RESEARCH PROJECT

TITLE: Biodiversity monitoring of Mediterranean marine species through citizen science

TUTOR: Prof. Stefano Goffredo

The conservation of natural ecosystems is crucial to the survival of mankind. Continuous monitoring allows decision makers to assess and react to environmental issues, implementing effective mitigation measures when necessary (Balmford et al., 2005). Large-scale monitoring efforts often come at a great cost and need for manpower, which hinders the possibility for government agencies and research institutions to carry out such tasks (Sharpe and Conrad, 2006). Both issues can be addressed by employing non-specialist volunteers into data collection, a methodology called "Citizen science" (Goffredo et al., 2010). Citizen science integrates public engagement and scientific research (Brossard, Lewenstein, and Bonney 2005; Dickinson et al. 2012; Bonney et al. 2014), helping researchers obtain scientific data and enabling long-term, large-scale data collection that would otherwise be unattainable (Bonney et al. 2009a; Silvertown 2009; Donnelly et al. 2014). By engaging volunteers in scientific data collection, citizen science can provide informal learning experiences and be used as a tool for conservation in various ecosystems (Bonney et al. 2009; Johnson et al. 2014). Traditional citizen science projects require volunteers to undergo extensive training in order to participate in data collection, which may hinder volunteer participation. Therefore, a recreational protocol with minimal training could promote greater participation of volunteers for the collection of large amounts of data in short periods of time (Goffredo et al., 2010). Although citizen science projects allow for the collection of robust amounts of data, there is some discussion in the academic environment regarding the quality of data collected by volunteers due to their lack of scientific training (Bonney et al., 2009b; Goffredo et al., 2010; Donnelly et al., 2014; Branchini et al., 2015; Meschini et al., 2021), so validation protocols are necessary when analyzing the reliability of data collected by volunteers compared to those of scientific researchers (Delaney et al., 2008; Roy et al., 2012; Van der Velde et al., 2017). The Marine Science Group, research group at the University of Bologna, has been carrying out recreational citizen science projects since 1999.

The research group's current project, active since 2017, Sea Sentinels, engages volunteers in monitoring the presence and abundance of 61 taxa encompassing flagship marine Mediterranean organisms, having surveyed 289 diving points over the Mediterranean (Figure 1).

