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Organisation HCMR

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Nature of the deliverable		
R	Report	✓
DEC	Websites, patents, filing, etc.	
DEM	Demonstrator	
O	Other	
ORDP	Open Research Data Pilot	

Dissemination level		
PU	Public	✓
CO	Confidential, only for members of the consortium (including the Commission Services)	

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NAUTILOS - New Approach to Underwater Technologies for Innovative, Low-cost Ocean observation is an H2020 project funded under the Future of Seas and Oceans Flagship Initiative, coordinated by the National Research Council of Italy (CNR, Consiglio Nazionale delle Ricerche). It brings together a group of 21 entities from 11 European countries with multidisciplinary expertise ranging from ocean instrumentation development and integration, ocean sensing and sampling instrumentation, data processing, modelling and control, operational oceanography and biology and ecosystems and biogeochemistry such, water and climate change science, technological marine applications and research infrastructures.

NAUTILOS will fill-in marine observation and modelling gaps for chemical, biological and deep ocean physics variables through the development of a new generation of cost-effective sensors and samplers, the integration of the aforementioned technologies within observing platforms and their deployment in large-scale demonstrations in European seas. The fundamental aim of the project will be to complement and expand current European observation tools and services, to obtain a collection of data at a much higher spatial resolution, temporal regularity and length than currently available at the European scale, and to further enable and democratise the monitoring of the marine environment to both traditional and non-traditional data users.

NAUTILOS is one of two projects included in the EU´s efforts to support of the European Strategy for Plastics in a Circular Economy by supporting the demonstration of new and innovative technologies to measure the Essential Ocean Variables (EOV).

More information on the project can be found at: https://www.NAUTILOS-h2020.eu/.

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I. INTRODUCTION

1.1. Objectives of this deliverable

The main objective of this deliverable is to report on the activities undertaken to raise public awareness regarding the instrumentation (sensors, tools and platforms) that were developed or used during the project NAUTILOS and how they encouraged participation of the general public in simple and user-friendly scientific activities. Monitoring of the ocean through Citizen Science (CS) approaches is a participatory method involving citizen volunteers, which broadens the scope of data collection across different spatial and temporal scales. Equipped with low-cost tools, the citizen scientists have the potential to collect data related to the chemical, physical and biological status of marine and coastal waters. This collaboration encourages co-creation of knowledge and aligns research with societal needs. The exchange between professional and citizen scientists deepens public engagement in marine science, promoting responsible environmental awareness.

1.2. Area of focus

The Citizen Science activities that have been performed within Task 10.4 are complementary to the CS activities performed in WP12. More specifically, Citizen Science activities implemented within Task 10.4 include the scientific fields of biodiversity and ocean measurements, while CS activities in Task 12.2 are specifically focused on plastic pollution. According to the Description of Work in the Grant Agreement, there are two parts of activities in Deliverable 10.9: I) Crowd-sourcing for visual marine image annotations, and II) Creation of a network of observatories for marine data collection. The main target audiences for both sections include the general public, school students, university students and recreational divers.

Section I - Crowd-sourcing for visual marine image annotations: Citizen scientists have annotated marine underwater photos and focused on the visual detection and classification of the larger fauna present in different habitats. As indicated in the GA, the campaign and mass imagery crowd sourced data generation have included specific parameters such as major seafloor organism types and the available images were provided from the partner's (HCMR) repositories.

Section II - Creation of a network of observatories for marine data collection: Citizen Scientists were provided with NAUTILOS novel low-cost sensors in order to monitor and record different environmental parameters and biological indices, such as algal blooms, underwater sound, dissolved oxygen and chlorophyl. The volunteers were able to upload their data to the dedicated online NAUTILOS platform under the relevant map layers. It is important to note here, that the sensors developed and the platforms used within the NAUTILOS project were primarily designed for advanced technological use and most of them require scientific platforms and experienced personnel to be operated. Since they are not yet designed and adapted for citizen science use, they might pose several restrictions, such as operation in great depths, not long-term autonomous use, specialized software for programming and data acquisition, heavy weight, necessity for permanent deployment on platforms or vessels, etc. Therefore, only some sensors were available for use by citizens, students and the general public and these are presented below.

II. CROWD – SOURCING FOR VISUAL MARINE IMAGE ANNOTATIONS

2.1. Marine Creatures – Zooniverse project

An online Citizen Science project for marine images annotations was created in the platform Zooniverse, which is currently the largest and most popular citizen science platform applying crowdsourcing to scientific research. Zooniverse was created in 2009 and has been successfully emerged during the last 15 years. Currently Zooniverse has 854,092,703 online classifications made by 2,799,017 registered users and hosting more than 500 projects; these numbers are increasing on a daily basis. On Zooniverse volunteers can easily contribute to real academic research, using authentic scientific data, on their own computer, at their convenience. Zooniverse offers great chances for increased visibility for a project, has customized project building options, good technical support and an active talk and feedback community.

The *Marine Creatures* project (Figure 1) was created within the activities of Task 10.4 in order to facilitate the target of crowd-sourcing image annotations using underwater photos derived from the repository of IMBBC-HCMR. Volunteers are being called to visually identify and classify the types of organisms present on the hard bottom seabed habitat and to detect the most important groups of marine sessile fauna present. Photos from a selection of three artificial and natural habitats are being provided: artificial reefs, marine ports and natural sea caves. A total of 214 photos have been included as subjects for the three habitat categories.

The aims of the project were to a) engage the public in scientific research, b) bring experts and volunteers effectively together, c) train citizens on collecting quality data and d) create awareness for marine biodiversity. Marine Creatures was launched in September 2022, and it is still ongoing with 1,378 volunteers engaged in the project (400 registered users) and 19,292 contributions (8,705 contributions from registered users).

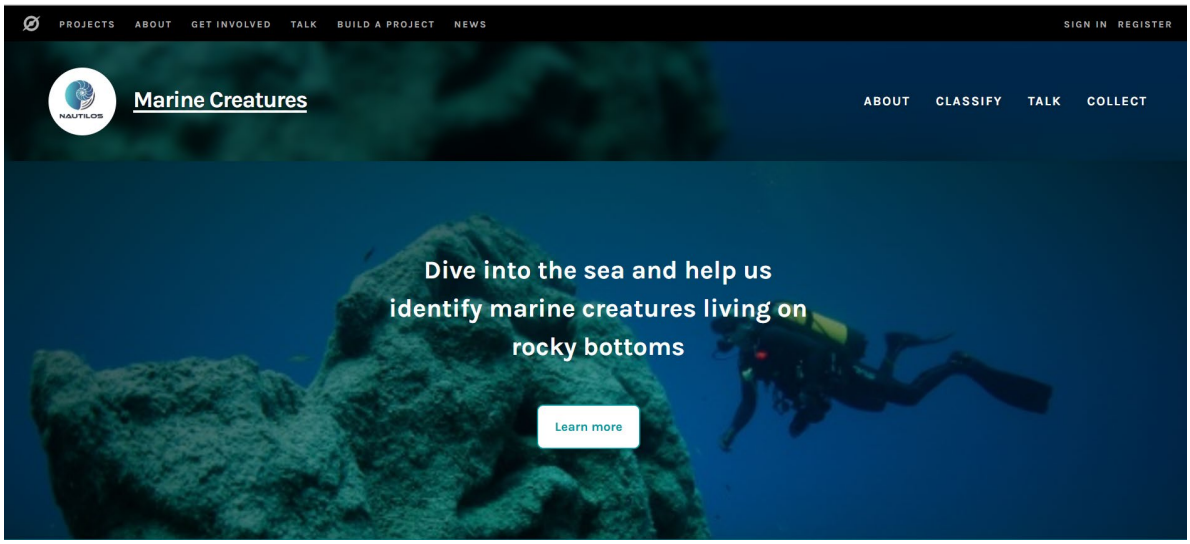

Figure 1. The *Marine Creatures* project created for crowd-sourcing image annotations using underwater photos aiming to identify the marine sessile fauna.

2.2. Content of the Marine Creatures project

The *Marine Creatures* project includes a central page with general information about the research included, the members of the scientific team and frequently asked questions (FAQ). Also, statistics about the number of volunteers, classifications and subjects completed, as well as external links (including all NAUTILOS website and social media links) are included. The Field Guide offers analytical and extended information on what benthos is, why it is important, which are the categories of the examined habitats and what is the methodology used (image annotation) (Figure 2a).

The project includes selected taxonomic categories and major seafloor organism types, such as Macroalgae, Sponges, Hydrozoans, Sea anemones, Corals, Polychaetes, Bivalves, Barnacles, Bryozoans and Tunicates. Some of these organisms are quite common and well known, while others often go unnoticed for the non-experts and can be easily mistaken. Therefore, an analytical guide with short descriptions and representative photos is provided for the volunteers, including also some tips for the groups that are commonly confused between them (Figure 2b). In addition, an analytical tutorial with videos is available for guidance and training on how to perform the identification (Figure 2c).

