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# CO-EVOLVE

Promoting the co-evolution of human activities and natural systems for the development of sustainable coastal and maritime tourism

# Deliverable 3.9.4

# Guidelines to involve tourists in citizen Science activities

**Activity 3.9**

Enabling factors for co-evolution - Mediterranean scale: Ecosystems protection

**WP3**

**CNR – ISMAR**

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## 1. Introduction and scope of work

Citizen science (CS) is a flexible concept, which can be adopted and applied within diverse situations and disciplines. This document has the aim of analysing the main aspects of the environmental CS and to provide guidelines for projects focused on the engagement of tourists in the evaluation of ecosystem value, protection and pressures.

We describe the principal characteristics and the architecture of CS projects in the field of environmental research, giving specific attention to the application of CS in the marine ecosystems. We also report and describe the main initiatives and organizations, which provide significative resources for the initiation or participation to CS projects.

In a specific section, we have collected the existing CS projects for the monitoring of coastal ecosystem, which the countries beneficiaries of CO-EVOLVE are coordinating or participating in.

In the last section the principles to be followed for the development of a CS programme are indicated and described.

## 2. The environmental citizen science

At present, the term “citizen science” (CS) has become quite common in scientific nomenclature, educational programs and projects aimed at the monitoring and conservation of the ecosystems. More than 500 English-language CS projects on biodiversity research have been counted (Kobori et al. 2015), a number of databases exists (e.g., CitizenScience.org, SciStarter.com) and the publication of data from CS projects in peer-reviewed journals is constantly increasing (Theobald et al. 2015).

Since the term "citizen science" was coined (Irwin 1995), many definitions have been used (Bonney et al. 2009, Wiggins and Crowston 2011, Roy et al. 2012). Hereafter we apply an operational definition modified from Miller-Rushing et al. (2012) and Theobald et al. (2015): a CS project is a project which engages volunteers (i.e., unpaid, and not receiving internship credit) to collect and/or process data as part of a ‘‘scientific research’’ defined as the collection of quantifiable information related to a specific issue or question.

CS is based on a framework which links citizens to scientists, allowing the implementation of a complete scientific approach which produces two main effects: on the one hand citizen scientists gain knowledge and scientific expertise, on the other hand scientists can benefit of a larger workforce and geographic area (a potentially unlimited sources of data). Devictor et al. (2010) described the architecture of this framework and the connections among the different (Figure 1).

A CS projects can also produce society benefits, mainly by contributing in changing the behaviours and attitude of citizens towards the environment and promoting environmental awareness. In the “Guide for citizen science practitioner” written by Pettibone et al. (2016), the benefits of CS for science, society and participants have been summarized and here reported (Figure 2).

A number of classifications exist for the CS programs (Wiggins and Crowston 2011, Roy et al. 2012, Haklay 2013); among them we have chosen a system that considers the rate and typology of involvement by citizens (modified from Roy et al. 2012 and Shirk et al. 2012). This classification divides citizen science programs in three categories, which depend on the modalities of collaboration between scientists and citizens:

1. The communities ask to professional researchers to conduct a specific scientific investigation and report on the results (**contractual projects**).
2. The scientists design a project and ask members of the public to contribute. In this category, the participation of the public could vary from the simple data gathering

(citizen as "sensors", **contributory projects**), to a strict collaboration in which citizens contribute to refining (eventually re-designing) the project (**collaborative projects**).

3. Citizens and scientist create a project together and, after the creation step, the involvement of the citizens could even be absent or occasionally (**co-created projects**).

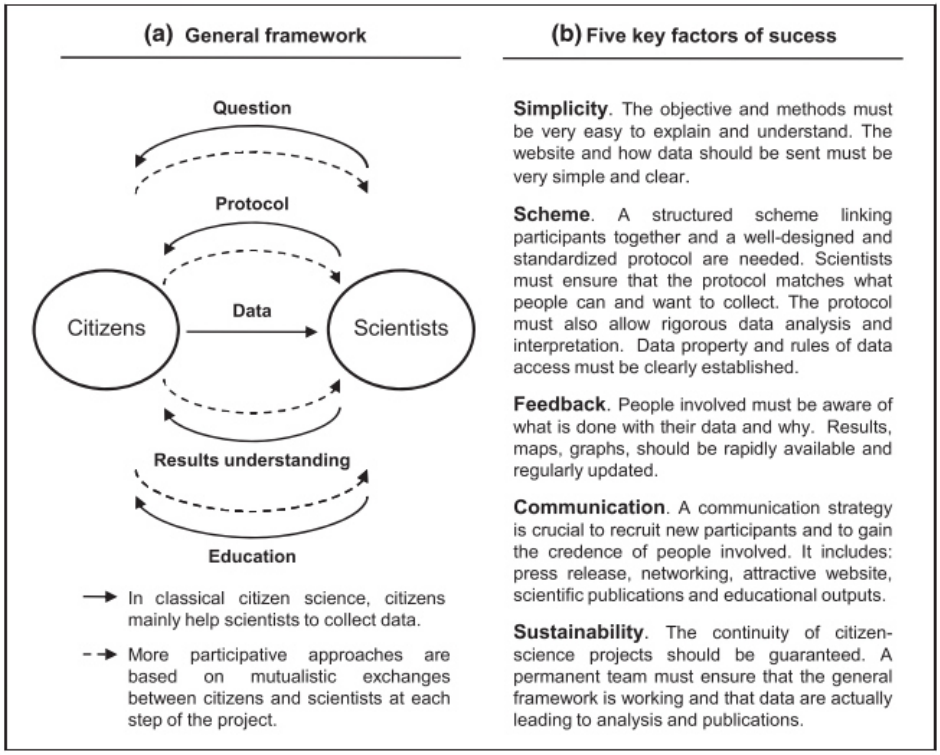



**Figure 1: Conceptual framework and key factors of success of a citizen science programme (from Devictor et al. 2010).**

