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Contribution to the Special Issue: "Ocean Literacy across the Mediterranean Sea region"

Walking on the Sea Traces: Developing a platform to bring Ocean Literacy and Citizen Science at Home

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Abstract

The process of the development of a citizen science platform on Ocean Literacy designed and implemented during the lockdown period of 2020 is described. As restrictions due to the COVID-19 health emergency did not allow researchers to organise public events and field data collection activities related to Ocean Literacy, it was decided to take advantage of this situation by building an online platform to bring Ocean Literacy issues directly into citizens' homes. The massive use of digital tools by all civic communities during this time has enabled both the implementation of this idea and rendering it effective. The pandemic control measures then provided a unique opportunity to focus citizen attention on the collection of household data and information and to highlight the more or less direct connections between citizens' lifestyles and the eco-marine system. Short questionnaires were used to ascertain and highlight citizens' household behaviours and daily attitudes during the lockdown towards water use, seafood consumption and plastic material use and disposal. Data and information were also proposed, collected and analyzed in terms of: general environmental awareness of the respondents, perception regarding their purchasing choices during this particular period, as well as any changes in lifestyles and habits during the lockdown with respect to previous periods. The collected data enabled the improvement of our knowledge on some aspects of people's domestic habits as well as their perception vs. real knowledge about the proposed environmental issues. We also realized that it is increasingly crucial for scientists to directly and extensively involve people and schools in educational and outreach activities and events as a good practice of science-society interaction. But to achieve good results there is a need to develop appropriate communication tools and effective involvement strategies to promote their widespread participation in citizen science projects.

Keywords: Ocean Literacy; citizen science; freshwater; seafood; plastic; human impact; marine litter.

Introduction

Ocean literacy is not only defined as the "*understanding of the ocean's influence on you and your influence on the ocean*", but also as "*being able to make informed and responsible decisions regarding the ocean and its resources*" (Cava *et al*., 2005; Santoro *et al*., 2018). Since the ocean covers almost 3/4 of the Earth's surface and the total volume of seawater is estimated at more than 1 billion km^3, the marine system also deeply influences all life, biogeochemical and meteo-climatic characteristics of our planet. For these reasons the marine environment comprises an essential component of the global life support system and represents an opportunity for sustainable development. Therefore, the importance of including marine issues in environmental education at school and within the society is now recognized both in Europe as well as in the rest of the world (Sullivan *et al*., 2019; Kelly *et al*., 2020). However, even as understanding of the importance of marine ecosystems to society grows (Selig *et al*., 2018), evidence shows that pressures from human activities on these ecosystems are increasing (Korpinen

& Andersen, 2016; Lotze *et al*., 2018), putting the health of the world's oceans at risk (Borja *et al*., 2016). Therefore, it seems necessary, in addition to political action, to promote widespread dissemination of the actions envisaged by, among others, Sustainable Development Goal 14 "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" (UN General Assembly, 2015) within society. Urgent options and incentives are needed for individual behavioural changes toward what is less harmful and more protective of the ocean, its ecosystems, and the people who live off them (Garcia-Soto *et al*., 2017). The responsibilities of individuals cannot be ignored: McKinley & Fletcher (2010) point out that "*the degradation of the marine environment can be partially attributed to the collective day-to-day impact of the behavioural and lifestyle choices made by individuals*". Individuals have in fact the potential to contribute substantially to a sustainable future on land and in the seas through the exercise of consumer choice, as well as the reduction of demand for marine resources and their impact on the environment (Vincent, 2011; Jefferson *et al*., 2015).

Towards this direction, many projects and initiatives in recent years seek to raise awareness among citizens and young people about the importance of maintaining a healthy and clean ocean, protecting and conserving marine ecosystems and biodiversity, and considering the terrestrial and marine environment as one closely interconnected system (Sullivan *et al*., 2019). Among these, citizen science initiatives have often proved to be a successful choice (Garcia-Soto *et al*., 2017) by achieving multiple goals at the same time: collecting widespread and low-cost scientific data, raising awareness of the issues at hand, and disseminating scientific methodology and critical thinking. The term "citizen science" was coined in the mid-90s, but it was only in 2014 that the definition "citizen science" was included in the Oxford English Dictionary (OED). In fact, citizen science is widely defined as "*scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists*" (Earp & Liconti, 2020).

These projects and initiatives also suggest a strict connection between the concepts of citizen science and ocean citizenship. It seems clear that the environmental education that takes place through citizen science projects plays a key role in the formation of a generation of more aware citizens who are acquiring true ocean citizenship. Understanding marine and coastal issues is in fact essential for the development of ocean citizenship, which describes a relationship between our everyday lives and the health of the coastal environment (Fletcher & Potts, 2007). It recognizes that individual behaviour can impact coastal and marine spaces and therefore "*reflects an individual's relationship with place, either in a direct sense through personal interaction, or indirectly through resource use and lifestyle choice*" (Fletcher & Potts, 2007). In recent years, the concept of ocean citizenship has been expanded to include environmental behaviour, and requires massive behavioural changes at the individual level (McKinley & Fletcher, 2010; Jefferson *et al*., 2015; Santoro *et al*., 2018) such as living as plastic free as possible, eating no or only sustainably caught fish, and committed to and engaged in ocean conservation.

Despite the acknowledged importance of an ocean-literate citizenry, schools in many European countries, including Italy, mostly do not address the marine sciences, offering curricular paths generally focused on terrestrial natural sciences (Schoedinger *et al*., 2006; Gotensparre *et al*., 2017; Mogias *et al*., 2019). The result is to that citizens (and media) are often unaware of how such an important element of the Earth's environmental system works and its role and influence on many aspects of their daily lives. This is especially true if they live far from the ocean. There are indeed several factors, such as demographic (age and gender), external (e.g., distance from the sea, household composition), and internal (e.g., motivation, awareness, attitudes, emotions, and priorities), that influence personal decisions and play an important role in shaping pro-environmental behaviour (Krajhanzl, 2010). Finally, it is extremely complex to try to explain the frequent inconsistency between knowledge and behaviour. Although many studies have been done, no definitive answers have yet been found (Lotze *et al*., 2018).

Thus, the idea of building an online platform dedicated to disseminating Ocean Literacy at home through citizen sciences activities was born out of these considerations and because during 2020, restrictions due to the COVID-19 health emergency did not allow researchers to organize public events and field data collection activities related to Ocean Literacy. The pandemic control measures provided in fact a unique opportunity to focus on collecting household data and information, thanks to the massive spread of digital tools to meet online, and to highlight the connections between citizen lifestyles and the eco-marine system. Last but not least, the COVID situation has also fostered the formation of new research teams, who share common interests but are physically distant and with few opportunities for contact.

Questionnaires were previously used in *SeaCleaner,* another citizen science project (https://sites.google.com/view/seacleaner/home-page) and in the *WaterWeWaste* project, both as part of a programme of dual learning with school pupils, to investigate citizens' household behaviours concerning plastic and water use and consumption. Despite their differences, these projects had in common the fact that they were both dedicated to citizenship and pupils and had a high rate of participation. These two aspects reinforce the idea of creating a platform for a new multidisciplinary citizen science project dedicated to Ocean Literacy. New questions were developed and used to test everyday attitudes during the lockdown about water use, fresh seafood, and plastic use and disposal. Data and information related to general environmental awareness, perceptions regarding purchasing choices, as well as any eventual change in lifestyles and habits during the lockdown were also collected and analyzed.

To summarize, the main research questions of our overall citizen science initiative were how to:

1. promote Ocean Literacy, and thus environmental edu-

cation, in a non-formal way, through a citizen science project;
2. evaluate different tools and strategies to promote this citizen science initiative;
3. collect numerical data on household use and consumption of different products/services;
4. analyse and compare the collected data across the different topics to improve our knowledge about people's behavioural aspects concerning the use of natural resources and the specific problems, challenges and opportunities that each of them could pose;
5. better understand the perception vs. real knowledge of citizens regarding the proposed environmental issues.

This paper aims to present the idea, the adopted methodology and communication/dissemination strategy used in the pandemic period to respond to the research questions listed above, with the objective of realizing a citizen science project. These issues are argued in the Materials and Methods section. Moreover, as an example of a practical application of our methodology, we present some results and discussions of project activities and survey results in the relevant sections (Results and Discussion). As for survey results, we have grouped some questions and analyzed the relevant answers, in three transversal topics common to the four questionnaires: *Basic demographic data*, *Knowledge about environmental and marine issues (Environmental awareness)*, *Attitudes/behaviour change due to the pandemic (Environmental behaviour)*. The great heterogeneity of the three issues addressed in the four questionnaires and the different results, in terms of the numbers of answers, do not allow us to present in this article all the results together. Therefore, the results from the specific questionnaires will be presented in future publications.

