D14.9 SUMMARY REPORT OF WP14

WORK PACKAGE 14 – CITIZEN OBSERVATORIES AND PARTICIPATIVE SCIENCE

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ABSTRACT

A necessary component of environmental Research Infrastructures is and will increasingly become participative or "citizen" science. This is for two key reasons: 1) it raises societal awareness and engagement about environmental change and 2) provides data that is otherwise logistically inaccessible for monitoring change on our planet. This work package developed and summarized resources for environmental Research Infrastructures to engage with the public in citizen science, an area providing innovative solutions for data or sample collection, management, processing, curation, annotation, and archiving. In particular, this work package moved beyond a review of status quo to targeted test cases in leading areas of citizen science to develop:

1. resources and best practices for public contributions to the annotation of imagery, a charismatic form of scientific information with which to engage the public, while also being a resource-intensive information source for RI's (Task 14.1) and

2. a framework for distributed networks of observers and sensors who collect data and can perform response actions (Tasks 14.2 and 14.3).

Task 14.1. Imagery Annotation: Taking complex scientific images and turning them into data

Task 14.2. Citizen virtual seismological observatory

Task 14.3. Marine biodiversity citizen participative science programme

Task 14.4. RI Citizen Science Toolkit – Best Practices augmented by Leading Area test cases

Note on timing:

The submission date at the end of the project was postponed until fall 2019 due to summer absences and the priority of completion of other earlier deliverables in Theme 4.

The change does not affect the budget or other elements of the project.

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TERMINOLOGY

A complete project glossary is provided online here:
https://envriplus.manageprojects.com/s/text-documents/LFCMXHHCwS5hh

PROJECT SUMMARY

ENVRIplus is a Horizon 2020 project bringing together Environmental and Earth System Research Infrastructures, projects and networks together with technical specialist partners to create a more coherent, interdisciplinary and interoperable cluster of Environmental Research Infrastructures across Europe. It is driven by three overarching goals: 1) promoting cross-fertilization between infrastructures, 2) implementing innovative concepts and devices across RIs, and 3) facilitating research and innovation in the field of environment for an increasing number of users outside the RIs.

ENVRIplus aligns its activities to a core strategic plan where sharing multi-disciplinary expertise will be most effective. The project aims to improve Earth observation monitoring systems and strategies, including actions to improve harmonization and innovation, and generate common solutions to many shared information technology and data related challenges. It also seeks to harmonize policies for access and provide strategies for knowledge transfer amongst RIs. ENVRIplus develops guidelines to enhance transdisciplinary use of data and data-products supported by applied use-cases involving RIs from different domains. The project coordinates actions to improve communication and cooperation, addressing Environmental RIs at all levels, from management to end-users, implementing RI-staff exchange programs, generating material for RI personnel, and proposing common strategic developments and actions for enhancing services to users and evaluating the socio-economic impacts.

ENVRIplus is expected to facilitate structuration and improve quality of services offered both within single RIs and at the pan-RI level. It promotes efficient and multi-disciplinary research offering new opportunities to users, new tools to RI managers and new communication strategies for environmental RI communities. The resulting solutions, services and other project outcomes are made available to all environmental RI initiatives, thus contributing to the development of a coherent European RI ecosystem.

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REVIEW OF WP14 RESULTS AND HOW THEY CAN CONTRIBUTE TO CITIZEN INVOLVEMENT IN ENVIRONMENTAL SCIENCE

A necessary component of environmental Research Infrastructures is and will increasingly become participative or "citizen" science. This is for two key reasons: 1) it raises societal awareness and engagement about environmental change and 2) provides data that is otherwise logistically inaccessible for monitoring change on our planet.

This work package developed and summarized resources for environmental Research Infrastructures to engage with the public in citizen science, an area providing innovative solutions for data or sample collection, management, processing, curation, annotation, and archiving. In particular, this work package provided a review focused on the needs of environmental science (D14.6, see Appendix 2), then moved beyond a review of status quo to targeted test cases in leading areas of citizen science to develop:
1. resources and best practices for public contributions to the annotation of imagery, a charismatic form of scientific information with which to engage the public, while also being a resource-intensive information source for RI's (Task 14.1) and
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Task 14.1. Imagery Annotation: Taking complex scientific images and turning them into data
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Participation in citizen science covers many degrees of involvement in the scientific endeavour, from large numbers of small contributions, to co-design, management, and analysis. Citizens can therefore be involved in a broad range of activities, including: instrument manufacture and maintenance, instrument deployment/sample collection, data collection and transmission, data analysis, data validation/verification, communication of findings, and proposals of new topics for research.