| Benefits for Science | Benefits for Society | Benefits for Participants |
|---|---|---|
| • Inspires new research topics by inviting new ideas, questions, methods, and societal knowledge<br>• Creates large datasets (spatially and temporally) that can be adapted to various uses<br>• Allows diverse evaluation capacities including photos, scans and video sequences<br>• Increases public acceptance of research results<br>• Promotes public evaluation of research<br>• Verifies the practical relevance and applicability of scientific results | • Generates and communicates socially relevant research topics<br>• Allows co-creation of transparent research<br>• Allows society to take on responsibility for research<br>• Introduces all participants to new perspectives<br>• Develops opportunities for societal transformation, e.g. towards sustainability<br>• Promotes better transfer of research results into practice through early involvement of societal actors<br>• Democratizes the discursive meaning of science<br>• Strengthens civil society and government agencies | • Allows contributions to scientific discoveries<br>• Improves understanding of science and sometimes advances scientific qualifications<br>• Increases understanding of complex problems<br>• Introduces innovative ideas into science<br>• Facilitates participation in political decision-making through scientific contributions<br>• Contributes ideas and suggestions for alternatives<br>• Allows critical examination of scientific results<br>• Promotes a better environment and a better society<br>• Is fun and promotes sharing |

**Figure 2: Benefits achieved by citizen science projects (from Pettibone et al. 2016).**

CS has been considered a fundamental resource for global change research (Theobald et al. 2015). One of the reasons is that citizen scientists are able to collect a large number of data that could implement databases at any temporal or spatial scales. The large sample size ensures a great statistical power (e.g. the probability of detecting a trend of interest using a regression) and high robustness. The other reason is that the data provided are readily available, with the majority of citizen science projects making their data accessible online.

The advances in information and communication technology (ICT) is one of the factors which has determined the success of CS in the present and some projects are carried out entirely in the cyberspace (the “citizen cyberscience”). The Web and mobile devices have created new opportunities for citizen participation to projects. They have made have not only speed up data gathering and delivering but also have provided opportunities of interactions among participants. Wireless devices can collect data efficiently and in an automated way. They limit human errors and incorporate important data-gathering functions (e.g. image/audio capture) into a single tool that can “stamp” the date, time and geographic coordinates associated with an observation (Teacher et al. 2013). Internet has greatly improved the ability to find participants and interact with them and it has facilitated data collection by communities of local people who were traditionally not involved in scientific projects;

additionally, it has offered new ways to potentially influence the policy-maker (Graham et al. 2011, Newman et al. 2012, Haklay 2013, Kobori et al. 2016).

A precise and comprehensive synopsis of the characteristics of a CS project is represented by the "Ten principles of citizen science" that have been developed in 2015 by the European Citizen Science Association (ECSA, https://ecsa.citizen-science.net/): see Table 1.

**Table 1: Ten principles of citizen science (developed by the "Sharing best practice and building capacity" working group of the European Citizen Science Association.**

| | |
|---|---|
| **1** | Citizen Science projects actively involve citizens in a scientific endeavour that generates new knowledge or understanding |
| **2** | Citizen Science projects have a genuine science outcome |
| **3** | Both the professional scientists and the Citizen Scientists benefit from taking part |
| **4** | Citizen Scientists may, if they wish, participate in multiple stages of the scientific process |
| **5** | Citizen Scientists receive feedback from the project |
| **6** | Citizen Science is considered a research approach like any other, with limitations and biases that should be considered and controlled for |
| **7** | Citizen, Science project data and meta-data are made publically available and where possible, results are published in an open access format |
| **8** | Citizen Scientists are acknowledged in project results and publications |
| **9** | Citizen Science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact |
| **10** | The leaders of Citizen Science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activity |

## 2.1 The marine citizen science

The Cs can be applied in the study of marine environment, for researches on coastal and open sea areas and for the survey of water quality and the wealth of marine life. The marine environment has been under-represented by CS studies if compared to the terrestrial environment (Roy et al. 2012, Theobald et al. 2015). As indicated by Garcia-Soto et al. (2017), the explanations of this phenomenon could be: (i.) the inaccessibility of the majority of marine systems; (ii.) the absence of the practice of sharing observations and knowledge among the persons who access marine environments; (iii.) the presence in marine environment of many taxa which usually do not capture the attention of general public (with the exception of fish, seabirds and cetaceans).

Among marine citizen science studies it result that the habitats most surveyed are those more accessible, i.e.: the intertidal (22.6%) and the subtidal (28.6%) zones and the beaches (10.7%, Thiel et al. 2014, Figure 3). Also the coral reefs result a popular subjects for volunteers (10.7 %).

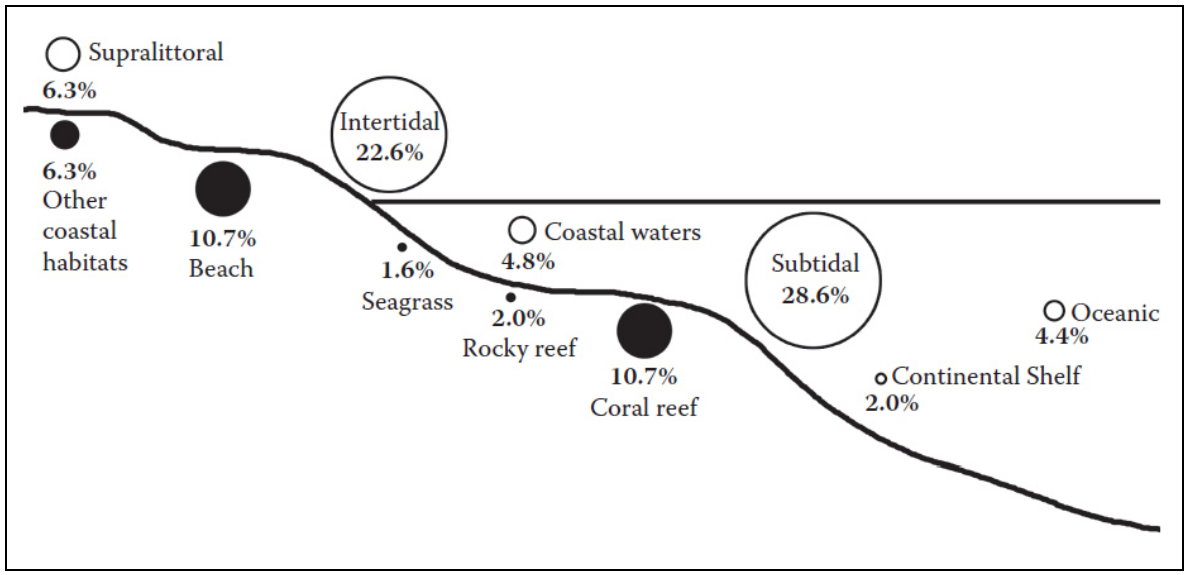



**Figure 3: Frequency of marine citizen science studies in particular habitats and depth ranges (from Thiel et al. 2014).**

There are three key drivers for supporting marine CS (Garcia-Soto et al. 2017):

1. Impacts of global change to marine systems should be seriously evaluated and monitored.
2. New policy frameworks have been built among the marine governance and management.
3. Need from volunteers: negative perceptions of marine environments, perceptions of powerlessness to enact change, the need for greater advocacy and stewardship and reported evidence of the desire amongst citizens to participate.