Materials and Methods

How to promote Ocean Literacy at home?

The need to ensure safety and social distancing during the pandemic was a major priority in the design of this platform. To do this, it was necessary to create a web portal to collect, streamline, and enhance the work previously done and to promote new data collection initiatives. In addition, it was important to let citizens know about this initiative and invite them to participate by motivating them in some way.

Based on previous experiences and as a result of a series of projects and activities that have promoted Ocean Literacy among Italian and European pupils and citizens (e.g., *SeaCleaner* and *WaterWeWaste*), we built the logical framework of *Walking on the Sea Traces* initiative (Fig. 1).

A website entitled *Walking on the Sea Traces* (https://

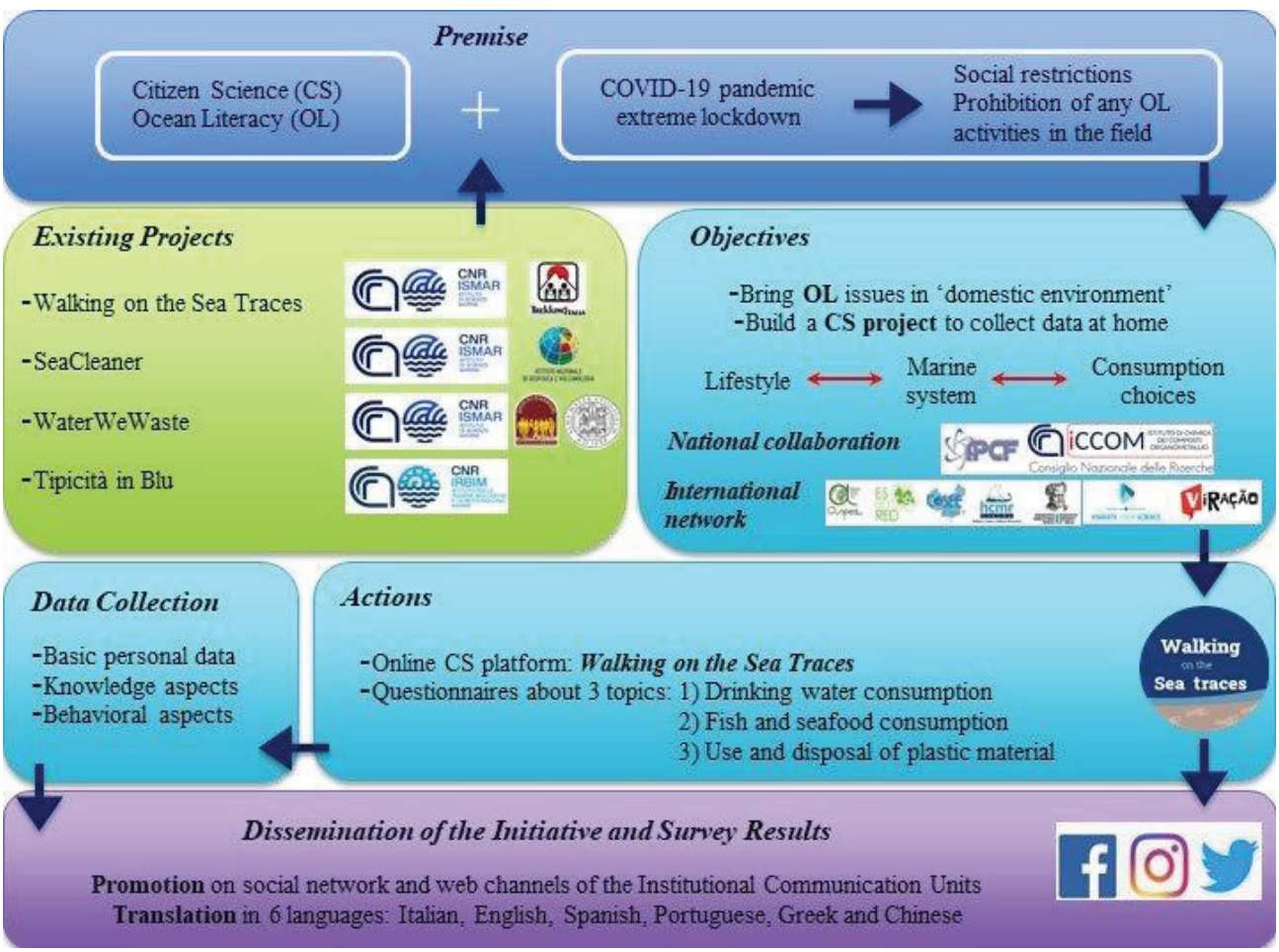

Fig. 1: Logical framework of Walking on the Sea Traces initiative.

sites.google.com/view/camminandosulletraccedelmare/home) was then designed in order to make available online all the information and materials needed for the data collection within a short time. To this aim, we chose a free and simple web application, i.e., Google Sites (https://support.google.com/). This app is one of the basic and very diffused services included in the Google Apps package, which allows the self-creation of websites. To build the website we took, as an example, a previous website created by physics colleagues of the CNR National Institute of Optics in Florence for a similar citizen science project (https://sites.google.com/view/scienzasulbalcone/home-page). In this regard, the graphical lay-out and logo, the first structure of the site and the style of dissemination language have been designed in an informal and appealing way.

How was the initiative promoted?

With the first data collection carried out within the *WaterWeWaste* project, the participation of high school pupils was a key to launch an awareness campaign on the social networks most used by young people and citizens. In April 2020, a working group of pupils opened dedicated pages on Instagram, Twitter and Facebook and started to post short news pieces and information about water and seafood as well as quizzes and easy games to attract the attention of peers and citizens to the survey.

In May 2020, the *Walking on the Sea Traces* platform was live streamed on the social channels (i.e., YouTube and Facebook) of the Communication Unit of the CNR. Two episodes dedicated to the three themes were aired. The first on May 14th 2020 in collaboration with the *WaterWeWaste* project pupils and teachers, and the second on May 21st in collaboration with INGV, CNR-ICCOM and CNR-IPCF of Pisa (Italy), and the high school in La Spezia previously involved in the *SeaCleaner* project (Merlino *et al*., 2015).

News about this initiative were also posted on social media and on the websites of CNR Headquarters, CNR Communication Unit, CNR-ISMR, CNR-ICCOM, CNR-IPCF, and INGV, as well as promoted through the authors' personal network of contacts.

Since its launch, we monitored the accesses to the different social pages and websites where the initiative was proposed and/or promoted (Table 1).

Table 1. Social networks, personal pages and websites where we posted messages and videos to promote the project/platform/survey.

Project/ Institution	*Social network/ website*	*Period*	*N. of posted messages/ videos*	*N. of follower*	*N. of following/ views*
WaterWeWaste	Twitter	24/4-20/7/20	17	6	5
WaterWeWaste	Instagram	24/4-20/7/20	20	47	7
WaterWeWaste	Facebook	24/4-20/7/20	22	9	8
WaterWeWaste	website	24/4/20-today	n.a.	n.a.	n.a.
CNR	website	08/6/20-today	1	n.a.	n.a.
CNR-ISMAR	website	14/5/20-today	1	n.a.	n.a.
CNR Comm Unit	YouTube	14/5/20-today	2	1550	531
CNR Comm Unit	Facebook	14/5/20-today	5	3029	20
CNR-ICCOM	website	14/5/20-today	1	n.a.	n.a.
CNR-IPCF	website	14/5/20-today	1	n.a.	n.a.
Walking on the Sea Traces	website	14/5/20-today	0	n.a.	n.a.
Personal mailing list	e-mail/ SMS	14/5/20-today	50	n.a.	2500
Citizen Science Italia	website/ portal	30/04/20-today	n.a.	n.a.	n.a.
EU Citizen Science	website/ portal	30/04/20-today	n.a.	n.a.	n.a.
INGVambiente	website/ portal	08/06/2020	1	n.a.	2562
INGVambiente	Facebook	20/05/2020 – 08/06/2020	5	19362	1228
INGVambiente	Instagram	08/06/2020	1	2072	2887
INGVambiente	Twitter	08/06/2020	1	1037	23
INGVcomunicazione	Facebook	08/06/2020	1	1014	38

What kind of data/information can be collected at home?