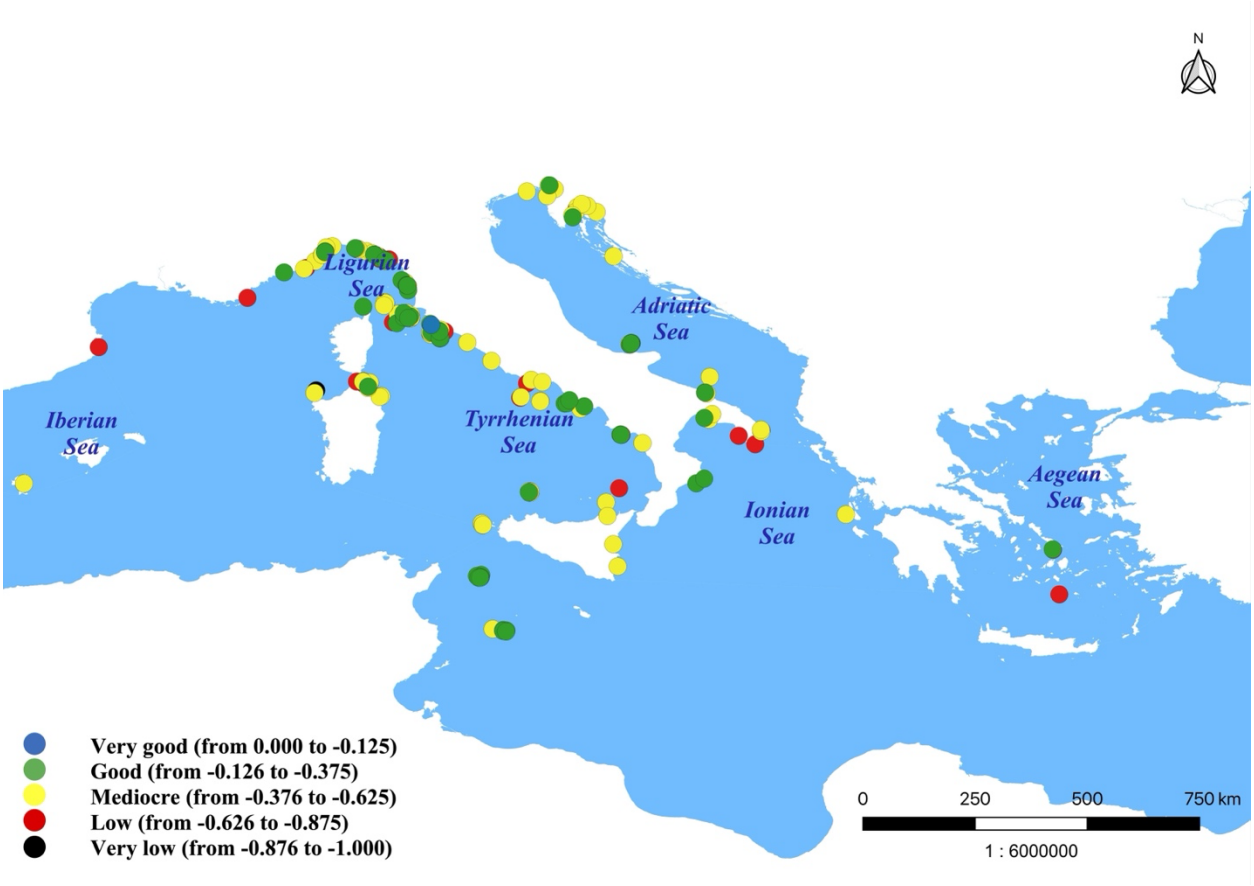
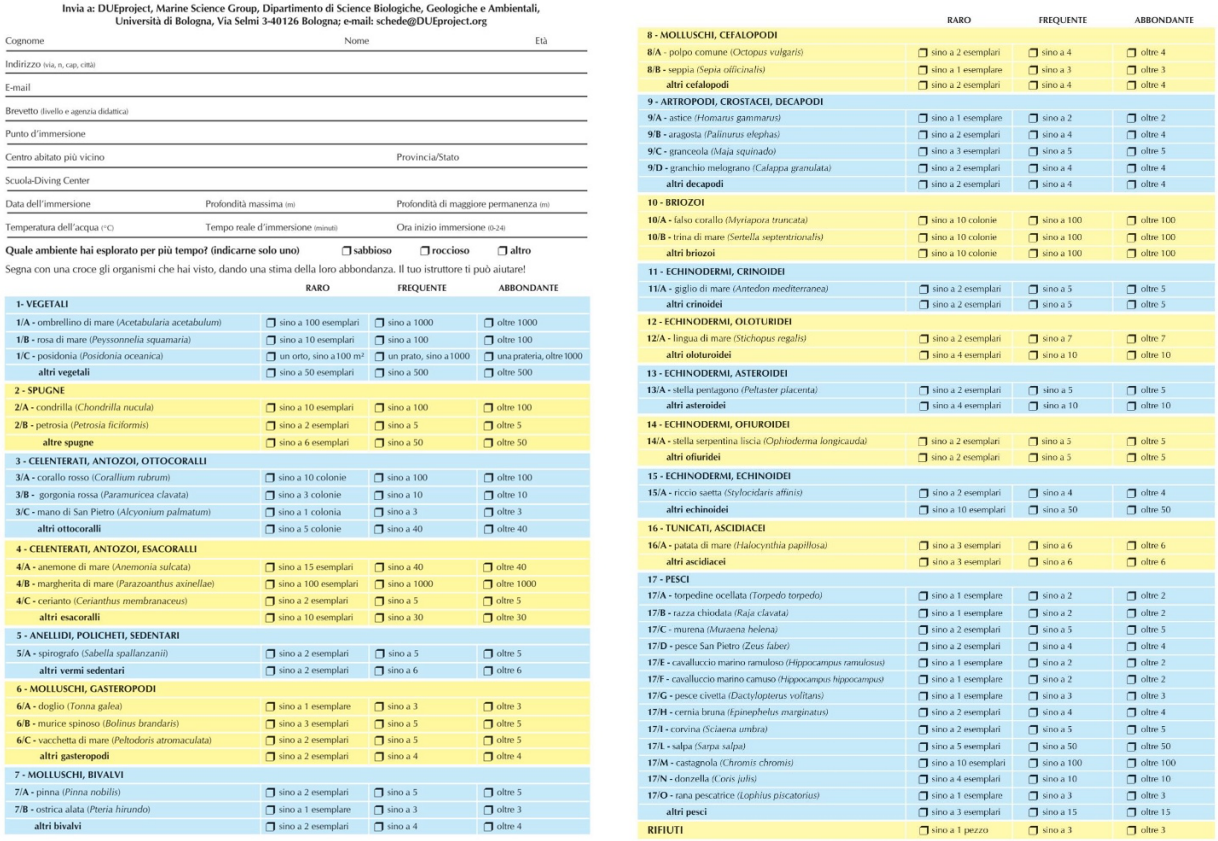


Figure 1. Indication of the 289 surveyed stations through the Sea Sentinels project. The environmental quality index calculated based on sighting frequency, relative, abundance, and Shannon-Wiener index of the 61 surveyed taxa, as well as litter, and divided in 5 classes, from very low to very good.