### *2.2 Main initiatives and resources at Global, EU or national level*

Recently, institutions, projects and initiatives on CS, at local or national level have been started to aggregate in larger consortia thus providing support and more visibility to the single participating entities. In the following part we list and describe the most important among them.

At global level, the **Citizen Science Association** (CSA, http://citizenscience.org/) is aimed to advance CS through communication, coordination, and education. It works on the establishment of a global community of practice for CS, advancing in the field of CS through innovation and collaboration, promotion of the value and impact of CS, providing access to tools and resources that further best practice, supporting communication and professional development services. CSA have been granted to over 1K projects and have engaged over 1M volunteers and 4K members.

In U.S., the **Citizenscience.gov** (https://www.citizenscience.gov/ ) is the official government website designed to accelerate the use of crowdsourcing and CS across the country. The site provides a searchable catalogue of federally supported CS projects, a toolkit to assist designing and maintaining projects, and a gateway to a federal community of practice to share best practices.

The **Australian Citizen Science Association** (ACSA, http://csna.gaiaresources.com.au/) was born in 2014 and actively works on promotion of broad and meaningful participation in CS, supporting the development of tools and resources that further best practice, ensuring that the value and impact of CS and its outputs are realised, establishing ACSA as an

effective, trusted and well recognised organisation and hub for CS in Australia. Among the resources provided there is a guide to run bioblitz, a project database and a publication listing.

The **Open Air Laboratories** (OPAL, www.opalexplorenature.org/) consist in a UK-wide CS initiative with the aim to make people more aware of the open spaces and conservation sites around them, and to promotes the knowledge of the potential of individual contribution to the nature protection. OPAL provides a wide range of innovative educational programmes for all ages and abilities and wants to ensure everybody can participate in projects to monitor the state of the natural environment and its biodiversity. The numbers of OPAL are impressing: more than 930,000 participants, more than 3,500 schools have taken part, over 2,800 organisations have worked with, approximately 270,000 survey packs have been distributed to the public, over 54,000 surveys submitted, and more than 23,000 sites were surveyed.

The **Extreme Citizen Science research group** (www.ucl.ac.uk/excites) brings together scholars from diverse fields to develop and contribute to the guiding theories, tools and methodologies that will enable any community to start a CS project to deal with issues that concern them. With an interdisciplinary research approach, the Extreme CS aims to provide any user, regardless of their background or literacy level, with a set of tools that can be used to collect, analyse and act on information according to agreed scientific methods. In extreme citizen science citizens are involved at all stages in the development of a project.

**Science et Cité** (www.science-et-cite.ch) is a Swiss platform which fosters the dialog between science and society. It contributes to the appreciation and understanding of all sciences and addresses their opportunities and limits. It also reports back to the scientists the reaction of the population in particular on value issues. Science et Cité specialises in low-threshold and innovative forms of communication, bringing, frequently, to close contact scientists and citizens. Science et Cité deals with pertinent, socially relevant topics and encourages the knowledge and the opinion-forming at the service of democracy.

The **Austrian Citizen Science** platform (http://www.citizen-science.at/) lists information on many projects and provides useful resources, e.g. information on CS conferences or events and thematic literature. Still in Austria is active the **Sparkling Science Program** (www.sparklingscience.at/en) aimed to the promotion of young scientists. Pupils of all levels of education are invited to join projects in which they are actively involved in the research process. In these projects schoolchildren support scientists in scientific work and in communicating the joint research results to the public.

The **Citizens Create Knowledge** (BürGEr schaffen WISSen or GEWISS, http://buergerschaffenwissen.de/en) is a joint project created by a consortium of scientific institutions and partners in order to support and develop citizen science in Germany. EWISS consists of a capacity-building program, focused on further developing CS through events and development of a strategy and practical toolkit, and an online platform, which seeks to connect current CS projects to each other and increase public awareness of CS).

## 3. Citizen science projects for monitoring of coastal ecosystem quality

In this section, existing CS projects specifically or partially applied to the monitoring of the coastal ecosystem are reported and described. We included projects coordinated or made in partnership with Countries that are part of the Project CO-EVOLVE Consortium, but, as result of our research, we did not found projects promoted by North-Mediterranean countries
In order to give a standard description of each project, we identified some characteristics considered significant for the scope of this deliverable and derived from the classification system adopted by Theobald et al. (2015).

**General information of the project:**

Headquarter type (governmental agency, academic institution, nongovernmental organization, a partnership between the above-mentioned institution types, or ‘‘other’’ institution, including individual people, or private institutions like zoos or museums).

Period of activity: first year and last year of activity (if the project was no longer active).

Project goal, coded as “education/outreach”, “data/research”, or both.

Project mission.

**Data collection process:**

Spatial scale over which sampling was conducted.

Biodiversity dimension (one or more of: taxonomic, genetic, functional, where the latter was included only if traits were measured for focal organisms).

Taxonomic dimension: taxonomic group(s) considered.