One of the main issues was to define what and how many environmental data people could collect in or around their homes. In fact, as early as March 2020, the government safety regulations limited people's ability to move to the immediate vicinity of their homes and, only for certain categories, along home-to-work routes. In addition, schools were closed and pupils were conducting distance learning. Furthermore, we did not want to restrict or limit data collection to those living within close proximity to the sea, but rather evaluate the possible influence of this factor on the given answers. An additional consideration was how would citizens collect the required data and what boundary information would they be willing to provide.

Then, we had to do a compromise between the amount of data we would like to obtain and the willingness of citizens to respond to questionnaire and to participate in requests that were too onerous in terms of time or commitment. It was also critical to decide how people could collect such environmental data at home. For example, while physical data such as temperature, noise or brightness levels are fairly easy to collect due to widely available mobile phone apps, data on geological, biological, chemical factors or consumption data, as well as on habits and life styles, are more complex and difficult to collect.The type of environmental data we wanted to obtain had to have some relationship with the marine environment and be easily collected at home or, indeed, within its surroundings. In this regard, we built upon our previous experiences and took into account our respective professional backgrounds, e.g., marine geology, physical oceanography, marine biology, chemistry. Therefore, we proposed three themes, related to the marine environment, to direct the attention of citizens to the relationship between their lifestyles and the health of the ocean, as well as of the impact of their purchasing choices on its resources. The chosen topics were: 1) domestic use and consumption of drinking water; 2) domestic consumption of fish and seafood products; 3) domestic consumption and disposal of plastic materials.

What kind of tool and strategies to collect the data?

After considering all the aforementioned factors, we opted for an initial survey based on questionnaires where the questions were formulated in a simple way and avoiding the use of too specific and scientific terms to allow the widest possible participation of citizens regardless of their level of scientific preparation. They consist of:

1. a first part devoted to the collection of anonymous basic personal data, in order to be able to correlate the provided answers in relation to age, sex, distance from the sea, household composition, etc.;
2. a second part focused on a tentative evaluation of the actual levels of citizens knowledge about the origin of some natural resources as well as on the qualitative and quantitative monitoring of their consumption (i.e., what type of consumption and relative quantities) by providing them with some basic information useful for the recognition of materials and products;
3. a third part where we wanted to collect information about personal purchasing and disposal choices, food preferences, or perceptions of a particular environmental issue.

The first two questionnaires on use and consumption of: 1) drinking water and 2) fish and seafood products at home, were already designed and built, in collaboration with a high school in Bologna (Italy) and the CNR-IRBIM of Ancona (Italy) within the *WaterWeWaste* project.

For *Water at Home*, we proposed 34 questions (Tab. 2): seven focused on personal information (e.g., age, sex, city and number of people in the household); 19 questions were devoted to collect data on domestic water use (e.g., for washing, cooking); four questions concerned general knowledge; four questions examined the awareness and daily habits. For *The Sea at the Table*, we proposed 28 questions: six focused on personal information; eight questions concerned general knowledge, with one question related to knowledge of the habitats in which some common commercial species live (Fig.4); and 14 questions concerned the respondent's personal behaviour, i.e., personal purchasing and disposal choices, food preferences, or perceptions regarding a particular environmental aspect.

Thanks to the initial results and feedback we received from the first two questionnaires, we realized that they were too long and complex to fill in. Therefore, we decided to split the plastic theme into two shorter and simpler questionnaires based also on the achievement of the project *SeaCleaner*. Their specific objectives were to: (1) assess the extent to which citizens were using personal protective equipment (PPE), and/or other plastic or plastic-packaged health and safety products, compared to the past; (2) verify if they were aware of the proper disposal of these products; (3) verify if they were aware of the possible impact of plastic waste on the environment, in general, and of the marine environment, in particular.

In the first *SOS Plastic at Sea* questionnaire, 12 questions were asked (Table 2): six on personal data information; one examined people's knowledge about the proposed themes; five were aimed to understand the degree of awareness. The total number of questions asked with the second *SOS Plastic at Sea* questionnaire were 13 (Table 2): six on personal data; three examined people's knowledge about the proposed themes; three were aimed to understand the degree of awareness.

How the data were analysed and compared?

Since the questionnaires (i.e., Suppl. Materials 1 - 4) were built and proposed for different topics and by different teams, we decided in this first analysis of the survey results to be presented only for common aspects among the questionnaires. Therefore, we analyzed the results in terms of behavioural vs. knowledge aspects, trying

Table 2. Structure of the 4 questionnaires.

Topic	Title	Total number of questions/ answers	N. of basic demographic data questions	N. of data measurements	N. of behaviour related questions	N. of knowledge related questions
Water	The water in my house	34 / 101	7	19	4	4
Seafood	How much sea is at your table?	28 / 92	6	0	14	8
Plastic use/ disposal	Watch where you throw me!	12 / 264	6	6	5	1
PPE use/ disposal	Did you wear the mask?	13 / 241	7	6	3	3

to evaluate: efficacy of the data collection, respondents' awareness concerning proposed topics, possible relationships within the local context, and personal characteristics of the respondents (e.g., age, sex, city). In order to coherently present the results and compare the received answers, we clustered them into three groups:

1. basic demographic data to contextualize the provided answers in relation to age, sex and local context (e.g., distance from the sea, household composition);
2. knowledge data about use of resources and related specific environmental problems in order to try to distinguish citizens personal perception from real knowledge regarding the proposed environmental issues;
3. behavioural aspects to highlight personal choices in terms of use, consumption, purchase and disposal of water, seafood and plastics.

Results

The citizen science platform as a promotional tool for Ocean Literacy at home

The information, dissemination and promotion tools (Table 1) were different. The software we used to create the online platform turned out to be very simple and intuitive to use and useful for organizing material, information, and data collection. But since we used the free of charge version, it was difficult to create versions in different languages. Also, the link to the site was too long and inconvenient to share. Finally, the site did not allow us to track access.

Concerning the websites of the institutions involved (i.e., CNR, INGV) and of the dedicated networks (i.e., Citizen Science Italia, EU Citizen Science), we found that in front of five news published between April 30 and June 8 on this initiative, only the INGV portal recorded 2,562 views while for the others this data was not available.

Regarding the e-mails sent through the mailing list of the authors, we can see that against the sending of 50 e-mails explaining and promoting the initiative, these had reached 2,500 people.

Social pages (i.e., TW, Inst, FB) created by students one month prior to the start of data collection were useful in engaging them directly in the project, but not as effective in promoting participation by peers and family members and citizens. In fact, a total of 20 follows were recorded against 59 posts, but for Inst there were as many as 47 followers. On institutional social networks (e.g., CNR and INGV), which have about 28,000 followers, compared to a dozen posts and two live streaming of May 2020 for the presentation of the project, there were about 4,700 follows.

Examples of first analysis and comparison of the obtained data and information

We received a total of 698 answers from the first survey: 101 for water, 92 for seafood and 241 and 264 for the two plastic (Table 2). Most responses came from women across the four questionnaires (i.e., 58%, 63%, 66% and 65%; Fig. 2A).

Basic demographic data

On average, the age of survey respondents were 44 years for females and 43 years for males, with a distribution in the different age classes for each topic as follows (Fig. 2c):

1. Water: 20% in the age group of 21-30 and 51-60 years old, followed by 41-50 (16%), 11-20 (15%) and 61-70 (14%). Less represented age groups were 31-40 (10%) and the oldest age group 71-80 (5%);
2. Seafood: 28% in the age group 51-60, followed by 41-50 (23%) and 31-40 (17%). Less represented age groups were 21-30 (13%), 61-70 (9%), 71-80 (6%) and the youngest age group (only 4%);
3. Plastic use: 34% in the age group 51-60, followed by 41-50 (19%) and 31-40 (14%). Less represented age groups were 21-30 (14%), 14-20 (11%), 61-70 (8%), and the oldest age group (0%);
4. Plastic disposal: 34% in the age group 51-60, followed by 41-50 (21%), 21-30 (14%), 31-40 (14%). Less represented age groups were 11-20 (9%), 61-70 (9%), and the oldest age group 71-80 (0.4%).