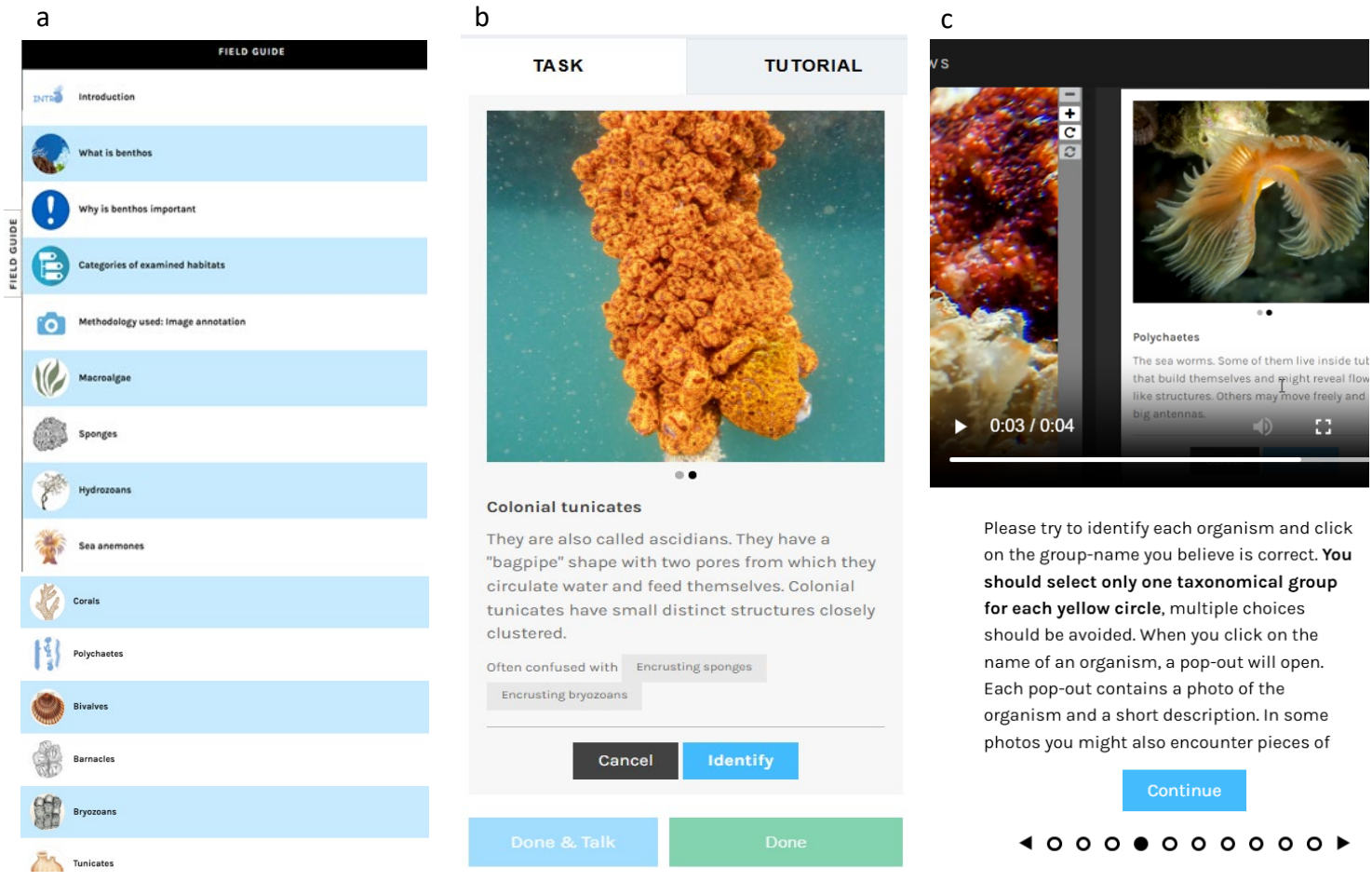

Figure 2. The (a) Field Guide, (b) pop-up windows with descriptions of marine organisms and (c) Tutorial of the *Marine Creatures* project.

The volunteers can select the type of habitat they prefer to work with and a series of underwater photos appears to them. The organisms that need to be identified are placed in a yellow circle. It is

also possible to zoom in, zoom out and rotate the image. The main task tab presents the available options of taxonomic groups from which a classification can be selected (Figure 3). Also, there are filters available in order to narrow down the search, such as colours, forms (encrusting or erect), shapes (branching, flat, tubular, etc) and status (colonial and solitary). There is also the option for participating in a discussion or submitting questions that will be monitored by the HCMR scientific team.

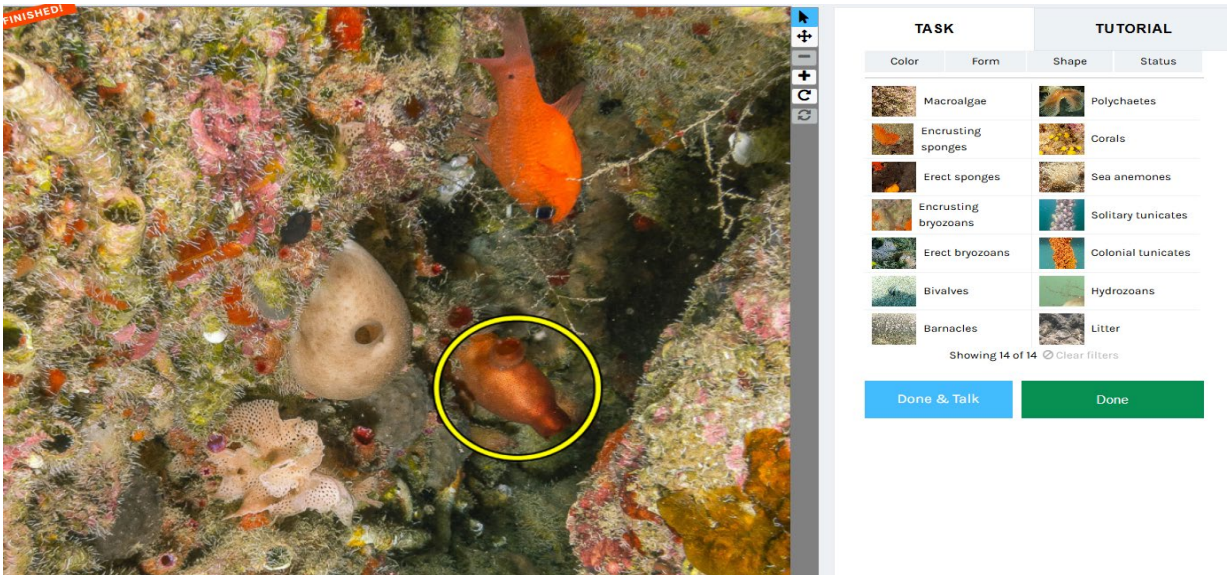

Figure 3. The main task tab presents the photo in which the organisms in the yellow circle need to be identified (left), the available options of taxonomic groups (right), and the available filters (colours, forms, shapes and status).

2.3. Data analysis and results

Metadata relevant to users and the work they performed for the *Marine Creatures* project were collected from the online Zooniverse platform at the beginning of March 2024, after completing a period of 18 months that the project was active and running. These metadata were analysed in order to identify if the project was successful in terms of popularity, as well as in terms of data quality. Therefore, a verification of the data derived from the classification of organisms was performed by the experts.

At that time (18 months after the project's initial launching) a total of 1,087 volunteers had been engaged in the project, from which the 256 were registered users. A total of 15,108 contributions were performed, from which 8,705 came from registered users. In Figure 4 the monthly distribution of users during this 18-month period is shown. It is obvious that after the project launch and the increased dissemination through the project's and other websites and social media posts, the contributions are increasing (see section V). The highest peaks pf participation were observed in November 2022 after the project was presented to the Athens Science Festival, in January 2023 after dissemination through newsletters (ECSA – European Citizen Science Association), mailing lists (MedOBIS) and institutional presentations (Ionian University) and in February 2024 after the presentation in a EMODnet workshop.

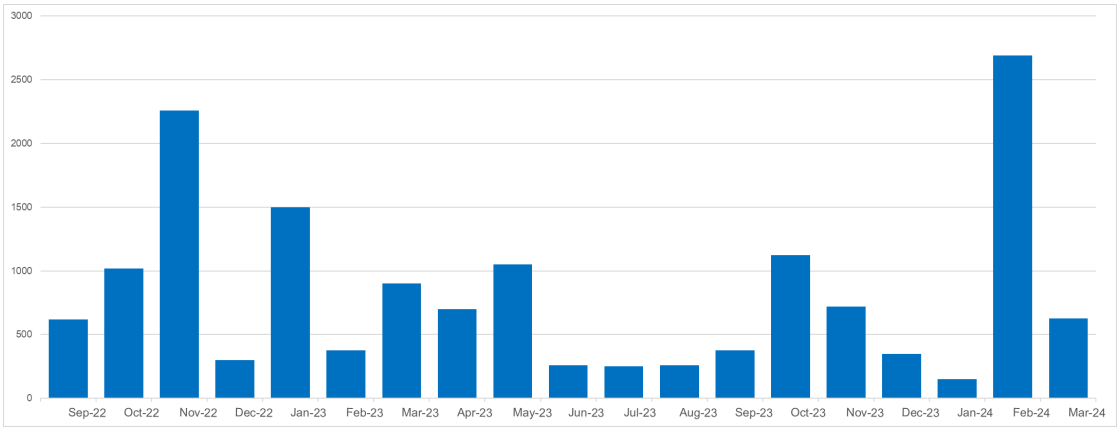

Figure 4. Monthly contributions of citizens scientists in the *Marine Creatures* project.

There were 256 registered users, corresponding to about 23% of the total 1,087 users (Table 1). The registered users were more engaged to the *Marine Creatures* project and performed almost 58% (8,705 classifications) of the total classifications. These registered users also did more classifications in total (34 per user) and spent more time (12:10 per user), in comparison to the non-registered users (7.7 classifications per user and 3:45 minutes spent, respectively). These findings suggest that it is important to disseminate a citizen science initiative targeting more enthusiastic and dedicated users who will invest more time and effort in the creation of CS data.

Table 1. Number of users, classifications and mean time spent for registered and not registered users.