The level of biological diversity is a good indicator of the state of environmental health (European Union 2008), and continuous monitoring helps identify biodiversity loss so decision makers can act accordingly. Hence the project aims to assess the state of environmental quality of the Mediterranean Sea by monitoring its biodiversity to aid policymakers and stakeholders in the environmental management planning process. Surveys are conducted by volunteers who submit their observations via questionnaires (Figure 2).



Invia a: DUEproject, Marine Science Group, Dipartimento di Science Biologiche, Geologiche e Ambientali, Università di Bologna, Via Selmi 3-40126 Bologna; e-mail: schede@DUEproject.org

Cognome Nome Età

Indirizzo (via, n, cap, città)

E-mail

Brevetto (livello e agenzia didattica)

Punto d'immersione

Centro abitato più vicino Provincia/Stato

Scuola-Diving Center

Data dell'immersione Profondità massima (m) Profondità di maggiore permanenza (m)

Temperatura dell'acqua (°C) Tempo reale d'immersione (minuti) Ora inizio immersione (0-24)

Quale ambiente hai esplorato per più tempo? (indicarne solo uno) ❒ sabbioso ❒ roccioso ❒ altro

Segna con una croce gli organismi che hai visto, dando una stima della loro abbondanza. Il tuo istruttore ti può aiutare!

	RARO	FREQUENTE	ABBONDANTE
1- VEGETALI			
1/A - ombrellino di mare (*Acetabularia acetabulum*)	❒ sino a 100 esemplari	❒ sino a 1000	❒ oltre 1000
1/B - rosa di mare (*Peyssonnelia squamaria*)	❒ sino a 10 esemplari	❒ sino a 100	❒ oltre 100
1/C - posidonia (*Posidonia oceanica*)	❒ un orto, sino a 100 m²	❒ un prato, sino a 1000	❒ una prateria, oltre 1000
altri vegetali	❒ sino a 50 esemplari	❒ sino a 500	❒ oltre 500
2 - SPUGNE			
2/A - condrilla (*Chondrilla nucula*)	❒ sino a 10 esemplari	❒ sino a 100	❒ oltre 100
2/B - petrosia (*Petrosia ficiformis*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
altre spugne	❒ sino a 6 esemplari	❒ sino a 50	❒ oltre 50
3 - CELENTERATI, ANTOZOI, OTTOCORALLI			
3/A - corallo rosso (*Corallium rubrum*)	❒ sino a 10 colonie	❒ sino a 100	❒ oltre 100
3/B - gorgonia rossa (*Paramuricea clavata*)	❒ sino a 3 colonie	❒ sino a 10	❒ oltre 10
3/C - mano di San Pietro (*Alcyonium palmatum*)	❒ sino a 1 colonia	❒ sino a 3	❒ oltre 3
altri ottocoralli	❒ sino a 5 colonie	❒ sino a 40	❒ oltre 40
4 - CELENTERATI, ANTOZOI, ESACORALLI			
4/A - anemone di mare (*Anemonia sulcata*)	❒ sino a 15 esemplari	❒ sino a 40	❒ oltre 40
4/B - margherita di mare (*Parazoanthus axinellae*)	❒ sino a 100 esemplari	❒ sino a 1000	❒ oltre 1000
4/C - cerianto (*Cerianthus membranaceus*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
altri esacoralli	❒ sino a 10 esemplari	❒ sino a 30	❒ oltre 30
5 - ANELLIDI, POLICHETI, SEDENTARI			
5/A - spirografo (*Sabella spallanzanii*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
altri vermi sedentari	❒ sino a 2 esemplari	❒ sino a 6	❒ oltre 6
6 - MOLLUSCHI, GASTEROPODI			
6/A - doglio (*Tonna galea*)	❒ sino a 1 esemplare	❒ sino a 3	❒ oltre 3
6/B - murice spinoso (*Bolinus brandaris*)	❒ sino a 3 esemplari	❒ sino a 5	❒ oltre 5
6/C - vacchetta di mare (*Peltodoris atromaculata*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
altri gasteropodi	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
7 - MOLLUSCHI, BIVALVI			
7/A - pinna (*Pinna nobilis*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
7/B - ostrica alata (*Pteria hirundo*)	❒ sino a 1 esemplare	❒ sino a 3	❒ oltre 3
altri bivalvi	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4