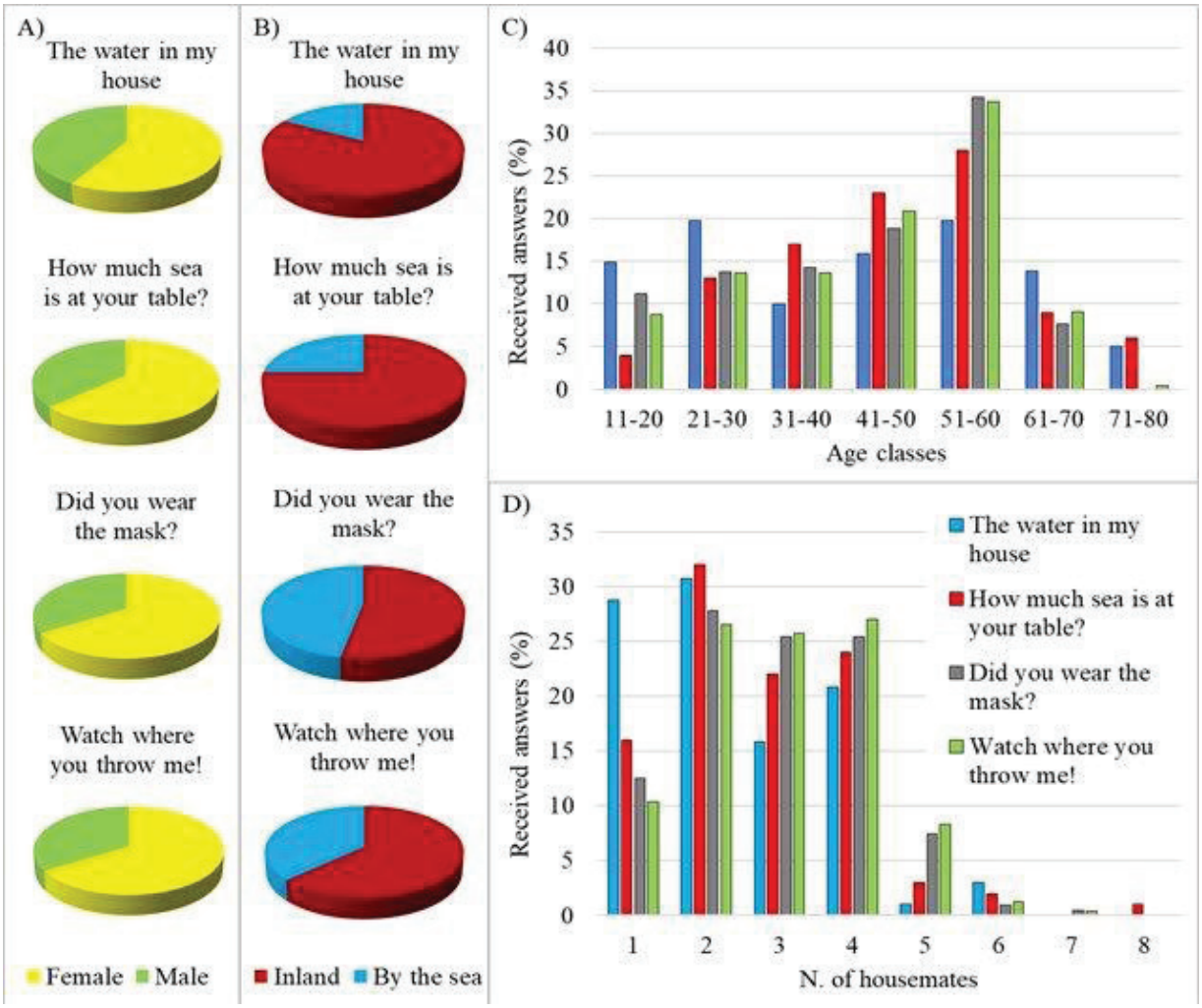

Fig. 2: Numbers of total received answers grouped by: A) male vs. female; B) inland vs. by the sea; Ψ) age classes; Δ) number of housemates. In supplementary materials, a detailed table with all info related to basic personal data is added.

In order to determine the respondents' physical connection to the sea, we asked them if they were currently living by the sea or inland (Fig. 2B). As for the water topic, most of the people used to live in an inland city (83%) and only the 17% lived by the sea. As for the seafood respondents, three out of four people lived in an inland city (75%). The same distribution was detected for the plastic use and disposal survey respondents. On the contrary, in the Personal Protective Equipment use and disposal survey, they were almost equally distributed between inland and by the sea locations (53% and 47%, respectively).

In order to better interpret the collected data, especially those linked to the use and consumption of goods and services, we asked about their household composition. The most frequent number of people in the household is 1 to 4 (i.e., 17%, 29%, 22% and 24%, respectively) (Fig. 2D).

Knowledge about environmental and marine issues (Environmental awareness)

From the different questionnaires, we extracted one or two examples that dealt with general or specific knowledge on the proposed topic.

The selected question about water knowledge was "Do you know that the toilet flush uses potable water?". With this question, we wanted to know if citizens were aware that potable water is commonly used in Italy for toilet flushing. Figure 3 shows that one out of four respondents did not know that, but also that the majority of people who were aware of it recognize that they cannot do anything about it. Only the 6% referred they had a different method to flush their toilets.

For seafood, the chosen question was "Do you know where these species live?". We wanted to verify if people knew about the habitats of the most common species of seafood and fish usually available at the market. All respondents (men and women) answered correctly regarding cephalopods, i.e. squid (*Loligo vulgaris),* cuttlefish (*Sepia officinalis),* octopus (*Octopus vulgaris*), and only about anchovy (*Engraulis encrasicolus*) among the fishes (Fig. 4). These results are probably due to the fact that these species live in a wide variety of habitats, spanning from coastal areas to the open sea and on different substrates, therefore it was easier to choose a correct option among the proposed answers. Incorrect answers mostly concerned crustaceans, where the correct answers were, males: 50% and females: 62% for Caramote prawn (*Melicertus kerathurus*), and males: 44% and females: 64%

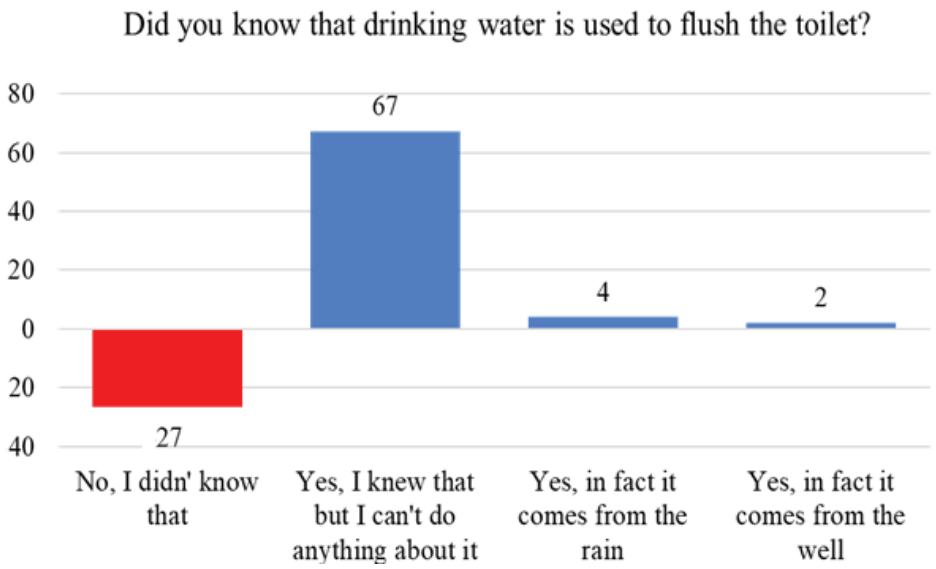

Fig. 3: Answers received about the question on the origin of domestic WC flushing water.