	Non-registered users	**Registered users**	**All users**
Number of users	831	256	1,087
Classifications	6,403	8,705	15,108
Number of classifications per user	7.7	34.0	13.9
Mean time spent per user (min)	03:45	12:10	05:27

Some taxonomic groups, such as corals, encrusting bryozoans, colonial tunicates and barnacles, require more time and effort from the users (Figure 5). In contrast, bivalves and hydrozoans, as well as images containing macro-litter, are easier and quicker to identify, and the users spent less time when working with them.

Considering the challenging nature of this project, the volunteers were quite successful and gave an average percentage of 35% of correct answers, almost equivalent to the percentage of wrong answers (Figure 6). However, when the taxonomic groups are examined separately regarding their percentage of correct/wrong answers, it is clear that some of them are easier and the volunteers are able to identify them correctly (Figure 7). Barnacles and sea anemones have very high success rates, reaching about 75%. On the contrary, bryozoans, both erect and encrusting, colonial tunicates and erect sponges reach less than 30% of correct answers from the citizen scientists, indicating that these taxonomic groups are less known and more difficult to be identified by non-experts. Furthermore, the taxonomic groups that are more easily misidentified by the volunteers were the hydrozoans with macroalgae, the sea anemones with polychaetes and the erect sponges with corals (Figure 8).

The above observations can be helpful when considering a revision of the training material for the volunteers, such as the field guide and the tutorial, in order to improve the percentages of their success. In addition, the identification of the "weak" points of the performance of these tasks by citizen science can be very useful and important for the quality check of the results. Some taxonomic groups are considered more difficult and therefore results on those may not be trustworthy.

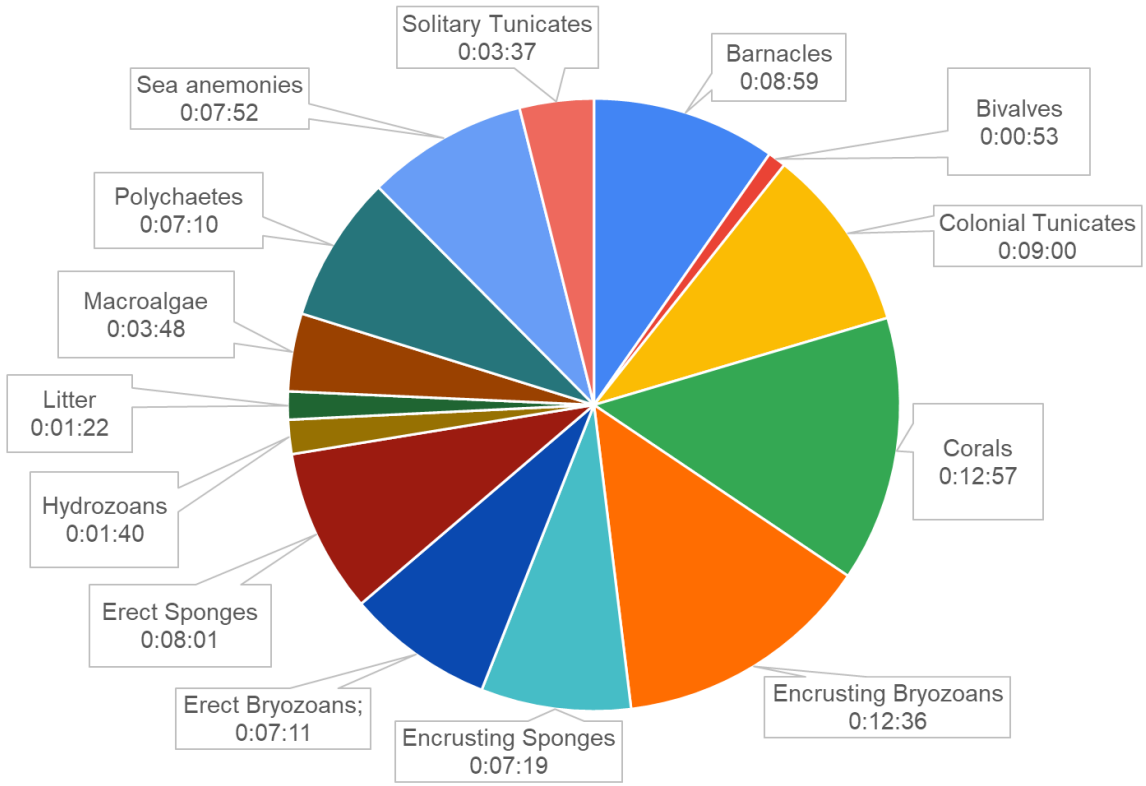

Figure 5. Mean time (hh:mm:ss) spent by users for the identification of the different taxonomic groups.

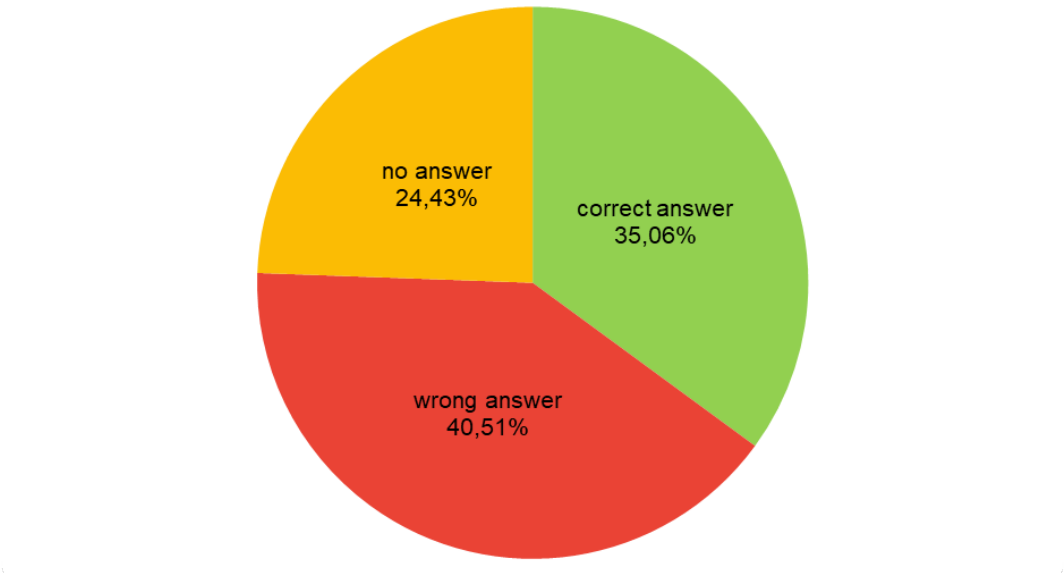

Figure 6. Percentage of success (correct answer), wrong answers or not answered tasks when all taxonomic groups are merged.

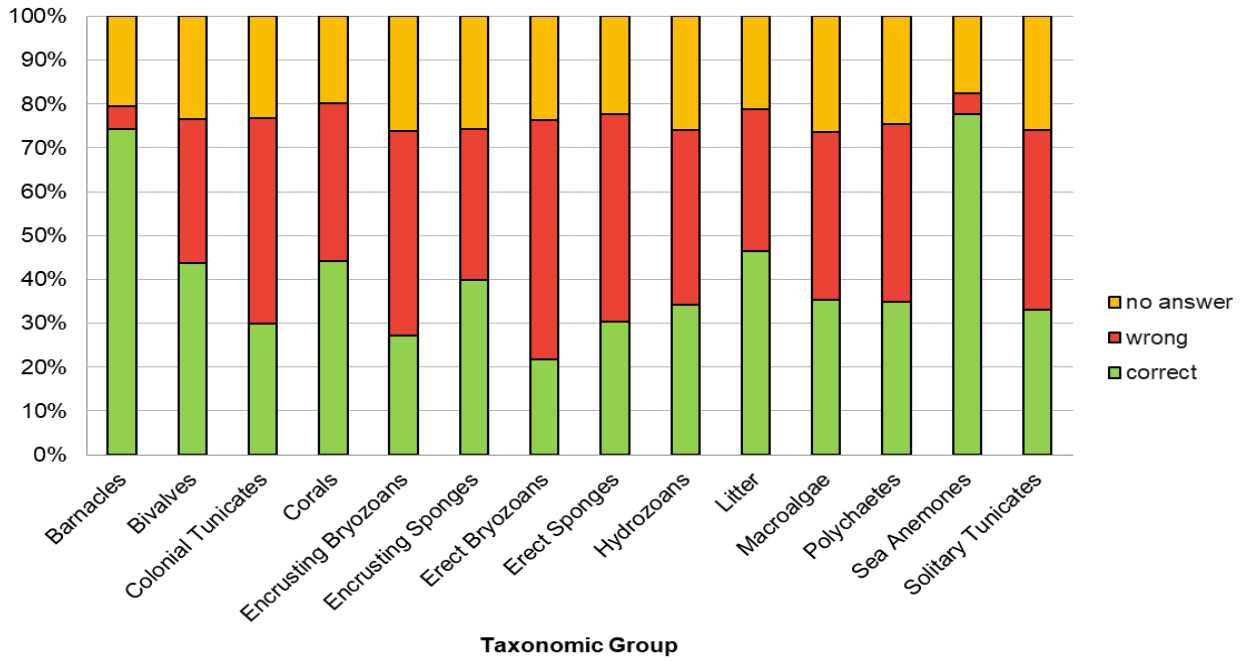

Figure 7. Percentage of success (correct answers), wrong answers or not answered tasks for each taxonomic group.