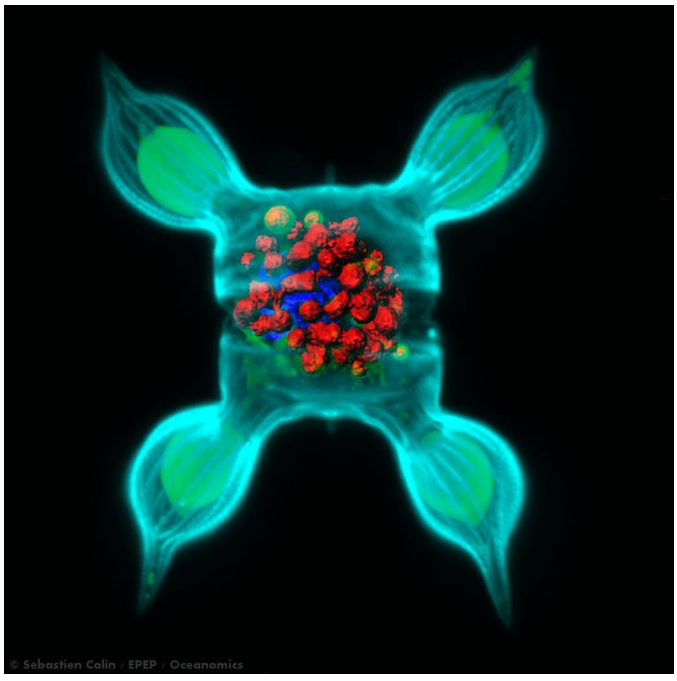
Training methods. Training method for the identification of taxa (none, or one or more of the following: in-person, electronic/web including downloadable pdfs, other, or some combination) and for sampling protocol (same list as for taxon identification training).

## 3.1 Italy

| General information | |
|---|---|
| Project name | Occhio alla medusa (in English: Watch the jellyfish) |
| URL | http://meteomeduse.focus.it/ (currently off line) |
| Headquarter type | Nongovernmental organization |
| First year of activity | 2009 |
| Last year of activity | ongoing |
| Project goal | Data/research |
| Project mission | Monitoring the distribution of jellyfish recording the presence and location of species |
| Funded by | University of Salento, Marevivo |
| **Data collection** | |
| Spatial scale | Mediterranean |
| Biodiversity dimension | Species of large planktonic invertebrates (Cnidaria, Ctenophora, Tunicata) |
| Taxonomic dimension | Taxonomic |
| Training methods | Not foreseen, photographic sheet provided |

## 3.2 France

| General information | |
|---|---|
| Project name | Plankton Planet |
| URL | https://plankton-planet.org/ |
| Headquarter type | Non-profit organization |
| First year of activity | 2015 |
| Last year of activity | Ongoing |
| Project goal | Data/research |
| Project mission | Mass sequencing of DNA barcodes from extracts of plankton communities collected worldwide by a fleet of "Planktonauts" |
| Funded by | Fondation d'enterprise Total, the Royal Society of New Zeland, Okeanos, Richard Lounsbery Foundation, Picific Ocean Initiative, Accastilage Diffusion, the Sir Peter Blake Trust, New Zeland Maritime Museum, Expeditions Foundation, Plancton & Innovation, Oceanomics, Ministry of Business Innovation & Employment New Zeland |
| **Data collection** | |
| Spatial scale | Global |
| Biodiversity dimension | Genetic |
| Taxonomic dimension | No limit |
| Training methods | |



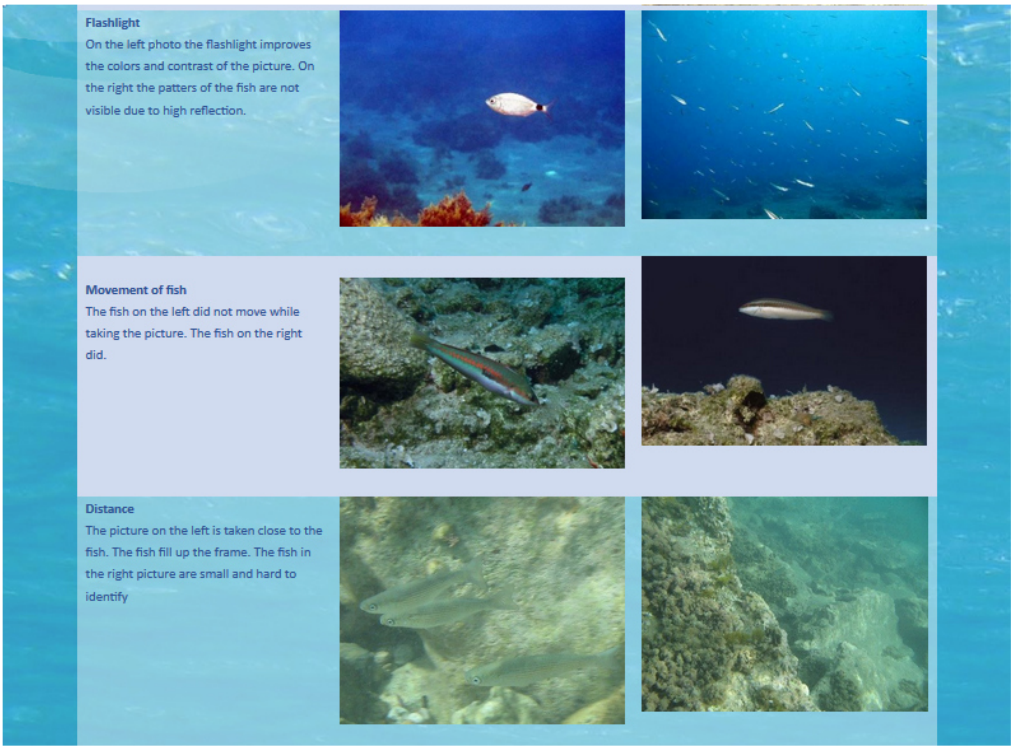
### 3.3 Croatia

| General information | |
|---|---|
| Project name | Adriatic Dolphin Project (ADP) |
| URL | http://www.blue-world.org/en |
| Headquarter type | Nongovernmental organisation "Blue World Institute of Marine Research and Conservation" |
| First year of activity | 1987 |
| Last year of activity | ongoing |
| Project goal | Data/research and conservation actions |
| Project mission | Research on populations ecology, genetics, acoustics and habitats of bottlenose dolphins and other Cetacean species in the Adriatic Sea. The ADP has successfully integrated scientific research with practical conservation and education. |
| Funded by | Porsche Croatia, the tourist office of Mali Lošinj, NETCET - EU IPA Adriatic CBC, National Foundation for Civil Society Development, Office for NGOs of the Republic of Croatia, Ministry of Science, Education and Sport, Public Institution for Managing Protected Nature Areas, the Rufford Foundation |
| **Data collection** | |
| Spatial scale | Lošinj-Cres archipelago, Croatia and Adriatic region |
| Biodiversity dimension | Taxonomic |
| Taxonomic dimension | Dolphins and other large marine vertebrates |
| Training methods | Data collection using pictures of dorsal fins (photo-identification) and hydrophone |