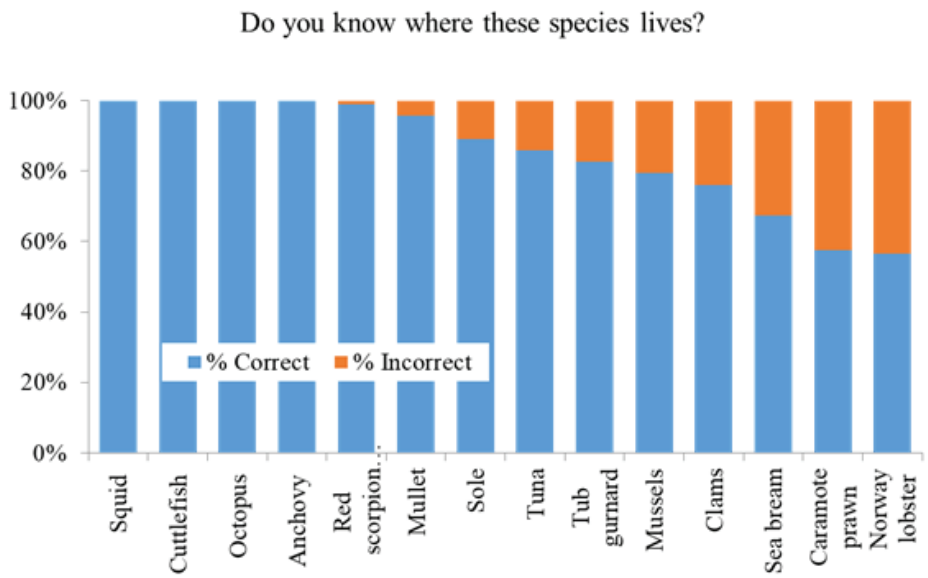

Fig. 4: Percentage of correct and incorrect answers related to the question "Do you know where these species live?". (Squid= *Loligo vulgaris;* Cuttlefish= *Sepia officinalis;* Octopus = *Octopus vulgaris;* Anchovy = *Engraulis encrasicolus;* Red Scorpionfish = *Scorpaena* spp.; Mullet = *Mullus* spp.; Sole = *Solea solea;* Tuna = *Thunnus spp*.; Tub gurnard = *Chelidonichthys lucerna;* Mussels = *Mytilus* spp.; Clams = *Chamelea gallina*, *Venus* spp.; Sea Bream = *Sparus aurata*; Caramote prawn = *Melicertus kerathurus*; Norway lobster = *Nephrops norvegicus*).

for Norway lobster (*Nephrops norvegicus*). But for fish, men responded almost always with more correct answers than women, except for tuna where the number of correct answers were similar (males: 85% and females: 86%).

With respect to plastic use and disposal, the questions addressed the expected environmental impact due to misuse and/or improper disposal of plastic items. Among them, we report here the results obtained for the question "In your opinion, during this period of lockdown due to the COVID health emergency, the contribution of plastic..." (Fig. 5), with the proposed response options shown on the X-axis. Responses refer to a general environmental impact (green bars) and to a more sea-specific impact (blue bars).

We can see that respondents during the blockade period were aware of environmental pollution that had increased due to heavy use of packaging and plastics, including those for hygienic purposes, but that this had not yet translated into increased pollution of the sea.

As for the 2nd questionnaire on *SOS Plastic at Sea* (Personal Protective Equipment (PPE) use and disposal survey), one of the questions regarding knowledge was: "Can you tell us what these acronyms mean?". It was aimed to investigate the people knowledge about acronyms used for commonly used plastic materials (PP for Polypropylene, PS for polystyrene, etc.), as well as acronyms associated with materials widely used during the lockdown period (DM for Medical Devices, PPE and FFP1 for Filtering Facepiece1). In Figure 6, we report the responses, separated into two categories: Health Workers

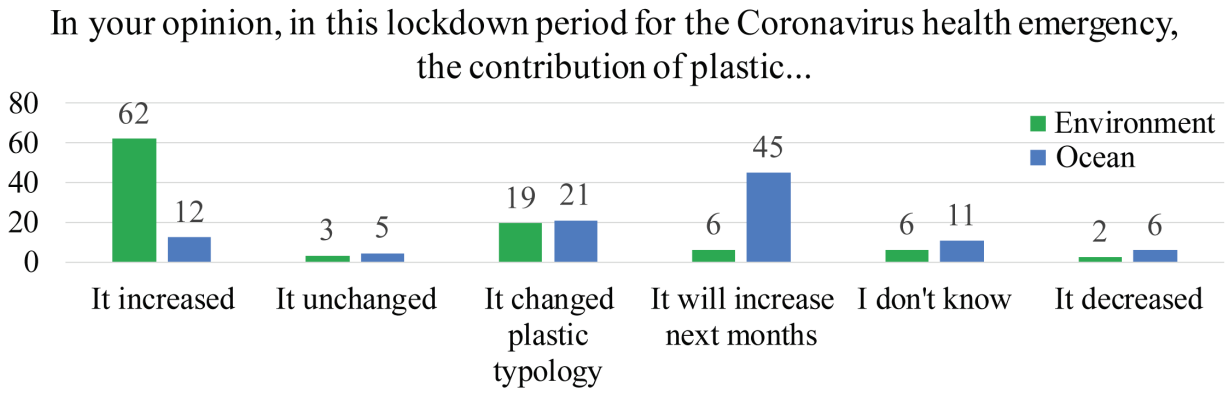

Fig. 5: The bars represent the received answers concerning the perception of: environmental pollution in general (Green bars) and on the impact on seas and oceans in particular (Blue bars).

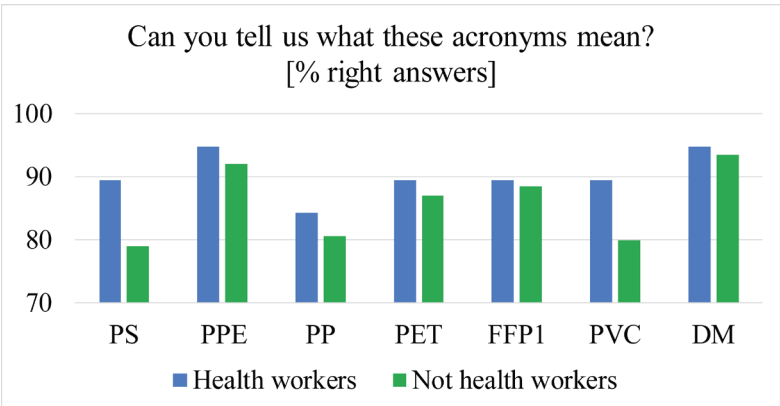

Fig. 6: Results of the question investigating people's level of knowledge about certain acronyms used for commonly used plastic materials and those associated with other materials, such as PPE, that are widely used during the lockdown period: HW (Blues bars); NHW (Green Bars).

(HW) and Non Health Workers (NHW).

HWs show greater general knowledge of all acronyms, and particularly of acronyms used to denote three of the most common types of polymeric material (PS and PP and PVC for Polyvinyl chloride, respectively). The difference seems to diminish between HWs and NHWs with regard to knowledge of acronyms associated with personal protective equipment (PPE, FFP1, and DM) widely publicized in the mass media during the survey period.

Attitudes/behaviour change due to the pandemic (Environmental behaviour)

Regarding the assessment of behavioural aspects (i.e., personal choices about the use, consumption, purchase, and disposal of water, seafood, and plastic), we compared the different questionnaires and extracted some comparable examples of the responses received.

For the Water topic, the selected question was "At home, where does the drinking water come from?". The proposed answers were what we expected to be the most common (i.e., plastic bottles vs. tap water) plus some more options (e.g., public vs. private spring, and public water distribution in towns). In Figure 7a, we grouped the different answers into two categories, to highlight the most frequent/common behaviours regarding the question asked. We can see that plastic bottles and tap water are the most common source of domestic drinking water, with 72% of respondents using tap water vs. 36% using plastic bottles. Other sources are generally unused or underutilized.

We also asked about the motivation for those choices in order to understand whether they were conscious or not, and whether there were different motivations for different sources (Fig. 7b). Therefore, we analysed the answers in terms of quality, comfort, money saving, and habits, and limited the analysis to the most common sources, i.e., plastic bottles and tap water. As for quality, plastic bottle consumers believed that it is of better quality than tap water, whereas tap water was massively preferred because it is cheaper. What is worth noting is that both are considered convenient to use, and both choices seem to be just a matter of habit.