Confusion Matrix Heatmap	BARNACLES	BIVALVES	COLONIALTUNICATES	CORALS	ENCRUSTINGBRYOZOANS	ENCRUSTINGSPONGES	ERECTBRYOZOANS	ERECTSPONGES	HYDROZOANS	LITTER	MACROALGAE	POLYCHAETES	SEAANEMONES	SOLITARYTUNICATES
BARNACLES														
BIVALVES	0													
COLONIALTUNICATES	0	0												
CORALS	0	0	0											
ENCRUSTINGBRYOZOANS	0	0	0	0										
ENCRUSTINGSPONGES	0	0	0	0	2									
ERECTBRYOZOANS	0	0	0	0	0	0								
ERECTSPONGES	0	0	1	3	0	0	0							
HYDROZOANS	0	0	0	0	0	0	0	0						
LITTER	0	0	0	0	0	0	0	0	0					
MACROALGAE	0	0	0	1	0	0	0	0	4	0				
POLYCHAETES	1	0	0	0	0	0	0	0	0	0	0			
SEAANEMONES	0	0	0	0	0	0	0	0	0	0	0	3		
SOLITARYTUNICATES	0	0	1	0	0	0	0	1	0	0	0	0	0	

Figure 8. Heat map presenting the taxonomic groups that are more often confused.

2.4. Benefits, restrictions and future steps

The benefits of creating a citizen science project such as Marine Creatures in a widely disseminated platform such as Zooniverse include the fact that a very broad pool of data is created and research can be performed on a large scale using cost-effective and time effective means. The importance of this task is the fact that volunteers from the general public can be engaged in research and gain the feeling of contributing to discoveries, which gives them a sense of accomplishment and fosters public trust.

Of course there are some restrictions, mainly dealing with misunderstanding of some tasks and biased results that are the outcome of low quality or non-reliable data. However, the creation and revision when needed of supportive training material, the maintenance of discussion forums and the support from experts are key aspects that can enforce a citizen science project and prove its reliability and importance.

III. CREATION OF A NETWORK OF OBSERVATORIES FOR MARINE DATA COLLECTION

3.1. AlgaWarning – Tool for algal cell counting

The NAUTILOS partner ETT Solutions has created a user's kit and a smart phone application called Algawarning (@lgawarning) for the participatory environmental monitoring of algal blooms. The accessory instrument (kit) consists of a DIPLE instrument and a Sedgewick Rafter counting chamber packed in an easy to use and transferable kit box, which contains the following components: 1) container and support structure for light source and stage, 2) stage for counting chamber/glass slide for a precise shift of the sample under observation, 3) 3 objective lenses, 4) LED light with battery, 5) Sedgewick Rafter counting chamber, 6) plastic pipette, 7) adjustable smartphone holder, 8) lens cleaning tissue and 9) screwdriver (Figure 9a).

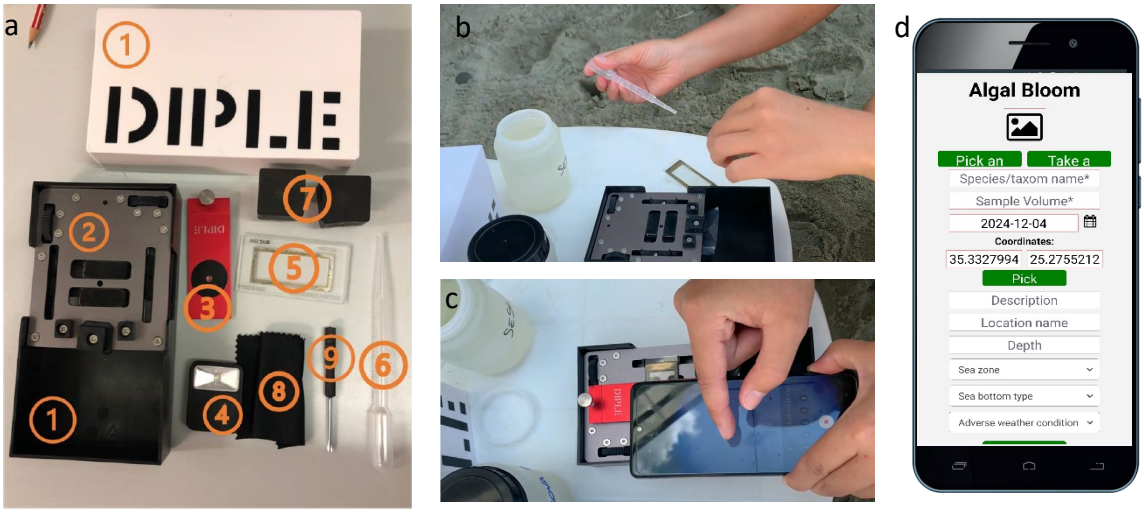

Figure 9. a) Components of the @lgawarning Citizen Science kit (numbers are explained in the text), b) Observation of seawater samples on the field using the microscopic chamber, c) Taking photo of a sample using a smartphone, d) Uploading data using the NAUTILOS CS App.

The citizen scientists can collect seawater samples from the field and observe them using the microscopic counting chambers and the objective lenses included in the kit (Figure 9b). Using their smartphones, they are able to collect image data (photos) of planktonic algal blooms at microscopic level (e.g. single microalgae) (Figure 9c) and upload them in the NAUTILOS data portal using the NAUTILOS Citizen Science App (Figure 9d). This gives the citizen scientists the opportunity to transmit reports on the anomalous presence of microalgae in aquatic environments directly from the detection site. The reports include photos, geo-located coordinates, name of location, sample characteristics (taxon name, volume), habitat attributes (sea zone, sea bottom type), weather conditions and other useful details (Figure 10). They are automatically uploaded in the NAUTILOS Data Portal and displayed on a map and can be downloaded as a .pdf file (Figure 11).

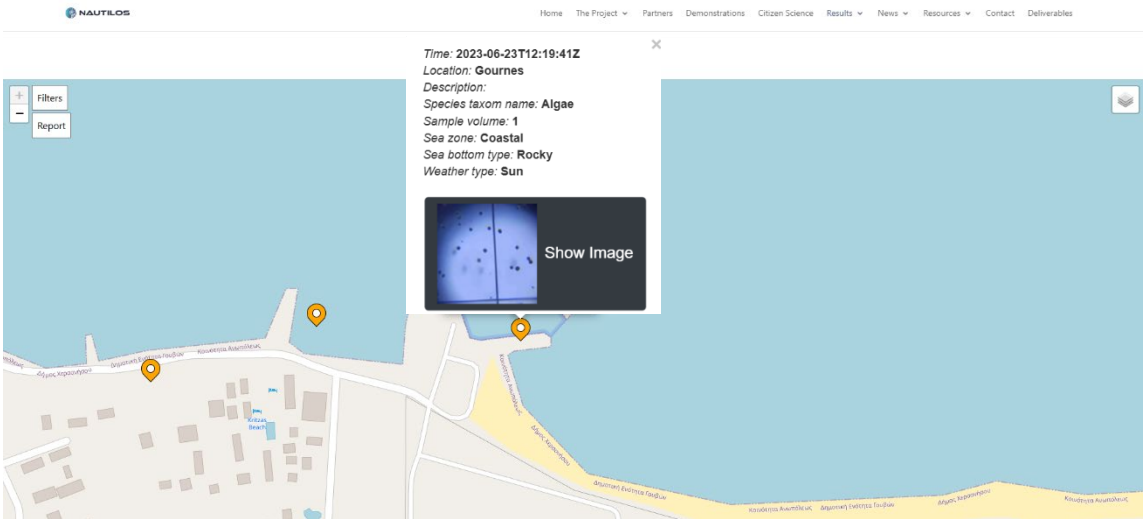

Figure 10. NAUTILOS Data Portal map and Algawarning photographic data.

NAUTILOS **Report** 1

AlgalBloom

Time	Location	Description	Species taxom name	Sample Volume	Sea zone	Sea bottom type	Weather
2023-06-21T07:12:54Z	Analipsi		Algae	1	Coastal	Rocky	Sun
2023-06-22T11:57:17Z	Analipsi		Algae	2	Coastal	Rocky	Sun
2023-06-23T12:15:38Z	Gournes		Algae	1	Coastal	Rocky	Sun
2023-06-23T12:17:22Z	Gournss		Algae	1	Coastal	Rocky	Sun
2023-06-23T12:19:41Z	Gournes		Algae	1	Coastal	Rocky	Sun
2023-06-25T12:20:54Z	Gouves		Algae	1	Coastal	Sand	Sun
2023-06-25T12:22:31Z	Aposelemis		Algae	1	Coastal	Sand	Sun
2023-06-26T12:23:29Z	Aposelemis		Algae	1	Coastal	Sand	Sun
2023-06-28T12:33:19Z	Chersonissos		Algae	1	Coastal	Sand	Sun
2023-06-28T12:34:26Z	Anisaras		Algae	1	Coastal	Rocky	Sun
2023-06-28T12:35:44Z	Stalida		Algae	1	Coastal	Rocky	Sun
2023-06-28T12:36:46Z	Anisaras		Algae	1	Coastal	Rocky	Sun
2023-07-01T11:40:09Z	Geropotamos beach		Algae	1	Coastal	Mud	Sun
2023-07-01T11:48:33Z	Geropotamos beach		Algae	1	Coastal	Sand	Sun
2023-07-01T11:49:39Z	Geropotamos beach		Algae	1	Coastal	Sand	Sun

Figure 11. Example of downloaded AlgaWarning report from NAUTILOS Data Portal.

HCMR has organized 10 Citizen Science activities using the AlgaWarning kit in 8 different locations in Heraklion (Crete, Greece). A detailed map of the locations where data (15 data files = 15 samples) were collected can be seen in Figure 12 as derived from the NAUTILOS data portal. Students from local primary schools have participated in these activities and had the opportunity to collect samples and upload their reports online (Figure 13). The locations, dates and number of students that participated can be seen in Table 2, while the data uploaded can be seen in Figure 11.