	RARO	FREQUENTE	ABBONDANTE
8 - MOLLUSCHI, CEFALOPODI			
8/A - polpo comune (*Octopus vulgaris*)	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
8/B - seppia (*Sepia officinalis*)	❒ sino a 1 esemplare	❒ sino a 3	❒ oltre 3
altri cefalopodi	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
9 - ARTROPODI, CROSTACEI, DECAPODI			
9/A - astice (*Homarus gammarus*)	❒ sino a 1 esemplare	❒ sino a 2	❒ oltre 2
9/B - aragosta (*Palinurus elephas*)	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
9/C - granceola (*Maja squinado*)	❒ sino a 3 esemplari	❒ sino a 5	❒ oltre 5
9/D - granchio melograno (*Calappa granulata*)	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
altri decapodi	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
10 - BRIOZOI			
10/A - falso corallo (*Myriapora truncata*)	❒ sino a 10 colonie	❒ sino a 100	❒ oltre 100
10/B - trina di mare (*Sertella septentrionalis*)	❒ sino a 10 colonie	❒ sino a 100	❒ oltre 100
altri briozoi	❒ sino a 10 colonie	❒ sino a 100	❒ oltre 100
11 - ECHINODERMI, CRINOIDEI			
11/A - giglio di mare (*Antedon mediterranea*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
altri crinoidei	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
12 - ECHINODERMI, OLOTURIDEI			
12/A - lingua di mare (*Stichopus regalis*)	❒ sino a 2 esemplari	❒ sino a 7	❒ oltre 7
altri oloturoidei	❒ sino a 4 esemplari	❒ sino a 10	❒ oltre 10
13 - ECHINODERMI, ASTEROIDEI			
13/A - stella pentagono (*Peltaster placenta*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
altri asteroidei	❒ sino a 4 esemplari	❒ sino a 10	❒ oltre 10
14 - ECHINODERMI, OFIUROIDEI			
14/A - stella serpentina liscia (*Ophioderma longicauda*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
altri ofiuridei	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
15 - ECHINODERMI, ECHINOIDEI			
15/A - riccio saetta (*Stylocidaris affinis*)	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
altri echinoidei	❒ sino a 10 esemplari	❒ sino a 50	❒ oltre 50
16 - TUNICATI, ASCIDIACEI			
16/A - patata di mare (*Halocynthia papillosa*)	❒ sino a 3 esemplari	❒ sino a 6	❒ oltre 6
altri ascidiacei	❒ sino a 3 esemplari	❒ sino a 6	❒ oltre 6
17 - PESCI			
17/A - torpedine ocellata (*Torpedo torpedo*)	❒ sino a 1 esemplare	❒ sino a 2	❒ oltre 2
17/B - razza chiodata (*Raja clavata*)	❒ sino a 1 esemplare	❒ sino a 2	❒ oltre 2
17/C - murena (*Muraena helena*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
17/D - pesce San Pietro (*Zeus faber*)	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
17/E - cavalluccio marino ramuloso (*Hippocampus ramulosus*)	❒ sino a 1 esemplare	❒ sino a 2	❒ oltre 2
17/F - cavalluccio marino camuso (*Hippocampus hippocampus*)	❒ sino a 1 esemplare	❒ sino a 2	❒ oltre 2
17/G - pesce civetta (*Dactylopterus volitans*)	❒ sino a 1 esemplare	❒ sino a 3	❒ oltre 3
17/H - cernia bruna (*Epinephelus marginatus*)	❒ sino a 2 esemplari	❒ sino a 4	❒ oltre 4
17/I - corvina (*Sciaena umbra*)	❒ sino a 2 esemplari	❒ sino a 5	❒ oltre 5
17/L - salpa (*Sarpa salpa*)	❒ sino a 5 esemplari	❒ sino a 50	❒ oltre 50
17/M - castagnola (*Chromis chromis*)	❒ sino a 10 esemplari	❒ sino a 100	❒ oltre 100
17/N - donzella (*Coris julis*)	❒ sino a 4 esemplari	❒ sino a 10	❒ oltre 10
17/O - rana pescatrice (*Lophius piscatorius*)	❒ sino a 1 esemplare	❒ sino a 3	❒ oltre 3
altri pesci	❒ sino a 3 esemplari	❒ sino a 15	❒ oltre 15
RIFIUTI	❒ sino a 1 pezzo	❒ sino a 3	❒ oltre 3

Figure 2. Survey questionnaire with indication of frequency and abundance of the 61 organismal taxa surveyed (4 vegetal taxa and 57 animal taxa). Volunteers were asked to fill out the questionnaire giving information on characteristics of the dive, their diving certification, and to report the presence and abundance of any of the 61 taxa observed during their recreational dive.