### 3.4 Greece

| General information | |
|---|---|
| Project name | ARCHELON Sea Turtle Protection Society of Greece |
| URL | http://www.archelon.gr/index_eng.php |
| Headquarter type | Nongovernmental organization; partner to the UNEP/Mediterranean Action Plan and member of the European Union for the Conservation of the Coasts (EUCC) |
| First year of activity | 1983 |
| Last year of activity | ongoing |
| Project goal | data/research and conservation actions |
| Project mission | Protection of the sea turtles and their habitats in through monitoring and research, developing and implementing management plans, habitat restoration, raising public awareness and rehabilitating sick and injured turtles. |
| Funded by | Certain projects are co-funded by the European Commission |
| **Data collection** | |
| Spatial scale | National, Greece |
| Biodiversity dimension | Taxonomic |
| Taxonomic dimension | Different species of sea turtles |
| Training methods | |

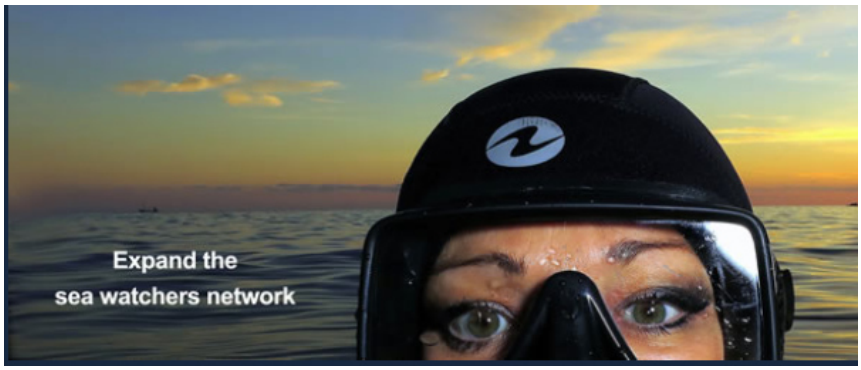
| General information | |
|---|---|
| Project name | COMBER (Citizens' Network for the Observation of Marine BiodivERsity) |
| URL | https://comber.hcmr.gr |
| Headquarter type | Hellenic Centre for Marine Research is a governmental research organization operating under the supervision of the General Secretariat for Research and Technology (GSRT) of the Ministry of Culture, Education and Religious Affairs. |
| First year of activity | 2010 |
| Last year of activity | 2013 |
| Project goal | data/research |
| Project mission | It is a pilot project that aims at engaging citizen scientists in a coastal marine biodiversity observation network. The purpose is to assist the understanding and sustainable management of our coastal biodiversity through its continuous observation and monitoring |
| Funded by | VIBRANT Union FP7 Project |
| **Data collection** | |
| Spatial scale | Regional, Crete (Greece) |
| Biodiversity dimension | Taxonomic |
| Taxonomic dimension | A number of species |
| Training methods | Lessons at associated diving centers |



### 3.5 Spain

| **General information** | |
|---|---|
| Project name | Red de Seguimiento de las Praderas de *Posidonia oceanica* de la Región de Murcia (in English: Monitoring network of the Mediterranean seagrass *Posidonia oceanica* in the Murcia Region) |
| URL | http://seagrassecology-ieo.com/ |
| Headquarter type | Governmental agency and academic institutions |
| First year of activity | 2004 |
| Last year of activity | Ongoing |
| Project goal | Data/research |
| Project mission | Development of a monitoring network in the Murcia Region to quantify and analyze long-term trends in *P. oceanica*. The monitoring activities are performed by researchers in collaboration with the Subaquatic Activities Federation of the Murcia Region (FARSM), diving centers and volunteer divers. |
| Funded by | Aquaculture and Fishery Department of the Murcia's Regional Government (CARM), the European Fishery Found (FEP) and the Spanish Oceanography Institute (IEO). |
| **Data collection** | |
| Spatial scale | Regional, Murcia (Spain) |
| Biodiversity dimension | Taxonomic |
| Taxonomic dimension | Single species (*Posidonia oceanica*) |
| Training methods | A training course is necessary for joining the project |

| General information | |
|---|---|
| Project name | Observadores del Mares (Seawatchers) |
| URL | http://www.observadoresdelmar.es |
| Headquarter type | Coordinated by the Institute of Marine Sciences of Barcelona (ICM) and La Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC), governmental research organizations |
| First year of activity | 2009 |
| Last year of activity | Ongoing |
| Project goal | Data/research, education |
| Project mission | Connect citizens and scientists in order to investigate together the current state of our seas and ocean: detect global warming impacts in biology and distribution of species, inform about the appearance and expansion of introduced or invasive species, inform about the presence of warning species as jellyfish or pufferfish, expand the knowledge about biology, habitat and distribution of native species, report the contamination of coasts and sea bottom and its impact in marine life and ecosystem |
| Funded by | Fundación Española para la Ciencia y Tecnología (FECYT), Govern Illes Balears, LIFE CUBOMED (LIFE08NATES0064), Jellyrisk Project, Vectors Project, Obra Social “la Caixa”, EnChanges, Total Foundation |
| **Data collection** | |
| Spatial scale | Mediterranean |
| Biodiversity dimension | Taxonomic |
| Taxonomic dimension | A number of species |
| Training methods | Identification guides provided |



| General information | |
|---|---|
| Project name | Crab Watch |
| URL | http://www.seachangeproject.eu/campaign/crab-watch |
| Headquarter type | The Sea Change consortium consists of 17 partners from nine different countries, coordinated by the Marine Biological Association of the United Kingdom. This consortium comprises Public research organisations, one SME, five non profit organisations and two higher education institutions. Spain is partner with SUBMON – Construint un future marí sostenible |
| First year of activity | 2015 |
| Last year of activity | 2018 |
| Project goal | education/outreach, data/research and conservation action |
| Project mission | Study of the distribution of crab species around the coast of Europe. The data collected by citizen scientists will be used to enhance knowledge of the changing distribution of native and non-native crabs, as well as information to support environmental management across Europe. |
| Funded by | European Union's Horizon 2020 Framework Programme for Research and Innovation (H2020-BG-2014-1), grant agreement No. 652644. It is part of part of the Sea Change Project |
| **Data collection** | |
| Spatial scale | Europe |
| Biodiversity dimension | Taxonomic |
| Taxonomic dimension | Species of crabs inhabiting the coastline |
| Training methods | Not foreseen, guidelines for recording provided |