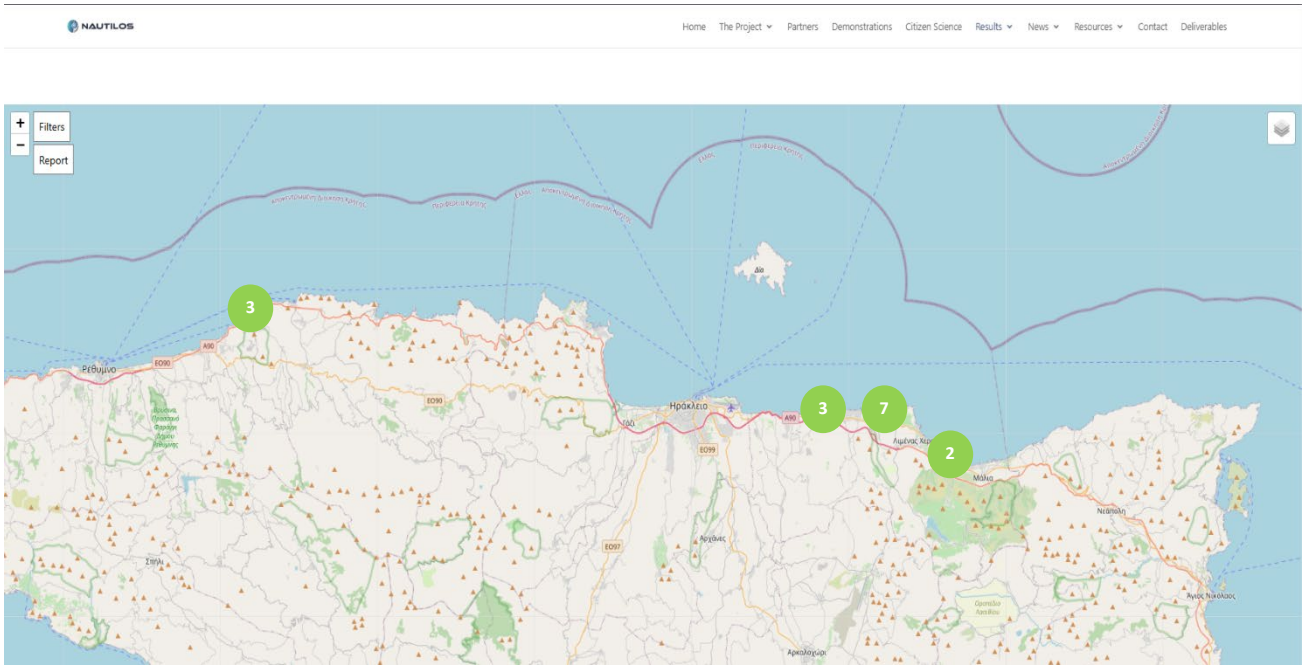

Figure 12. Map of the locations where samples and photographic data were collected using the AlgaWarning kit in Crete.

Table 2. Locations, dates and number of students that participated in the CS activities in Crete.

Location	Date	Students
Analipsi	21/6/2023	22
Analipsi	22/6/2023	19
Gournes	23/6/2023	41
Aposelemis	25/6/2023	18
Gouves	25/6/2023	32
Aposelemis	26/6/2023	29
Anisaras	28/6/2023	45
Chersonisos	28/6/2023	23
Stalida	28/6/2023	25
Geropotamos	1/7/2023	36

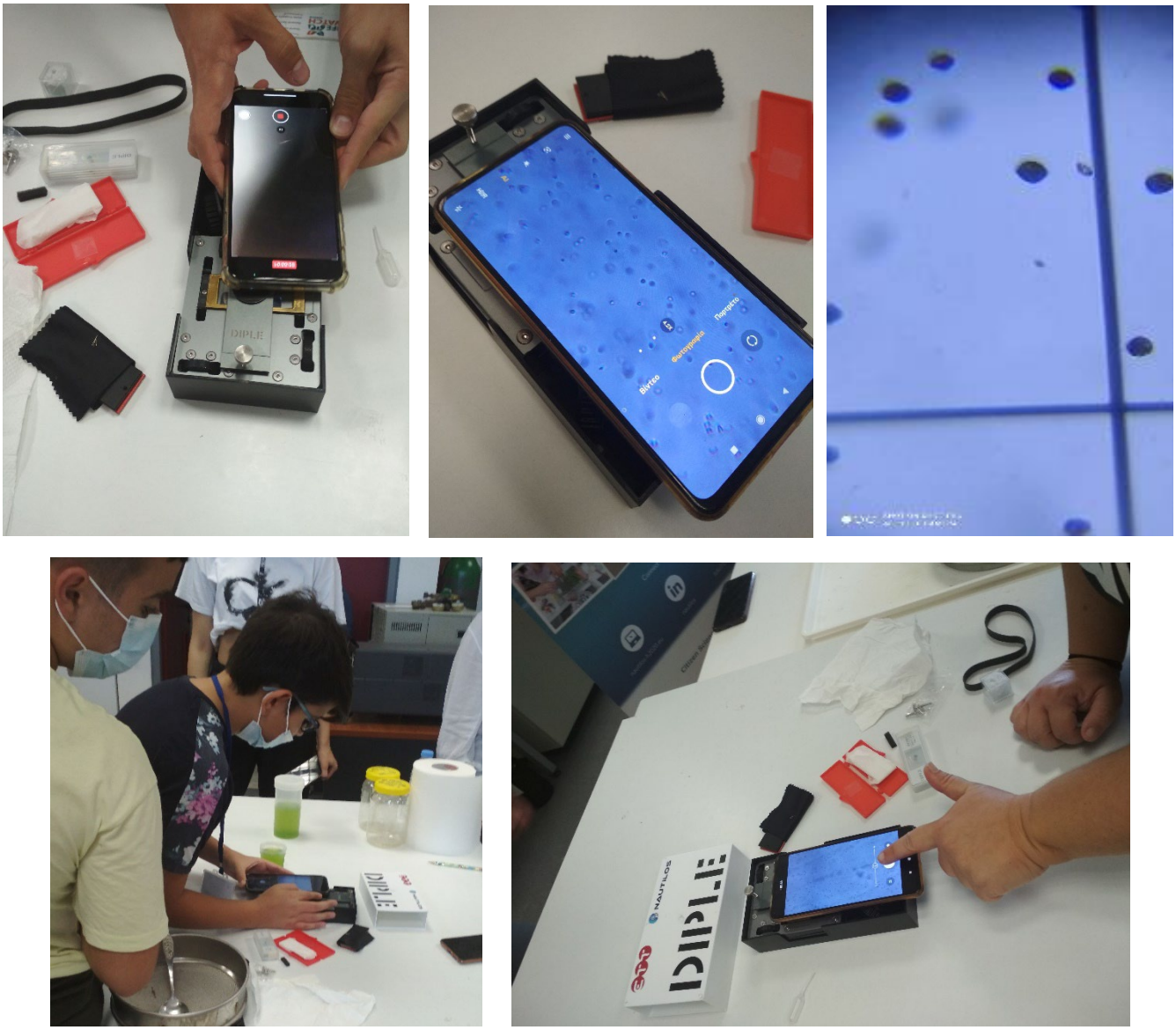

Figure 13. Participation of primary school students in the citizen science activities organized by HCMR in Heraklion (Crete).

ETT has organized 11 Citizen Science events using the AlgaWarning kit in 5 different locations in Ligurian Region (Italy) (total of 17 samples), and 1 event in 1 location in the Svalbard Islands (Norway) (total of 6 samples). Figures 14 and 15 show detailed maps of the locations where data were collected as derived from the NAUTILOS data portal. Different groups of citizens (general public, students) participated in the data collection. Of particular interest, 9 samples collected in Genova (Italy) were recorded during the Science Festival (2023 and 2024 editions) and 6 samples were collected during citizen science cruises on the Swan Hellenic Vega ship in the Svalbard Islands (Norway). The locations, dates and number of citizens that participated can be seen in Table 3.

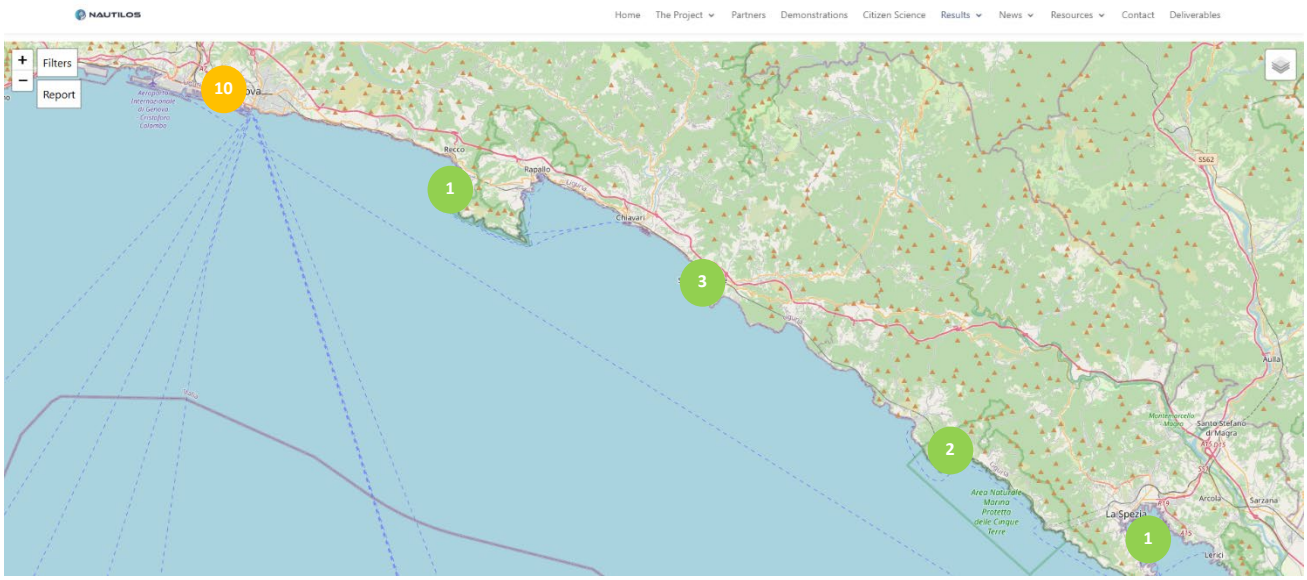

Figure 14. Map of the locations where samples and photographic data were collected using the AlgaWarning kit in Ligurian Region (Italy).