Citizen science is often presented as a means for increasing scientific literacy and engagement within the general public. However, particularly for environmental science, it is important to note that there are certain aspects of citizen science that can overcome limitations of standard sampling/monitoring the Earth. Firstly, we seldom have adequate spatial coverage for many key Earth observations. Engaging citizen scientists around the globe can help address this problem, particularly in remote, and often sensitive regions, such as the polar environments. A related issue is not only spatial coverage, but the density of observations, particularly in areas of rapid transition such as the coastal interface between land and sea – where remote sensing techniques perform poorly because of lack of resolution. Temporal resolution is equally important to spatial resolution when trying to understand evolving processes over time. Finally, while software and automatic processing can help analyse scalar data, computer programs are still far from optimally extracting information for more complex data like video imagery or acoustics. One solution is to outsource the data analysis part to online contributors via web applications, as long as the tasks required remain simple and do not require substantial training. For a more extended

discussion of citizen science and available resources, see D14.6, and Appendix 1 for some useful organisations.

Public contributions to imagery annotation: Taking complex scientific images and turning them into data

Much of our information about the natural world around us is visual, particularly in ecology and biodiversity studies. As a result, much of the sampling is done through images and video, as a means to working in challenging environments where observation time is limited, and as a means to capture elusive biota or phenomena. Note however, images are samples, not data. Turning environmental images into data most often requires human effort, as the images often are too complex to lend themselves well to automated analysis.

Task 14.1 attacked this problem, using hard-won footage from the abyss that is now streaming into data centres due to recent development of ocean observing sensor systems. When one minute per hour of footage is collected, across multiple cameras/sites/observatories, the amount quickly adds up. What used to be manageable by scientists, because the opportunity to collect the footage was so rare, now needs more human resources – enter crowd sourcing and gamification (Deep Sea Spy, https://www.deepseaspy.com/). Now data such as numbers and sizes of individuals and area of coverage can be collected by thousands of participants, greatly improving the understanding of ecology and biodiversity in these remote locations.

Distributed networks of observers and citizen deployed sensors who/that collect data and perform response actions

A common challenge in environmental sciences is achieving necessary spatial and temporal distribution and density of data. Tasks 14.2 and 14.3 address this through the use of citizens who deploy sensors and/or make observations, often providing data return real-time.

Task 14.2 addressed the use of citizen deployed sensors in seismology, an area with great potential for the high spatial resolution data that can greatly improve earthquake outcomes in cities for example. Sensor technology can evolve quickly, which provides a challenge when attempting to build up a significant sensor system. As with most technology, this seems to resolve itself with greater standardisation and compatibility – in this case though the original sensors were replaced with newer technology, the replacement brought with it better compatibility with professional seismic systems (D14.3, D14.4, D14.5). This evolution shows how important the initial choice of technology is to engage citizens in a long term, key for the success of citizen science sensor initiatives.

Both Tasks 14.2 (LASTQUAKE http://www.emsc-csem.org/) and 14.3 (Crab Watch, https://www.mba.ac.uk/crabwatch/) also used smartphones as mobile sensors (camera, GPS…), as well as real-time data reporting devices. In this case, apps on the phone provide the standardised framework and information to guide structured observations, as well as the connectivity to produce real-time data. Task 14.3 took this one step further and provided detailed information on sources and processes of developing such apps, as well as the training required for citizen scientists to use them.

Data systems for acquisition, storage, assessment, access, and analysis of distributed data sources

Data management is a challenge in many of these scenarios, given large amounts of data being generated by citizen science approaches. This increase in data size and complexity is not only a

desired outcome – the benefit of engaging many more observers/analysts – but also a requirement as data generated by non-specialists requires larger sample sizes to allow for assessment of outliers and error.

In addition to increasing amounts and complexity of data to manage, another challenge in this area is the speed with which both software and hardware components are changing (see sensor systems above). All Tasks needed to change components of their data systems from what was originally proposed, so their reports provide readers with helpful discussions of pro's and con's that drove their decisions.

Task 14.1 made major progress in improving the algorithms available for complex image analysis, and also addressed challenges in storing and retrieving images and their annotations (D14.1, D14.2).

Task 14.2 produced and developed an international seismic observation application called LastQuake to provide professional seismic information to citizens and to collect their experience of felt earthquakes, both in in real time. They tested two different sensor (seismometer) systems, developped platforms (D14.3, D14.5), and produced guidelines for citizen sensor systems (D14.4).

Task 14.3 developed various versions of apps that enable citizen scientists to participate in data collection and submission from field locations, both for broad spatial data, and for targeted campaigns. Further, they then documented this process to help teach scientists what tools are out there that can be adapted to this kind of citizen observer role (D14.7, D14.8).