## 4. Principles for the involvement of tourists in the monitoring of ecosystem quality

One fundamental assumption is to be considered when putting the theory of CS into practice: the creation of an efficient interdisciplinary architecture that links citizens and scientists which is successful for generating satisfaction and usefulness.

As stated above, a number of databases and repositories exists that collects and categorizes CS initiatives and projects. Scistarter (https://scistarter.com/finder) is one of these and it can be used for finding a CS project suitable to tourist request. The portal allows tourists to search for projects in a particular location based on the types of activities they're most interested in — such as "at night," "at the beach" or "at a zoo" — and also filter by projects that are suitable for kids, free or low-cost, designed for students or other criteria.

Ecotour operators can also facilitate the research of suitable CS programmes to be included in a touristic trip package. For example Oceanic Society (https://www.oceanicsociety.org/) is a conservation non-profit organization and offers trips that include research as a part of the adventure (many activities are incorporated: from studying dolphins, humpback whales or manatees to help researchers monitoring coral reef systems or sea turtle nesting habitats). Citizen Science Trips (http://citizensciencetrips.com/) creates vacations that revolve around CS, and includes "work" such as stargazing and fishing. According to their program: "We organize vacation trips where you travel to a research field site, which is often in a wilderness location, and spend some time every day participating in a Citizen Science Project. All projects are part of a validated research program to ensure that the contribution you make is an important one."

The developing and managing of a successful CS projects requires to follow precise steps and an accurate workflow. Several authors have provided useful systems for guiding this process, among others we refer to: Bonney et al. (2009), Shirk et al. (2012), Pocock et al. (2014), Pettibone et al. (2016) and Garcia-Soto et al. (2017). However, specific studies aimed at guiding the design of CS projects in which the “citizens” are “tourists” have not been found.

In the following section, we propose and describe the steps to be considered during the process of development and management of a CS project that engages tourists. Each step is identified by a specific question.

**Which phenomenon is going to be studied?**

At the base of every CS project there should be a scientific question.

Environmental monitoring initiatives can also be considered but the program should follow a scientific approach, with a clear identification of the processes to be monitored and the relation between the process and the objects surveyed.

Considering that the project should be appealing for members of the public, the scientific questions should be understandable by citizens and articular effort should be devoted to this aspect. Moreover, the phenomenon to be studied or monitored should take place and/or be detectable during the touristic season (e.g. if the scope is the monitoring of a specific species, the period or activity or visibility of the species should be coincident with the period in which tourists are at that place) and reachable by tourists (e.g. the monitoring of habitats that occur only in private properties of the resident citizens should not be taken into consideration).

**How do scientists and tourists communicate?**

For the success of a CS project the volunteers should feel to be part of a scientific project and researchers should not be unreachable in their "ivory tower". For this reason, the way of interaction between public and researchers is to be carefully addressed in the framework of the project. Researchers and citizens can periodically and physically meet (e.g. during events or initiatives organized by the tourist offices or diving centres) or can communicate indirectly (e.g. by digital way: e-mails, forum, social web). However, the locations where tourists spend time (e.g. tourist offices, facilities where tourists stay, paths, parks, recreational points, harbours from where cruises leave, shops, diving centres) should provide comprehensive and clear information about the project.

**How are the measures taken or the data gathered?**

Protocols, data forms, timeline, all the tools and steps necessary for the collection and data should be detailed. Ideally, the data collection should be tested with a representative pilot group before the project is launched. The method proposed should be accessible by tourists and speditive. In fact, tourists could not be available to attend training courses in which they will spend part of their vacation period. Finally, a grade of flexibility is needed and it is important to manage the expectations of participants.

**How are the tourists recruited and how may the citizen engagement be maintained?**

If scientists have designated the project, a strategy for informing potential participants about the project existence is necessary and the project should catch the attention of the tourists even before they have reached the locations. There are different strategies: personal interaction, interaction with tour operators that have been informed about the project, interactions with already established groups (professional societies or non-governmental organizations), creation of links with specific locations (museums, aquarium), concerted activities (sampling days, bioblitz) and use of media and social media platforms.

At the touristic site, the possibility of engage volunteers for the CS campaign depends on the efforts that have been devoted to dissemination. In places typically visited by tourists (facilities were tourists stay, tourist offices, ticket shops, souvenir shops, post office, restaurants, touristic boats, diving centres, etc.), materials of the project should be available (e.g. leaflet, notice boards, postcards with project description and the way for joining).

When tourists are engaged in the project it is important to ensure their satisfaction, considering the volunteer-character of the cooperation and that it takes place in a “holiday” period for citizens. The retention of participant can be obtained with a dedicated feedback strategy. The contribution of participants should be evident, for example through the indication of participant names in the products of the project (report, scientific publication, etc.), in the project portal, in the presentation of collected data, in a dedicated page on the tourist office website.

The volunteer is informed on the results of validation of the records provided and the upload in the project database in short time. The visual indication of the record in the interactive map, see for example Project MIPP (www.lifemipp.eu, Campanaro et al. 2017) or SeaWatchers (http://www.observadoresdelmar.es).