We also wanted to see if awareness about the limited nature of water resources as well as the respondents' thinking/sensibilities about this issue changed at all because of this survey. In Figure 8a, we can see that 90% of the respondents did know about limited water resources. However, one out of ten people remains unaware. Further examination of this indicates that those who are unaware are young women (i.e., 24 years old) and middle-aged men (i.e., 47-65 years old). In terms of increased sensitivity to the issues at hand, Figure 8b suggests that three-quarters of respondents will pay more attention to

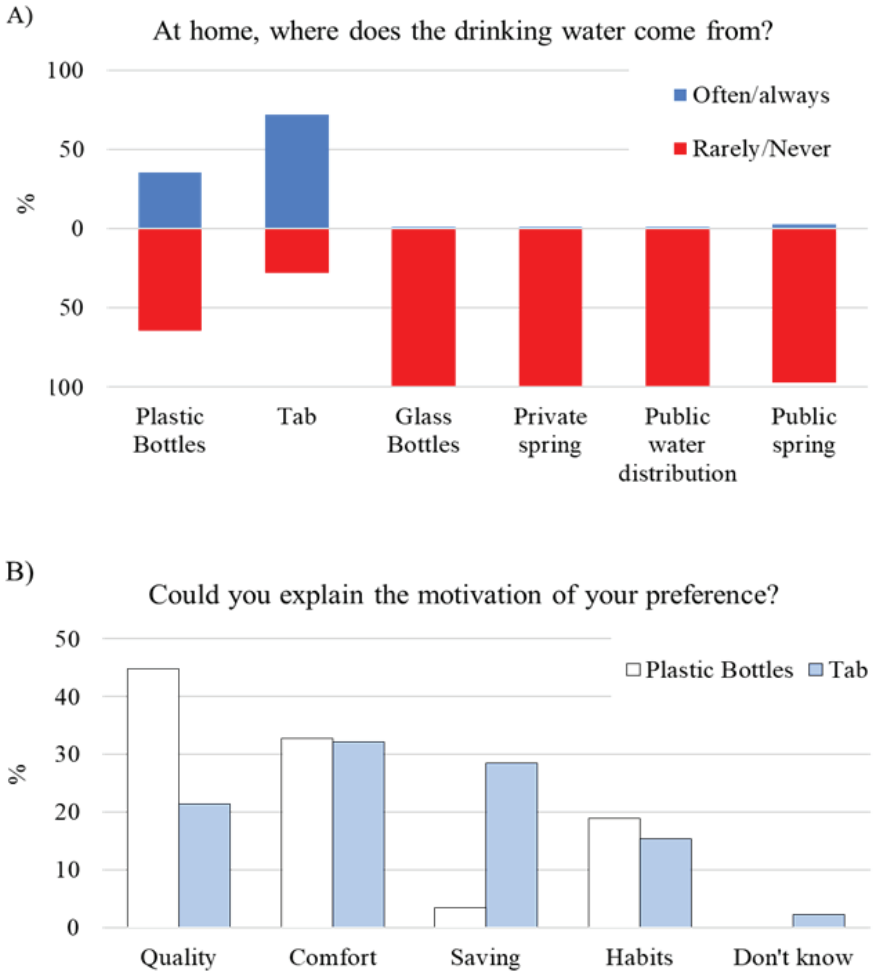

Fig. 7: A) Comparison among the different drinking water sources at home (% of total answers). B) Comparison of the different choice motivations for the source of drinking water at home (values are in % of the total positive answers, i.e. = total answers – I don't use it).

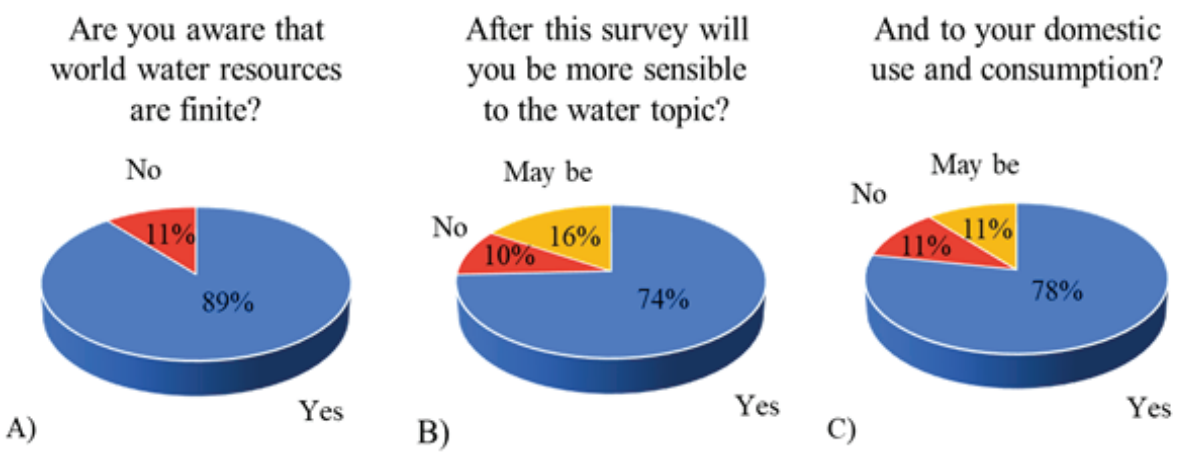

Fig. 8: A) Results (% of the total answers) about the awareness on limitation of water resources; B) Results (% of the total answers) about people availability to make attention to the water issues; C) Results (% of the total answers) about people availability to be more attentive to the water use at home.

water resource issues in the future and that 78% will be more attentive to water management at home (Fig. 8c).

For the Seafood topic, the chosen question was "What is the most important aspect you consider when buying fish products?" (Fig. 9). We analyzed the given choices in terms of: conscious behaviour (i.e., freshness, nutritional properties, origin of the products), marketing aspects (i.e., expiry date, prize, preparation and portioning of seafood); habits (i.e., social or familiar heritage/tradition); sustainability (i.e., preferred consumption periods). The results showed that many consumers (42%) consciously choose seafood by favoring freshness, nutritional properties, and the origin of the products (Fig. 9). Marketing aspects also had an important role in the purchase decision

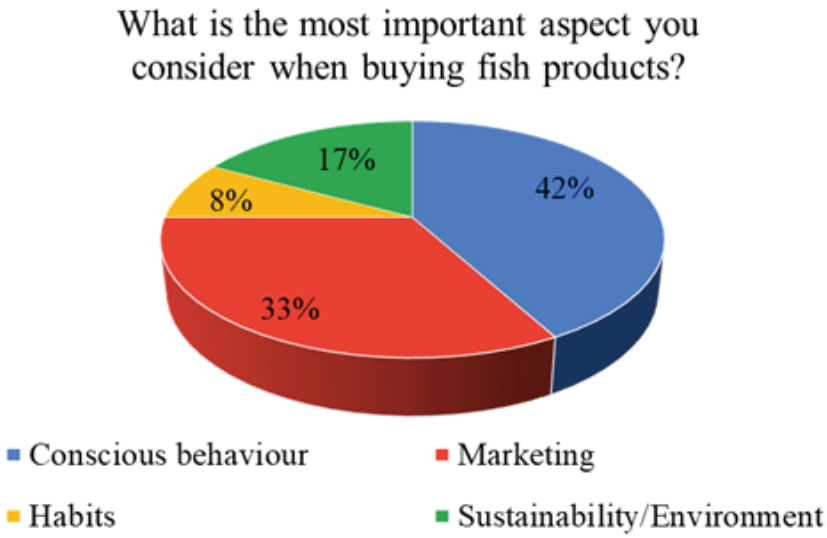

Fig. 9: Results (% of the total answers) of the question regarding the most important aspect considered when people buy fish products.

(33%), while the environmental impact and seasonality seemed to be little considered by consumers (17%). More seafood is consumed in spring and summer. In contrast, family traditions (habits) had minimal impact on their choice of seafood purchase and consumption (8%).

The supermarket was the main place to shop (for comfort and convenience), followed by the fishmonger (for better quality), online (purchase speed and convenience) and, finally self-caught/recreational fishing (safe origin).

Regarding the motivation to consume seafood, 45% of people consume it because they like the taste, however, the concept that eating fish promotes "well-being" lead 39% of respondents to frequently introduce seafood into their diet. Among those surveyed, there is a widespread awareness that eating fish promotes health and well-being, thanks to the presence of polyunsaturated fats such as omega-3 and minerals.

When compared to the period before COVID-19, the consumption of seafood remained unchanged for 56% of the respondents (Fig. 10). For those who saw a reduction in seafood consumption (33%), the primary reason was lockdown imposed movement restrictions - people could only shop in stores close to where they live. For the 11% of participants who saw increased consumption, this was primarily due to having more time to cook as a result of working from home.

Regarding personal choices in purchase and disposal of plastic materials that can have direct effects on environmental pollution and, more specifically, on the sea, we report the results for the question "In recent years television, internet, and social media have spread information about the troubling problem of plastics in the sea. Has this affected your daily plastic use behaviours?" (Fig. 11). Respondents were able to give more than one answer to this question and most answered that knowledge of the environmental damage caused by plastics, especially in

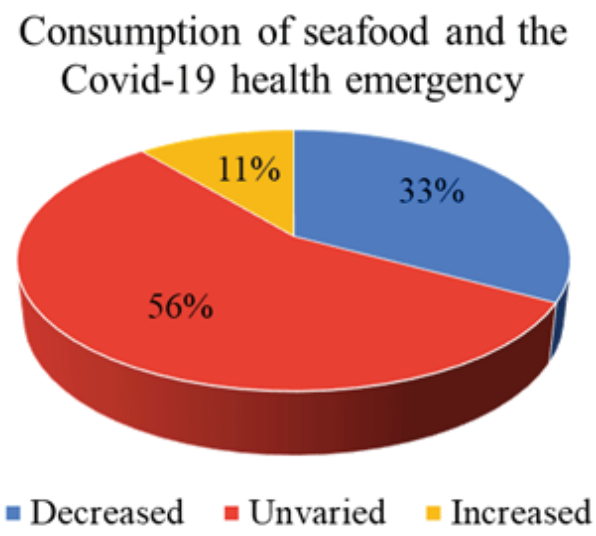

Fig. 10: Results (% of the total answers) to the question related to changes in the seafood consumption habits before and during the pandemic period.