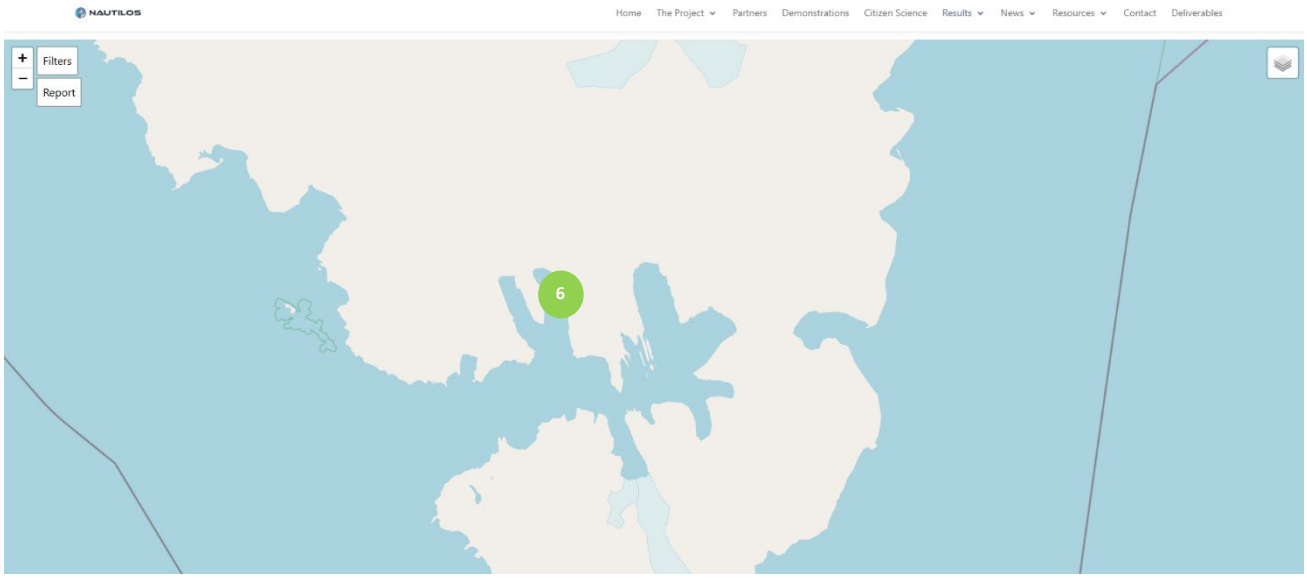

Figure 15. Map of the locations where samples and photographic data were collected using the AlgaWarning kit in Svalbard Islands (Norway).

Table 3. Locations and dates of the CS activities in Ligurian Region (Italy) and Norway.

Location	Date	Citizens
Sestri Levante (Italy)	28/07/2020	20
La Spezia (Italy)	25/08/2021	15
Sestri Levante (Italy)	25/08/2021	20
Sestri Levante (Italy)	09/09/2021	25
Camogli (Italy)	19/06/2022	15
Monterosso al Mare (Italy)	24/07/2022	15
Genova (Italy)	25/07/2022	25
Genova (Italy)	25/10/2023	20

Genova (Italy)	24/10/2023	20
Genova (Italy)	31/10/2023	60
Genova (Italy)	30/10/2024	30
Svalbard Islands (Norway)	01/08/2024	40

3.2. Aquatec passive acoustic sensor

The passive broadband acoustic recording sensor for noise monitoring (Figure 16) created by Aquatec within the activities of the NAUTILOS project (Task 3.3) can be used to survey underwater soundscapes across diverse aquatic environments. This advanced instrument features a 150kHz bandwidth sound recorder for capturing an extensive range of marine sounds that can facilitate crucial underwater soundscape analysis for various research fields, such as investigation of sea ice dynamics, identification of seismic events and monitoring the acoustic impacts of human activities in aquatic environments. This instrument operates on a configurable electronics platform with simplified firmware and hardware. The design covers all aspects in terms of deployment, data uploading and post-processing with a user-friendly software.

Figure 16. Passive broadband acoustic recording sensor for noise monitoring created by Aquatec.

The passive broadband acoustic recording sensor has been delivered to HCMR in January 2024 and was used for Citizen Science activities performed by a local enthusiastic team of 9 recreational divers (Figure 17). The divers were carrying the sensor with them until a depth of about 6-10 m was reached and then deployed it around the middle of the seawater column using a floating buoy for a duration of about one hour. The sensor was programmed to record sound every 2 minutes. The deployment by divers took place in 2 locations: Schinaria (south Crete) in May 2024 where one sound datafile was uploaded, and Alykes (north Crete) in February 2024 where 2 datafiles were uploaded.

Figure 17. Citizen science activities performed by recreational divers using the passive broadband acoustic recording sensor for sound data collection in Crete.

In addition, the passive broadband acoustic recording sensor was used during the Capacity Building Summer School (Task 12.3) that took place in Crete on 17-19th of April 2024 (Figure 18). The target audience in this second occasion was a group of 10 participants which were advanced level students (MSc or PhD) or early career scientists and professionals. During the hands-on demo experience in the research vessel PHILIA the sensor was deployed using a metal frame for an hour and 3 data files were recorded. All the geo-referenced data collected (sound files) have been uploaded in the NAUTILOS Data Portal and are freely available for download (Figure 19).

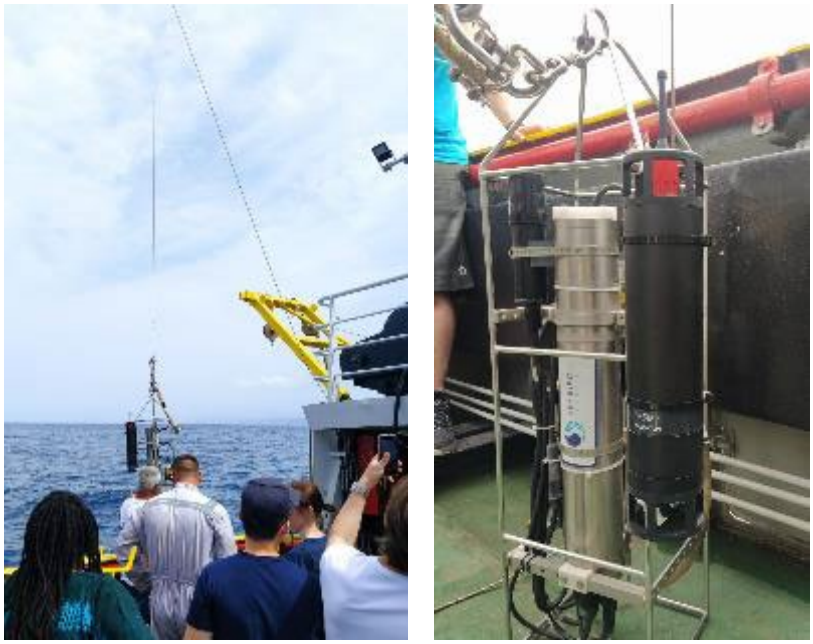

Figure 18. Deployment of the passive broadband acoustic recording sensor onboard the research vessel PHILIA during the Capacity Building Summer School in Crete (April 2024).

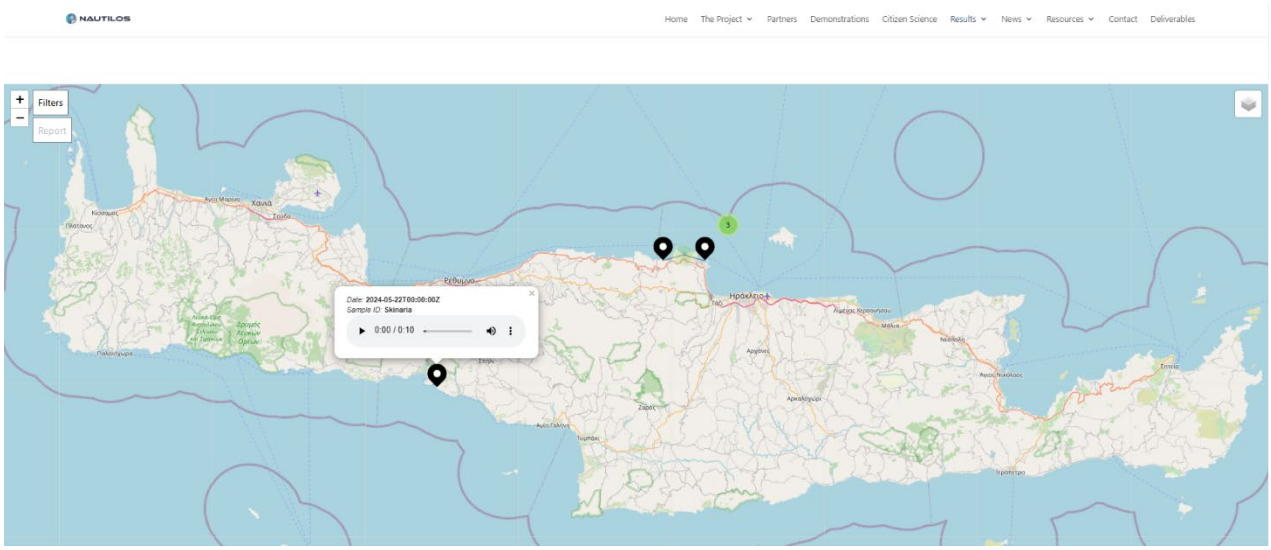

Figure 19. Locations of deployment of the passive broadband acoustic recording sensor during citizen science activities performed by divers (black points) and capacity building summer schools (green points). Data files have been uploaded in the NAUTILOS data portal.