**How could the results of the project be effectively advertised?**

From a scientific point of view, the publication in peer-reviewed literature is one of the primary outputs for a CS project. For CS projects results, it should be fostered the publication of the scientific input on an open access journal, which could be easily available to the general public. Besides, a number of dissemination activities and large use of media (TV local or national, newspaper local or national, journals, radio, etc.) need to be carried out in the framework of the project: organization of celebration events, creation of blogs, forum or newsletter dedicated to the project, organization of seminar or workshops, exhibitions, etc.

Citizens may have analytical skills, in this case they can be involved in the analysis of data giving input also in this phase of the project which is usually predominately undertaken by scientists.

### *4.1 Parameters to be monitored*

Citizens may collect original data for a marine CS project according to two main typologies (from Garcia-Soto et al. 2017):

- Counts or measurements: the data provided is in a numerical format, the data can be taken directly (e.g. counting the number of specimens) or through an instrument provided by the project or possessed by the volunteer
- Descriptive observation: the data can consist in information that is not "numerical", e.g. images, sound registrations, etc.

On the basis of the examples provided by the same authors, we build a table connecting the coastal touristic typologies identified in the Deliv. 3.16.1 with the marine science data gathered by tourists in a CS project (Table 2).Scuba divers represent a tourist category of particular interest for the monitoring of life and habitats underwater and several researches exist that used data collected by non-professional divers (within the CO-EVOLVE consortium the following studies can be cited: Goffredo et al. 2004, 2010, Bramanti et al. 2011).

**Table 2: Coastal touristic typologies (see Deliv. 3.16.1) associated with examples of data collected in marine citizen science programmes (modified from Garcia-Soto et al. 2017). Abbreviations: Beach/Maritime tourism (MAR), Urban/Cultural tourism (CUL), Cruising (CRU), Recreational boating (Yachting/Marinas) (RBO), Nature/Ecotourism (NAT).**

| **On land and along shorelines** | |
|---|---|
| Online identification of organisms and features etc. from image banks and archives | MAR, NAT, RBO, CRU |
| Microclimate monitoring | MAR, NAT |
| Monitoring of beach morphology changes | MAR, NAT |
| Reports on shoreline changes (sand, water level) | MAR, NAT |
| Reports on stranded organisms (fish, cephalopods, gelatinous organisms, marine mammals) during periodic visits to the shoreline | MAR, NAT |
| Monitoring of fresh fish catches for invasive species | MAR, NAT CUL |
| Beached seabird observations | MAR, NAT |
| Mammal and turtle observations | NAT |
| Reports on stranded litter and organic matter (wood, flotsam) | MAR |
| **In shallow waters** | |
| Surveys of shallow water hotspots by diving clubs or other watersports associations | MAR, NAT, RBO |
| Long-term monitoring programmes of Marine Protected Areas | NAT |
| Monitoring of changes in protected benthic communities | MAR, NAT |
| Reporting on anthropogenic damage to shallow water communities | MAR, NAT |
| Coral and artificial reef monitoring | MAR, NAT |
| Night observations of shallow water biodiversity | NAT |
| Invasive species observations | MAR, NAT, RBO |
| Studies of diverse but accessible habitats | NAT, RBO |
| Extensions of fish and seafood databases by divers and anglers | MAR |
| **In the open sea** | |
| Sampling from ships of opportunity | RBO |
| Mobile applications to determine water colour, reflectance, clarity | |
| Collaborations with eco-volunteer organisations for survey and sampling | NAT, RBO, CRU |
| Use of drones for observations of mammals and floating debris or coastal and intertidal habitats | MAR, NAT, RBO, CRU |
| Ferry boxes for underway sampling | RBO |
| Use of tethered underwater robots | CRU |

### 4.2 Site management

The management of a certain area can effectively benefit CS, which is particularly important when site managers have limited resources. The data recording activity performed by citizens can, in fact, ensure (1) long term data, (2) vast area of monitoring and (3) early warning (detection of episodic events).

Some examples of long-term ocean resource management projects have been analyzed by Cigliano et al. (2015):

- COASST, a program of the University of Washington, has been engaging state, public agencies, environmental organizations, and community groups since 1998 to monitor seabirds along the coast of California, Oregon, Washington, and Alaska (depts.washington.edu/coasst/what/ vision.html).
- LiMPETS has been using students and adult volunteers since 2001 to monitor rocky intertidal and sandy beach habitats in California's National Marine Sanctuaries (http://limpets.org/, Osborn et al., 2005).
- Beach Watch, started by the Gulf of the Farallones National Marine Sanctuary, has been using CS since 1993 to survey the shoreline of the north-central California to provide early detection of environmental perturbations, including epizootic outbreaks, El Nino-Southern Oscillation (ENSO) events, and oil spills, as well as provide a network of citizen scientists who can respond to oil spills (http://www.farallones.org/volunteer/beach_watch_2.php, (Roletto et al. 2003).
- REEF has been conducting reef fish surveys using divers and snorkelers since 1993 (http://www.reef.org, Pattengill-Semmens and Semmens 2003).

A significative example of the potential as “early warning” of the CS initiatives is reported by Scyphers et al. (2015). They compared observations of the invasive Indo-Pacific lionfish in the Gulf of Mexico by citizen scientists to observations made during traditional reef fish monitoring from the earliest reports to 2012 and found that citizen scientists reported the presence of lionfish 1-2 years earlier and more frequently than traditional reef fish monitoring programs did. Another example come from the results of surveys of the CS project Beach Watch that were used to determine the impact of oil pollution on bird mortality and the negative effect on bird reproduction from sunken vessels and from oil spills of working vessels (Roletto et al. 2003, NOAA 2013).

According to Cigliano et al. (2015) the main recommendations for a successful site and species management are: 1) methods must be consistent and standardized, 2) the data

collection tools adequate for citizens, 3) researchers responsible for planning the monitoring should exactly know the needs of managers; 4) the scale of projects should be appropriate, 5) the program should be "transparent" (citizens know the process followed by the data provided) 6) a point of contact should exist for explaining results and analytical process to managers.

### *4.3 The use of remote sensing*

The observation of coast and oceans carried out by instruments mounted on satellites are essential for the monitoring of marine environment, for the marine safety and for the weather or seasonal forecast.

Citizens can access to a variety of parameter registered by remote-sensing (water temperature, transparency, wave height and direction, surface currents, etc.) (e.g. http://www.sea-conditions.com/en/). Citizens can also support the earth observation, providing in-situ validation of remote-sensing data.