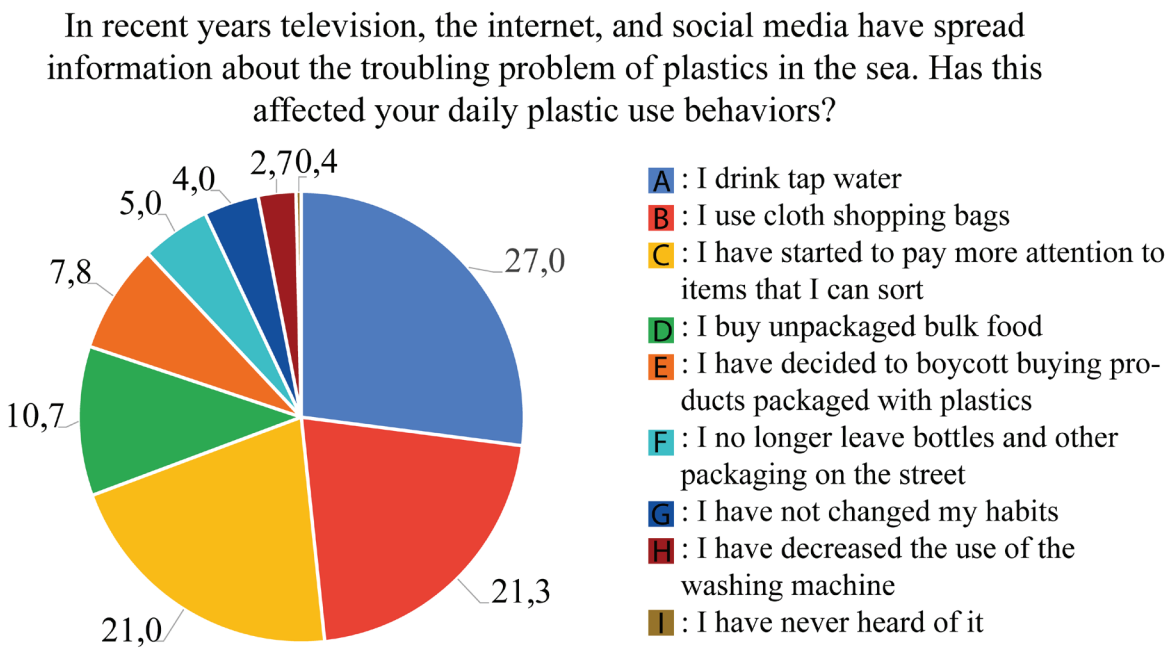

Fig. 11: The pie represents the different answers received for the given question (% of total answers).

the marine environment, had influenced their choices and habits with regard to the actions described in answer options A, B and C (i.e., drinking water from the tap instead of bottled water, using cloth bags instead of plastic bags for shopping, separate waste more carefully).

Regarding the PPE survey, the selected question was "Where did you dispose of gloves and masks once used?". Figure 12 groups the different responses into two categories, which denote a "correct" behaviour regarding the question asked, or an "incorrect" one. For sake of simplicity, we also merged some questions that were about very similar topics, to get an overall score (see the complete set of questions in Supplementary Material). The received answers have been separated between HW

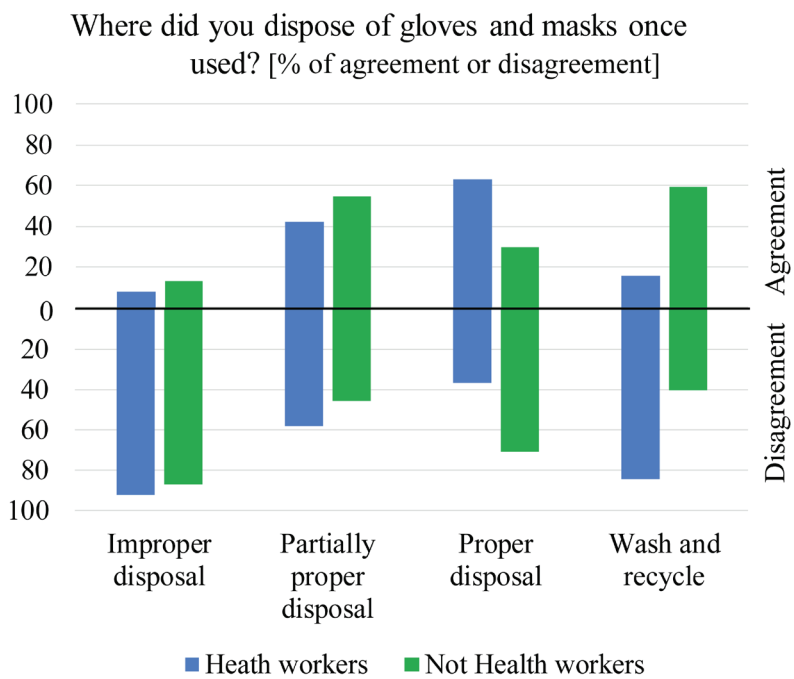

Fig. 12: The bar graph shows the number of received responses (as a % of the total number of received responses) for those who are in: Agreement (i.e., columns above the 0 line) or Disagreement (i.e., columns below the 0 line) with the three proposed methods of glove and mask disposal (i.e., incorrect, partially correct, and correct disposal) and with the last action (i.e., wash and recycle gloves and masks multiple times). Blue color: HW; green color: NHW. See the Supplementary Material for a detailed description of all questions in the different categories.

and NHW.

In this specific case, it was not possible for us to directly compare what was the behaviour of citizens regarding the problems investigated before or after the COVID 19 emergency with the behaviour of citizens during the emergency period. In fact, the questionnaire was circulated only in May 2020, therefore in full lockdown, and we haven't got any data before that period except for what was the reported behaviour/attitude in some of the answers of plastic questionnaires.

Discussion

When evaluating the initial results of this initiative, we considered the following: a) Did we advertise enough and through the right channels? b) Did those who responded do so through direct communication with us or through social web communication?

The overall low number of responses for the first survey, focused on water and seafood products, suggests the partial lack of effectiveness of the information campaign and this despite the fact that three social media channels (Facebook, Twitter and Instagram) were immediately activated by the pupils of the involved schools, while the *WaterWeWaste* and *Walking on the Sea Traces* websites were being constructed. Even the use of mailing lists from the authors' network of personal contacts (family members, colleagues, friends and acquaintances) was only partially effective in engaging people to participate in the survey. In fact, an important constituent of these respondents was from "Inland" cities (e.g., Bologna; Pisa and La Spezia for the Plastic topic) where some of the authors had already developed most of their previous citizen science or dissemination school projects (Merlino *et al*., 2015; Mioni *et al*., 2015; Locritani *et al*., 2019; Merlino *et al*., 2021). This aspect coupled with the age of the respondents (e.g., aged 11-20 years old) suggests that they had previously been involved in those projects (e.g., pupils) or had close ties of kinship or friendship with them.

