to collect a large amount of data, because the involvement of different people can consider the different interests of people and give a complete picture of the current state of biodiversity in the areas studied. The Consistency parameter achieved the lowest score in both project I have analysed. In the STE project there were also some correlations between parameters scores and independent variables such as diving certification level, dive time, date. Most reliability parameters were positively correlated with diving certification level and dive time, suggesting that more experienced divers can collected more accurate data and that longer dives lead to higher data accuracy. This project provided further proof that "recreational" and "easy and fun" citizen science is an efficient and effective method to recruit many volunteers and provide

reliable data, if well designed. The outcomes of these studies led to two papers, one has already been published[22] and the other one is in preparation and will be submitted soon[23].

ii) evaluate the long-term impact of environmental education activities performed during the STE project following the study of Branchini et al., (2015)[24]

This study built on the short-term one performed by (Branchini et al., 2015a) that showed an increase in both knowledge about the coral reefs and environmental awareness of the human impact after tourists participation in the STE project. The long-term study I conducted was the first follow-up study on the effects of participation in a citizen science project on cognitive and psychological aspects that form the basis for environmentally friendly behaviour. The results of this study showed that three years after their participation in environmental education activities, the volunteers were not able to maintain their knowledge, but they were able to maintain good scores of awareness. In the same study, we found that psychological variables, such as satisfaction for participation in project activities and motivation to behave in an environmentally friendly way, are fundamental to long-term retention of awareness.

iii) evaluate the short[25] and long-term[26] impacts of Glocal Education project (2016-2019)

After the success of the environmental education activities within the STE project, the MSG decided to develop a specific project for environmental education in mass tourism facilities. Following the same approach used in the STE study, a specific questionnaire was developed for Glocal Education project. In this case nearly 2,000 tourists participated in the short-term study, showing an overall increase in all studied variables between the pre-activities and post-activities scores, while in the long-term knowledge and attitude decreased and awareness remained constant. In most cases, the psychological components showed a positive relationship with the studied variables, indicating that they play an important role in long-term retaining volunteers' abilities.

[22] Meschini, M., Machado Toffolo, M., Marchini, C., Caroselli, E., … & Goffredo, S. **2021**: Reliability of data collected by volunteers: a nine-year citizen science study in the Red Sea. **Frontiers in Ecology and Evolution**

[23] Meschini, M., Machado Toffolo, M., Marchini, C., Caroselli, E., … & Goffredo, S. (**manuscript in preparation**): Reliability analyses of data collected by volunteers during an eight-years citizen science project in the Mediterranean Sea.

[24] Meschini, M., Prati, F., Simoncini, G.A., Airi, V., Caroselli, … & Goffredo, S. **2021**: Environmental Awareness Gained During a Citizen Science Project in Touristic Resorts Is Maintained After 3 Years Since Participation. **Frontiers in Marine Science**

[25] Meschini, M., Machado Toffolo, M., Caroselli, E., Franzellitti, S., … & Goffredo, S. **2021**: Educational briefings in touristic facilities promote tourist sustainable behavior and customer loyalty. **Biological Conservation**

[26] Machado Toffolo, M., Simoncini, G.A., Marchini, C., Meschini, M., … & Goffredo (**accepted by Frontiers in Marine Science Marine Affairs and Policy**): Long term effects of an informal education program on tourist environmental perception.

iv) coordinate DUE project activities and data collection (2017-2020) to monitoring the biodiversity status of studied sites for a follow up study of SPA project (2002-2005)[27]

The Volunteers Marine Biodiversity Index (V.MBI) developed by the MSG aims to show general trends in the biodiversity status of studied sites using all data collected during different years. In order to present aggregated data from the previous SPA project and the current DUE one, we performed statistical tests to assess if there were significant differences among years. Results showed no difference between years, expect for the 2020. As, we all know, the 2020 has been a particular year for the Covid-19 pandemic spread. This could have resulted on some changes in terms of underwater life due to the reduced human impact due to the lockdowns. Apart from the 2020, the biodiversity status of studied sites seems not to be varied in the last 20 years. The fact that few dive sites were in common between the SPA and the DUE project, could have influenced this result. In fact, these results need to be deepened in future studies that will evaluate species distribution among years.

v) develop a questionnaire to investigate people's perceptions of natural sites and characteristics they give importance to, in order to have a more inclusive understanding of what might need to be prioritised in considering management of natural sites[28]

This study was developed during my visiting research period at the University of Liverpool between February and August 2021, and it showed that childhood experience of natural sites is fundamental in building future interest for natural places and attention towards nature. Although social media are increasingly used in everyday life and when travelling, our study showed that for planning/researching visits to nature, websites are the most used channels to get information. The results also suggest that membership or volunteering in an environmental education association could be a predictor of people's interest in more participatory approaches to nature management. Indeed, a higher level of participation requires more effort from participants. Activities that require less effort from participants could effectively engage a larger number of people. The results showed that the frequency of visiting natural sites did not change in most cases before (before February 2020) and during the pandemic COVID -19 (from February 2020 since the study period, August 2021), while it correlated with the frequency of visiting natural places in childhood. While people would continue to

[27] Meschini, M., Machado Toffolo, M., Adelmi, A., … & Goffredo, S. (**preliminary results**) Trends in Mediterranean Sea organisms' distribution through data collected by citizen scientists over a period of 20 years.

[28] Meschini, M., Culhane, F., Goffredo, S., & Robinson, L. (**Manuscript in preparation**) Peoples' perceptions of natural sites before and during COVID-19 pandemic for a more inclusive natural management.

choose professional guides instead of audio guides despite the pandemic, most of them would limit the number of visitors to natural sites and would have the option to book their visit in advance.

All the projects developed by the MSG using the recreational citizen science approach have been successful case studies of bridging citizens, scientists, private sector, and local authorities. This participatory approach has led to the collection of a huge quantity of data on the marine biodiversity over a period of nearly 20 years. These projects have showed that, despite a recreational approach, citizens are able to collect good quality data that could be implemented in environmental management plans with a novel participatory vision. Results also showed that environmental education programs on volunteers' knowledge, attitude, and awareness could have far-reaching implications for environmental conservation, because people's actions have the power to affect biodiversity and sustainability in positive or negative ways. The environmental education program developed within the STE project and Glocal Education project have shown that tourists are interested in informal education activities, and they are able to retain awareness about human impact on the environment in the long term, which can bring to a more sustainable approach towards the natural ecosystems. Psychological variables, such as satisfaction for participating in the project, were discovered to be fundamental for long-term retaining of notions.

The present research contributed to advance the knowledge and the understanding of participatory approaches with different levels of citizen engagement and on the reliability of data collected by volunteers. While the results of my research are encouraging in terms of the reliability of the data, in my opinion they strongly support the need and potential for future environmental education programmes that could be developed in tourism facilities to reduce human impact on the environment as part of conservation strategies. In parallel with the development of environmental education programmes, co-management approaches could be further explored and promoted to involve society in the design and implementation of conservation strategies.

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