3.3. Sensors for Dissolved Oxygen and Chlorophyl-a

NKE has developed within NAUTILOS project (Task 3.1, Malardé et al., 2022[i]) the WiSens dissolved oxygen (DO) sensor (Figure 20a) and the Chlorophyll-a (Chl-a) (Figure 20b) sensor which are digital smart dataloggers designed to be deployed on fishing gears at depths of up to 600 metres. Both devices include also integrated temperature and pressure sensors to measure depth profiles. The whole unit for each sensor is mounted in a compact, robust, and ergonomic mechanical body. These sensors can be operated in a standalone version or associated with an automatic data recovery and transmission system for fisheries applications.

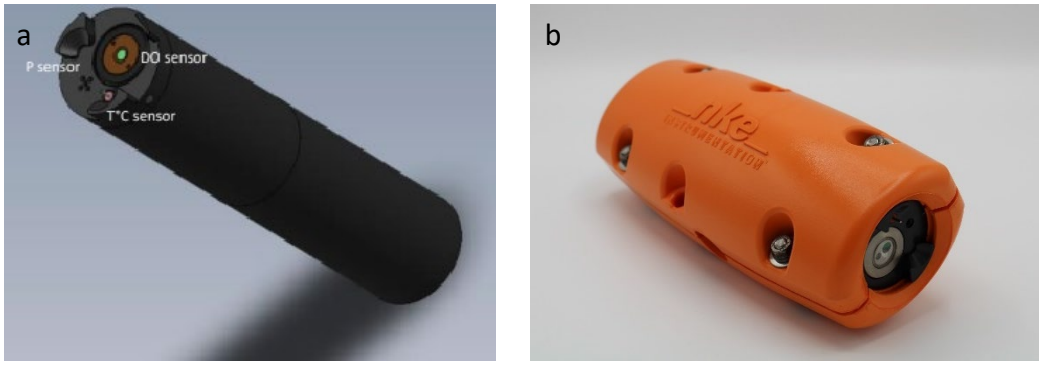

Figure 20. a) Dissolved oxygen sensor and b) Chlorophyl-a sensor inside the plastic protective cases designed for their use on fishing gears.

In addition to the set of sensors currently in use in the Adriatic Sea on a commercial pair trawler (Martinelli et al. 2024[ii]), another set of sensors, previously used by Ifremer on a fishing vessel in the Bay of Biscay, was delivered to CNR-IRBIM in November 2024. CNR-IRBIM is planning to use this set of sensors to organise a citizen science activity involving recreational divers. For this specific application, the sensors will be attached to the diver's buoyancy compensator (BCD) jacket as displayed in Figure 21. Through a web app application, the divers will be instructed on how to select

the acquisition settings selected for this purpose (Figure 22). The parameters that will be monitored include pressure, temperature, oxygen concentration and saturation, and fluorescence. The sampling regime will be continuous with a 5 sec interval and set at manual mode. The data collected will be uploaded on the NAUTILOS Data Portal.

Figure 21. Positioning of WiSens DO and Chl-a sensors (red circles and arrows) on the BCD jacket of the divers.

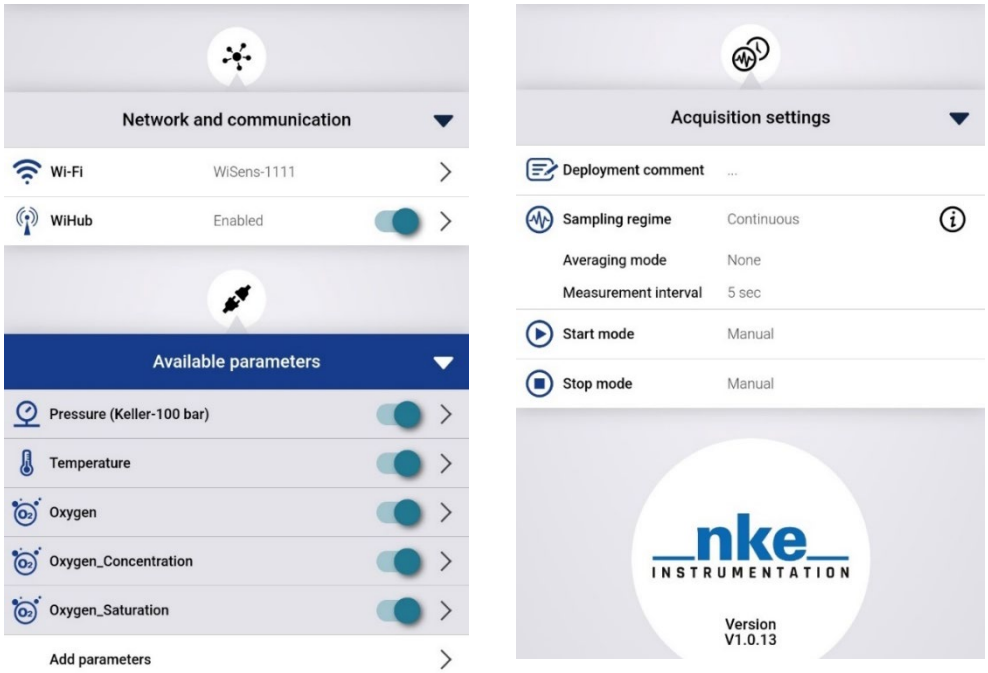

Figure 22. Activation of parameters and acquisition settings for the WiSens DO and Chl-a sensors for the performance of citizen science activities with divers.

IV. OCEAN LITERACY ACTIVITIES RELATED TO TASK 10.4

4.1 MANTAA animal tag sensor

CEiiA has developed the device MANTAA within the project NAUTILOS (Task 5.5), which is a non-invasive towed marine animal tagging platform for measuring behavioral and oceanic data (Figure 23). This new-to-market and cost-effective animal-borne tracking device for ocean data monitoring has been created and is comprised by a dissolved oxygen sensor, capable of archiving a diversity of animal behavior data (activity, acceleration, orientation and velocity) and ocean habitat parameters (depth, satellite positioning, temperature and dissolved oxygen). Mission duration is up to one week, with an easy-swap and rechargeable battery and the platform can be deployed up to 2000m, enabling non-invasive deployments on marine animals like Manta Rays and Blue Sharks, while at the same time novel ocean data is being collected.

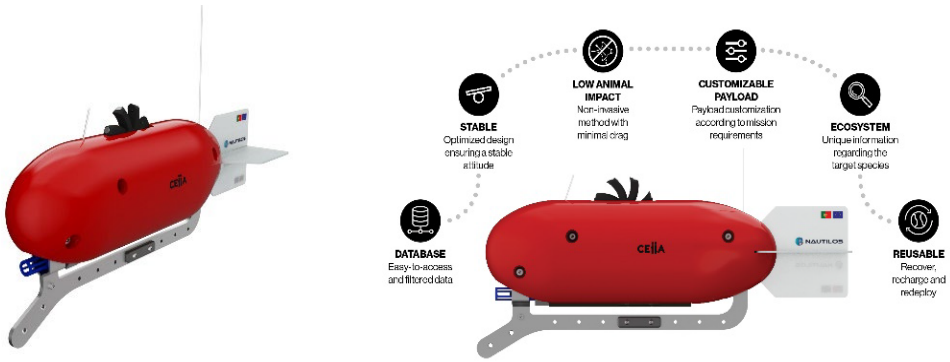

Figure 23. The MANTAA device developed as a tagging platform for measuring oceanic data and behavioral data in sharks and mantas.

Tiago Bartolomeu (CEiiA) and Jorge Fontes (IMAR) have participated in an Ocean Literacy event during the "Jornadas do Mar" event organized by AEICBAS that took place in Porto (Portugal) on 10-12th of March 2023. They had to opportunity to present the MANTAA animal tag sensor to approximately 200 participants from academia, the scientific community and the general public within the session entitled "Bioengineering and Marine Biology: Tags in the work of documenting animal life".

4.2. Autonomous Underwater Vehicle (AUV) in kindergarten

Researchers from UAlg – CIMA, João Janeiro and Lara Mills, visited the Escola Básica da Lejana (Faro) on the 4th of May 2022 and showcased the Autonomous Underwater Vehicle (AUV) that was used within NAUTILOS project as a navigating platform hosting sensors (Task 5.1). CIMA is using AUV technology to collect valuable ocean information in a periodic way, which will be used to better understand the regional ocean dynamics, develop more accurate ocean forecasts to support the region's blue economy and maritime safety, and evaluate climatic trends.

Figure 24. The kindergarten young students of Escola Básica da Lejana in Faro followed a presentation CIMA's Autonomous Underwater Vehicle (AUV).

The kindergarten young students, as the emerging generation of future oceanographers, followed a short talk on what being an oceanographer is all about and the need to better understand the ocean (Figure 24). Then they were asked to help on the important task of giving a name to CIMA's Autonomous Underwater Vehicle (AUV) and some cool names started to emerge from their creative minds. In the end, Shark Max was the most voted name by the class, and this is now the official name of CIMA's AUV.