Furthermore, the specific days chosen to ask for surveys to be completed were not a good choice as these comprised a single weekend (May 9 and 10) at the beginning of the reopening phase following the first quarter of the more severe lockdown. People were most likely distracted by the chance to finally get out of the house and enjoy a spring weekend with a little more freedom of movement and not tied to an internet connection. Following these initial results, we reopened the first two questionnaires by adding new questions concerning the use and consumption of plastics. Participation was higher (more than double) with regard to plastics, probably due to the presence of a more structured network of contacts and collaborations developed through seven years of work in the *SeaCleaner* project in comparison with the newer *WaterWeWaste* or *Walking on the Sea Traces*. In addition, higher media coverage about plastics could have also influenced the number of responses obtained (e.g., plastics are well known and have often been discussed in the media recently). Conversely, the simple publication of the projects on the Italian portal of Citizen Science as well as the live stream of the project on CNR's social media channels in May 2020 do not seem to have been effective enough to widely promote participation (Table 1). In fact, if we compare, for example, our results with those obtained for another similar citizen science CNR project, La Scienza sul Balcone (https://sites.google.com/view/scienzasulbalcone/home-page) from which this project was inspired, we see a much higher participation with more than 7,000 responses. Both projects were presented on the same channels as the CNR. However, the CNR was able to count on the presence in its team of a well-known populariser of science, who also publicized the project through its personal social channels and in the national and local media, and on the other hand, on the collaboration with an association of people passionate about the proposed theme. Moreover, their request to collect only a single environmental measure through an easy downloadable app for mobile phones could have further facilitated participation. In addition, we should take into account that the promotion of the survey was also realized within the authors' personal network of contacts. This may have introduced some bias. Therefore, we should take into account all the considerations made so far for the future data collection in order to develop, a more appropriate form of promotion and management of questionnaires through our platform.

We also wanted to see how respondents felt about the questionnaires: a) Were the questionnaires simple and "enjoyable" enough to do? b) Do people feel engaged in the data collection?

After the first round of responses, we received some feedback from participants stating that the water questionnaire was too complex and long (34 questions), required too much effort to monitor so much data and for too long a period (2 days). The same was partially true for seafood. Therefore, we decided to split the plastic questionnaire into two and to simplify it as much as possible, keeping the questions on perception, knowledge and behavioural aspects. We also added some more persuasive elements, as suggested by other authors (Garcia-Soto *et al*., 2017; Sullivan *et al*., 2019), such as asking participants to post pictures of masks and gloves found abandoned nearby, which seems to have further encouraged and motivated participation.

Finally, we wanted to see if there was a correlation between knowledge on the specific issue and relevant behaviour (Lotze *et al*., 2018). That is, whether the same people who demonstrate better knowledge are also those who behave in a more correct way and/or with greater awareness. Regarding the topic of water, the responses received seem to be the result of a matter of habit and/or the result of a popular belief in the safer quality of bottled water, even if it is bottled in plastic.

It was very interesting to note that conscious seafood consumption is widespread among respondents. The main reason that leads the consumer to buy seafood seems generally to be an awareness that its consumption promotes "well-being". In particular, the most important aspect

that drives the choice of seafood consumers is mainly related to quality/safety of fish products (e.g., colour/freshness and nutritional properties) as well as the information about their origin (e.g., traceability and labelling) rather than marketing aspects (e.g., price or preparation and portioning of seafood). Environmental sustainability aspects (i.e., fishing gears, seasonality) seem to play a secondary role in the purchase decision. Thus, although the importance of the nutritional value of seafood is well recognised and appreciated by consumers, the concept of sustainability and the environmental impact of fishing do not seem to be widespread as already observed.

A lower sensitivity in respect of the environmental impact of fishing is also highlighted by the results obtained from the question "What is the most important aspect you consider when buying fish products?". These aspects suggest that a wider awareness/educational campaign for schools and citizens about the marine ecosystem characteristics and functioning could facilitate a greater respect for and a better management of marine resources (Sullivan *et al*., 2019).

As regards the topic of plastic use and disposal (corresponding to the question "*In recent years television, the internet and social media have spread information about the troubling problem of plastic in the sea. Has this affected your daily plastic use behaviour*?", a very low percentage of respondents avoid leaving bottles and other packaging on the street compared to the others who prefer tap water to bottled water or no longer use plastic bags for shopping or pay more attention to a separate collection of rubbish. All statements demonstrate that knowledge and awareness of the problems caused to the marine environment by improper waste disposal have led to a change in their behaviour (e.g., Qian, 2018; Ashley *et al*., 2019; Kelly *et al*., 2019). Knowledge of the problem of marine litter dispersal in the environment therefore contributed to increasing their awareness, and to their taking further measures to prevent pollution, as seen also in other areas (Lotze *et al*., 2018; Kelly *et al*., 2020).

Concerning the behavioural aspects related to the disposal of gloves and masks, all the respondents are very clear about what "shouldn't be done." Some indecisiveness emerged, particularly among NHW (non health worker) compared to HW (health worker) people, concerning the treatment and re-use of gloves and masks. This consideration is probably due to the higher level of risk the HW faces (because of working in a risky environment) than the NHW.

In general, the results seem to show that better knowledge of an environmental problem, process or phenomenon improves the awareness of how to behave, what choices to make and the reasons why it is necessary to make them (Ashley *et al*., 2019; Nelms *et al*., 2021). While the mere perception of them, especially if based only on little or no personal experience, provokes a more emotional, intimate and irrational response in people, thus hindering their understanding and taking up a possible stance to help solve them (Stoll-Kleemann, 2019; Earp *et al*., 2020). However, since perception is the psychic process that synthesizes sensory data into meaningful forms, we can act through citizen science to involve people in direct experiences of environmental research and data collection to help improve their perception on environmental issues and challenges (Vincent, 2011; Jefferson *et al*., 2015; Lotze *et al*., 2018).

Conclusion

This paper focuses on the strategy and methods which were used to develop the project. It presents our citizen science project framework, the general approach used to share and diffuse the initiative and some very preliminary results on the first four surveys.

In the first phase of this initiative, various approaches were tested in terms of topics proposed, questions formulated, time, and style of questionnaires to bring Ocean Literacy to the home. From this initial experience, we learned that there is a need for environmental issues to be communicated in a way that allows citizens to both understand the information and increase their motivation to actively participate in conservation and education projects, initiatives, and events (when possible), and to encourage them to increase and/or maintain participation by demonstrating the value of their contributions. Indeed, our results seem to indicate that our initiative was successful in engaging primarily citizens who were already ocean-literate and/or already familiar with the proposed topics and/or already involved by the authors in such activities. Therefore, it will be important in the future to modify the communication plan to involve different and new audiences and to develop a wider network of contacts. One possible approach could be to involve high school students in disseminating the questionnaires to their relatives and friends. In this way, we expect to achieve greater heterogeneity (age, gender, social background, etc.) in responses. With a more "capillary" approach, through our citizen science platform we could also propose to the schools and/or citizens involved, specific Ocean Literacy and citizen science activities, and prepare pre- and post-activity questionnaires that would allow us to understand if their knowledge and attitude towards the proposed topics have changed. This was not possible in our case, since the proposed questionnaire was "one shot" and anonymous.

In addition, to increase citizen participation in this type of survey, questionnaires should be easy to understand, short enough (i.e., few data to collect) and "pleasant" to fill out, accompanied by a good communication plan with wider use of social channels and known scientific disseminators in national and local media.

For these reasons, a re-styling of the platform, which is constantly evolving, was begun at the end of 2020. It has been enriched with images that could potentially increase the appeal of the site. Thanks to previous collaborations and personal networks of the authors, the questionnaires have been further translated into four different languages (i.e., Spanish, Portuguese, Greek and Chinese), in order to promote our research and improve the dissemination of information. This improvement will give us a valuable

tool to use in current and future Ocean Literacy citizen science projects, and to involve Italian and foreign colleagues in data collection on current and future topics. In fact, we plan after this first pilot phase to promote a second phase in which the proposed questionnaires will be used in EU-funded projects, including the ongoing project entitled "Supporting the development of socially-inclusive Blue Challenges in schools in the Mediterranean sea-basin" (BlueS_Med) funded by the Erasmus+ program as well as other EU4Ocean initiatives.

The applied methodology and the collected data can be useful in creating effective survey tools and developing an awareness base upon which citizen science projects can be built and implemented. One of the main goals of the citizen science initiatives, in fact, is to address behaviours and attitudes, improving the ability of citizens to make informed, responsible, and environmentally sustainable decisions. In fact, exploring the range of complex interactions between humans and the environment is a first step in identifying the most important factors that might have some influence on responsible pro-environmental behaviour (e.g., minimizing resource and energy consumption, using non-toxic substances, reducing waste generation).

Finally, the construction of an entire section dedicated to Ocean Literacy, realized in the context of a curricular internship of the Master of Science in Marine Sciences at the University of Milan-Bicocca proposed by CNR-ISMAR, represents a further enrichment of this platform dedicated to the knowledge of the sea. In this section, it is possible to access, visualize and download for free all the material concerning the basic principles of OL and the essential concepts, areas and sequences translated in Italian, to date the only opportunity in Italy.

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Supplementary Data

The following supplementary information is available online for the article:
Q1_The water in my house.pdf
Q2_How much sea at your table.pdf
Q3_Watch where you throw me.pdf
Q4_Did you wear the mask.pdf