All agree any data gathering system should have a clear data policy, including clear discussion of privacy provisions, intellectual property, and expectations in terms of acknowledgement and/or co-authorship in publications and other dissemination

How to effectively engage, train, and maintain Citizen Scientists

The deliverables in this work package provide not only road maps of how to engage and train citizen scientists, but also provide full training materials for environmental scientists and organisations wishing to set up citizen science initiatives.

Extensive experience and documentation were developed through Task 14.1 (D14.2) on how multiple organisations can partner to a) engage schools and students and b) provide embedded activities in public museums, zoos, and aquariums. In this case, a gamification approach to complex image analysis (Deep Sea Spy, https://www.deepseaspy.com/) was developed with an educational website and resources, and launched with the partnership of whole school districts and public institutions.

Training materials developed through Task 14.3 not only address engagement and training of citizen scientists, but more importantly engage and train scientists and organisations on how to develop citizen science projects and programmes (D14.7, D14.8). Goals of the training sessions were:

- Share and discuss best practice for using citizen science to generate scientifically useful information.
- Demonstrate and discuss systems and tools to help citizen scientists share marine biodiversity data.
- Identify when a citizen science approach is and isn't appropriate.
- Empower participants to set up their own online data collection scheme

In task 14.2, experience from development of the very successful LastQuake (http://www.emsc-csem.org/, described in D14.3, D14.5) reiterates recommendations seen in many fields:

- Develop simple and user-friendly web interfaces to show and play with the data
- Develop simple games
- The tools/devices/interface must be free of charge and easy to install/use
- Target schools as teachers may be keen on such projects and more available
- Reward the best or most frequent users in some way

SUMMARY

Work Package 14 has brought together some key experience and insight into some of the most exciting and challenging areas in citizen science. The experience and resources gained through this work is immediately applicable to many areas of environmental science and beyond. All of the partners in this work package brought some citizen science experience to the table, allowing them to quickly identify and address frontier issues for both citizen science and environmental science in general.

Technology can evolve quickly, which provides a challenge when attempting to build up stable sensor systems, algorithms, applications, and data systems for citizen science. As with most technology, this seems to resolve itself with greater standardisation and compatibility, but is a serious consideration when designing a citizen science program. Therefore do not re-invent the wheel, but look to adapt and expand existing tools with a constant eye on compatibility and system evolution in the longer term. The effort to engage, train, and retain citizen scientists requires that both obsolescence and duplication of effort in these systems is avoided.

An emergent observation is that citizen science can facilitate and strengthen cooperation among institutions which may have some common interests, but because of culture might not otherwise easily interact. Therefore citizen science is not only an effective means to include science in schools, generate training material, and build citizen engagement in science, but also to grow data coverage, improve communication, and leverage effort among scientific and educational institutions.

All WP14 deliverables are available through envriplus.eu (see Appendix 2).

IMPACT ON PROJECT

This overview of the scope and leading edges of citizen science provides a summary of contributions by the tasks in WP14 as they expand current frontiers in citizen science.

IMPACT ON STAKEHOLDERS

This document will serve as a primer on citizen science for those RI's that have not developed much experience in this area, or have considered citizen science only in subsets of the full range of activity.

APPENDIX 1 List of citizen science organisations and amalgamators which are excellent sources of further information and linkages.

Organisation	**Website**	**Country(ies)**
Citizen Science Association	citizenscience.org	U.S.A.
European Citizen Science Association	ecsa.citizen-science.net	E.U.
Australian Citizen Science Association	citizenscience.org.au	Australia
Canadian Network for Ocean Education: CaNOE	oceanliteracy.ca	Canada
UK Earth Observation Framework (UK-EOF)	www.ukeof.org.uk/our-work/citizen-science	UK
Wikipedia List of citizen science projects	en.wikipedia.org/wiki/List of citizen science projects	International
Scientific American listing of Citizen Science projects	scientificamerican.com/citizen-science	International
Citizen Science Alliance	citizensciencealliance.org	International

APPENDIX 2 List of work package 14 deliverables (see envriplus.eu)

No.	Title
D14.1	Prototype of a web-based annotation tool for user testing.
D14.2	Report describing image annotation results
D14.3	Report on development and implementation of a citizen seismology sensor observatory and education platform
D14.4	Guidelines for developing citizen sensor observatories and education platform
D14.5	Test version of a EMBRC citizen observatory system
D14.6	Review of existing Citizen Science tools
D14.7	Citizen observation training program, training delivery and evaluation, and impact assessment report
D14.8	Collection Training sessions/presentations
D14.9	Summary report of WP14