Examples of services for citizens are:

- Copernicus assists in monitoring risks and planning for response to marine pollution (http://copernicus.eu/news/copernicus-assists-monitoring-risks-and-planning-response-marine-pollution)
- Copernicus Atmosphere Monitoring Service (CAMS) delivers Forecasts of UV radiation on a free and open basis. HappySun (http://www.happysun.co.uk/) is a smartphone application, based on the exploitation of data coming from CAMS, which enable real time forecasts.
- Copernicus Marine environment monitoring service (CMEMS, http://marine.copernicus.eu/) provides regular and systematic core reference information to any user (service provider or end-users) related to 4 areas of benefits: Maritime Safety, Coastal and Marine Environment, Marine Resources, and Weather, Seasonal Forecasting and Climate activities.

An example of citizen contribution comes from the study of jellyfish expansion: here the Contribution of citizens has been used for ground-truth validation of satellites data. Copernicus satellites, in particular Sentinel-3, can assist jellyfish presence prediction by providing information on a range of physical and biological ocean parameters that favour jellyfish blooms. Ocean temperature, salinity, water currents, sea-surface height and

chlorophyll concentration strongly affect jellyfish density. To locate jellyfish, field data from beach observations are entered in a model to identify the conditions for the presence or absence of jellyfish. Carte de Méduses (http://meduse.acri.fr/home/home.php) is a web-service for the monitoring the presence of jellyfish along the French Mediterranean shoreline. It is using observations from citizens in situ (more than 7,000 volunteers contributing to a database of about 30.000 observations so far) combined with data from CMEMS as a pilot demonstration.

### *4.4 Data management*

As stated above, one of the peculiarities of CS is that it can deal with large datasets delivered by citizens. For this reason, it is important to carefully design the data management process, which includes the legal aspects (data management must be transparent), the data storage (how the data can be secured in the long term), the data accessibility and usability (the use of adequate metadata standards) (see also Pettibone et al. 2016).

Many aspects of data management are referred to the back-end technology with several projects that have developed approaches to sharing best practice and infrastructures for efficiently sharing data (Roy et al. 2012). In the next future, the scenario could the existence of a number of big “cyber-infrastructures” that links project together (the database systems are interoperable) and ensure data standards. Good examples of marine environment DATA repository are the “Marine Environmental Data and Information Network” (MEDIN: http://www.oceannet.org/) and the UK Archive for Marine Species and Habitats Data (DASSH: http://www.dassh.ac.uk/).

### *4.5 Data quality*

The data provided by citizens are susceptible of errors and for this reason the project should implement: 1) systems for minimize the possibility of errors for citizens (training participants is the “safest” way in order to minimize the errors, but it is not always feasible), 2) a data validation process carried out after the datum has been delivered, in order to clean the database from information that could produce incorrect results.

In order to minimize the errors for citizens, a range of solutions can be adopted (Garcia-Soto et al. 2017): (i) providing close training and supervision; (ii) cross-checking for consistency with existing literature; (iii) cross-checking with scientists' own observations; (iv) quiz style questionnaire at end of survey; (v) simplifying the tasks asked of the public and/or adapting the research questions; (vi) database management; (vi) filtering or subsampling data to deal with error and uneven effort; and (vii) technologies and statistical techniques to identify signals of change in noisy ecological data (Crall et al. 2011, Newman et al. 2012, Bird et al. 2014, Riesch and Potter 2014).

The data validation can be ensured by the community ("democratic" system, e.g. iNaturalist) or through the implementation of a validation protocol (a team of experts validate the data).

The data cleaning process will, inevitably, produce a reduction of the initial datasets, monitoring the trends in the rate of erroneous data vs. corrected data, could represent a good indicator for estimating the effectiveness of volunteer training or other strategies carried out for guiding the volunteers to a correct data gathering.

If a validation process after the data have been delivered is not possible (e.g. pictures cannot be taken) a possible way is to conduct a previous experiment by expert and compare the results obtained.

### *4.6 Ecological awareness*

Participating in environmentally-focused CS projects means going outdoors and being in contact with the natural environment. This represents the first step for the increasing of personal ecological awareness: the nature observation and the contact with organisms and their habitats produce an increasing of interest on the biosphere and could produce motivation for more sustainable behaviours and individual attitudes.

Cigliano et al. (2015) analysed a number of marine CS case studies and found that the change in individual behaviour related to environment produce in adult citizens: increased attitude to pro-environmental practice (e.g. coastal habitat restoration, reduction of harmful material), influence of decision makers (thorough community changes in everyday activities), identification of community leaders, who are empowered in the protection of local resources, for communicate and disseminate information. In the same framework, when the citizen projects go into the classroom, the big environmental themes are situated in the context of

the real world and children are motivated for the contribution that they can provide to nature conservation.

Marine habitats are less accessible for groups of students than terrestrial environment (transportation, logistics, water safety). In this case teacher can benefit from the potential of technology and social media.

In the project focused on single species, citizens might galvanize the support for this species and change the community perception of it.

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**Web-pages of projects, databases and initiatives**

European Citizen Science Association (ECSA)
https://ecsa.citizen-science.net/

Citizen Science Association (CSA)
http://citizenscience.org

U.S. Citizen Science official government website
https://www.citizenscience.gov

Australian Citizen Science Association (ACSA)
http://csna.gaiaresources.com.au/

Open Air Laboratories (OPAL)
www.opalexplorenature.org

Extreme Citizen Science research group
www.ucl.ac.uk/excites

Citizen Science Swiss Platform (Science et Cité )
www.science-et-cite.ch

Austrian Citizen Science platform
http://www.citizen-science.at/

Sparkling Science Program (Austria)
www.sparklingscience.at/en

Citizens Create Knowledge (BürGEr schaffen WISSen or GEWISS, Germany)
http://buergerschaffenwissen.de/en

Citizen Science projects finder
https://scistarter.com/

Copernicus Marine environment monitoring service (CMEMS)
http://marine.copernicus.eu/

Access point to the meteorological and oceanographic forecasts for the Mediterranean Sea
http://www.sea-conditions.com/en