The taxa list is designed to evaluate environmental quality based on biodiversity status of the surveyed stations. The surveyed taxa, familiar to recreational divers or easily identifiable, are historically expected to be present across the entire Mediterranean Sea and are representative of key trophic levels (plants, mollusks, crustaceans, fishes, etc.). Other variables such as date, temperature, depth and length of the dive are also requested in the questionnaires. Variations in biodiversity across geographic areas are not exclusively due to natural differences, with estimated biodiversity levels being influenced by local conditions (Goffredo et al., 2010). Volunteers are briefed, before going on a recreational dive, on the surveyed taxa. During the survey dive, each diver is responsible for observing any organisms, as well as litter. Soon after the dive, each participant completes a recording questionnaire.

Key objectives of the proposed project:

1. Expand the reach of the Sea Sentinels project, increasing the number of surveyed stations and targeting areas with scarce or inexistent data (e.g. northern Adriatic Sea);
2. Enhance data collection through the development of multimedia platforms;
3. Carry out reliability analysis of volunteer data in comparison with scientific researchers;
4. Disseminate project results through participation in communication events.

ACTIVITY PLAN AND WORKPACKAGES (WP):

WP1: Data collection and multimedia platform development

The researcher will contact stakeholders (e.g., diving agencies, diving centers, associations) to propose the project and obtain collaboration for data collection **(T1.1)** to increase the number of surveyed stations **(objective 1)**; and participate in the development of multimedia platforms to increase the reach of data collection **(T1.2) (objective 2)**. Specifically, a mobile application and a dedicated website will be developed in collaboration with the DWB agency, to promote the monitoring of marine biodiversity along the Italian coasts in a new and more informative way with the possibility of reporting the abundance, and distribution of surveyed species. This will allow to reach unprecedented numbers of users enhancing people awareness and engagement for environment conservation and increasing the quality and the amount of the scientific data on the Mediterranean biodiversity.

WP2: Statistical analysis of collected data and reliability assessments

The environmental quality index can be obtained through the technical information about the dive (place, date, time of day, depth, length of the dive), type of habitat explored (rocky bottom, sandy bottom, or other habitat) and sighting frequency and abundance of the 61 surveyed taxa, as well as the presence of litter, for diving points that reach the quorum of at least 10 filled questionnaires per year. The researcher will perform statistical processing of all the data collected by the volunteers to obtain the environmental quality index of the surveyed stations using the software SPSS, PRIMER+PERMANOVA, R, QGIS **(T2.1)**, to determine whether there are any trends in increase or decline of biodiversity and environmental standing.

Data reliability will be assessed **(objective 3)** through the following indices using the software SPSS, R **(T2.2)**:

- **Accuracy:** Similarity of the data generated by the volunteers with the reference values of a control diver.
- **Consistency:** Similarity of the data collected by separate volunteers during the same dive.
- **Percent identified:** The percentage of the number of taxa observed during the dive that were recorded by the volunteer diver. The total number of taxa present was obtained from the control diver observations.
- **Correct identification:** Percentage of volunteers who correctly identified individual taxa when the taxon was present.
- **Correctness of abundance ratings:** The percentage of the 61 surveyed taxa whose abundance has been correctly rated by the volunteer in comparison with the control diver.

WP3: Dissemination of the biodiversity monitoring results

The researcher will participate in at least 2 communication events (scientific congress, fairs), with an estimated outreach of thousands of people **(T3.1) (objective 4),** and will write at least one scientific article and one research proposal **(T3.2)**.

WP	Tasks	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1	**Preparation for data collection**												
	1. Contact stakeholders	■	■	■	■	■	■	■					
	2. Multimedia platforms	■	■	■	■	■	■	■					
2	**Data analysis**												
	1. Surveyed station analysis					■	■	■	■	■	■		
	2. Reliability analysis					■	■	■	■	■	■		
3	**Dissemination of results**												
	1. Participation in communication events	■	■	■	■					■	■	■	■
	2. Scientific publication									■	■	■	■

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