4.3. Autonomous Underwater Vehicle (AUV) in advanced students

An AUV course was held in October 2020 with presenters and trainers from UAlg. The participants were 25 researchers and advanced level students (PhD, Post Docs) from all around Europe (Figure 25). The course ran for three days with two days of theory and the one day of field work, during which the AUV was launched at the marina and the oceanographic data collected were analyzed.

Figure 25. Researchers and students participated in the AUV course organised by UAlg.

V. DISSEMINATION OF CITIZEN SCIENCE ACTIVITIES RELATED TO TASK 10.4

5.1. CommOCEAN 2024 Conference

The online citizen science project *Marine Creatures* developed within Task 10.4 of the NAUTILOS project in the platform Zooniverse was presented during Session 2 "How to ensure engagement in your Citizen Science project" of the 6th International Marine Science Communication Conference (CommOCEAN 2024). The conference took place on 26-27th November 2024 hosted at the Málaga Oceanographic Centre and organised by the European Marine Board Communication Panel and the Spanish Institute of Oceanography (IEO-CSIC).

5.2. Athens Science Festival

IMBBC presented the NAUTILOS Citizen Science project "Marine Creatures" created in the Zooniverse platform during the Athens Science Festival 2022 «Worlds of Tomorrow» (#ASF2022) which took place in Technopolis of the Municipality of Athens (Greece) during 21 – 23 October 2022. The visitors had the opportunity to assist scientists to identify marine benthic sessile organisms using underwater photos from natural or anthropogenic habitats (underwater caves, ports, artificial reefs). The online project "Marine Creatures" was launched on 7th of September 2022 and has already reached 1517 responses from citizen scientists.

5.3. Metrics for impact

The Citizen Science activities related to Task 10.4, i.e. the release of the Zooniverse project *Marine Creatures* and the activities related with the use of NAUTILOS sensors, were disseminated and communicated to targeted audiences using several types of relevant means. The websites and social media accounts (Facebook, X and LinkedIn) of the project NAUTILOS and of the IMBBC institute of HCMR were used for the publication of short articles and posts (Figure 26), respectively. Also, posts were released in the websites of other relevant websites, such as the ESFRI Research Infrastructure LifewatchGreece (the national biodiversity node of Lifewatch), the CretAquarium affiliated with HCMR and the Sci-Starter platform, which is a website for finding volunteer opportunities for science projects. The information was released as part of the newsletters of the European Citizen Science Association (ECSA) and LifeWatch ERIC, and also disseminated through several mailing lists. Presentations about the Zooniverse project Marine Creatures were performed in an EMODnet data workshop, in the Ionian University (Greece), in the IMBBC institute and in 4 local schools in Heraklion (Crete). Detailed metrics about the events, number and type of audience reached have been presented in Table 4.

Table 4. Dissemination and communication means for the Zooniverse project Marine Creatures and the Citizen Science activities related with the use of NAUTILOS sensors, including number of posts/participants and type of audience reached.

Communication means	Description	Posts/participants	Target audience
Website posts	NAUTILOS, HCMR-IMBBC, CretAquarium, LifeWatchGreece	15 posts	Scientists, general public
Online platforms	Sci-Starter platform	1 entry	General public, students
Social media (Facebook, X and LinkedIn) posts	NAUTILOS, HCMR-IMBBC	11 posts (+many reposts)	Scientists, general public
Newsletters	European Citizen Science Association (ECSA), LifeWatch ERIC	2 newsletters	Scientists, Education, Teachers
Mailing lists	HCMR-IMBBC institutional mailing list; NAUTILOS mailing list; MedOBIS mailing list	3 mailing lists	Scientists
Institutional presentations	IMBBC December 2022; IMBBC June 2024; Ionian University, Local schools	180	Scientists, Educators
Workshop	EMODnet – LifeWatch ERIC Autumn Data School	15	Scientists, Students
Festival	Athens Science Festival	18.000	General Public, students
International conference	CommOCEAN 2024	120	Scientists, Communicators, Policy makers, EU representatives, Press

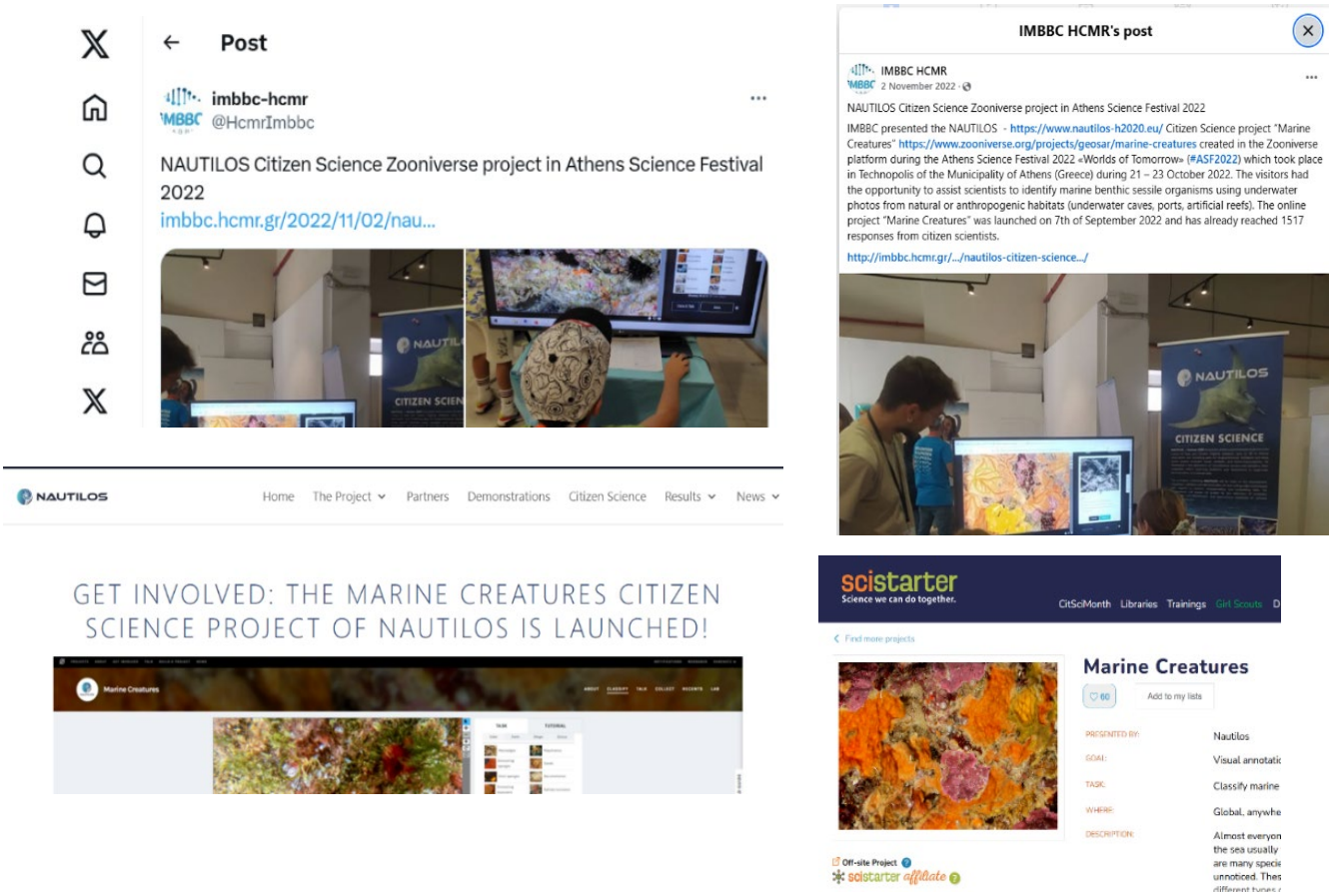

Figure 26. Examples of social media posts about the the Citizen Science project *Marine Creatures*.

VI. CONCLUSION

The Citizen Science activities that were developed within Task 10.4 aimed to create awareness and offer opportunities for training and engagement regarding the evaluation of biodiversity (benthic and algal blooms), and the monitoring of oceanographic parameters that are important for ocean life (sound, dissolved oxygen and chlorophyl). Scientific expertise and advanced equipment developed during NAUTILOS were offered by the project partners in order to achieve those targets and invest in future generations that will hopefully be more enthusiastic and interactive for the improvement of the fate of the ocean environment.

The activities within Task 10.4 have actively interacted with the general public (1,378 volunteers for the biodiversity online project in Zooniverse and 305 participants in AlgaWarning activities in Italy and Norway), young school students (290 participants in the AlgaWarning activities in Crete), early career scientists (10 participants from the summer school) and recreational divers (10-15). Furthermore, the ocean literacy, dissemination and communication activities delivered during the project have ensured reaching a far more wide and diverse audience, thus contributing to the legacy and long-term impacts of NAUTILOS Citizen Science activities.

[i] Malardé D., David A.., Paillot A., Schaeffer C. Benoît Jugeau D 3.2 Report on the development of Dissolved Oxygen and chlorophyll-a sensors for fishery vessels, WP3 "Biogeochemical and Biological Instrument Development" H2020 NAUTILOS project "New Approach to Underwater Technologies for Innovative, Low-cost Ocean observation", 31/03/2022.

[ii] Martinelli, M., Duchene, J., King, A., Marty, S., Ntoumas, M., Berghöfer, E., Alonso, I., Penna, P., Moro, F., Zacchetti, L., Cecapolli, E., DOMENICHETTI, F., Le Gall, C., Malardé, D., Misurale, F., & Smerdon, A. (2024). NAUTILOS D7.1 - Fisheries and Aquaculture Observing Systems demonstration mid-term. Zenodo. https://doi.org/10.5281/zenodo.14260995