ABSTRACT

The Cies Islands are globally recognized as a space of countless natural beauty, ecological richness and cultural heritage, that together, sustain its exceptional values, which makes them the central element within the context of the National Park of the Atlantic Islands of Galicia. Among others, they stand out for the geomorphological characteristics of their ecosystems (cliffs, beaches and dune systems ...), the richness of their marine habitats, or the nesting areas of important colonies of seabirds. They also constitute a territory of great heritage and cultural value, which is integrated with environmental value. At the same time, all these characteristics make them a place of enormous attraction for the development of scientific, fishing, tourism and leisure activities, which, a priori, could constitute a potential risk for the maintenance of the natural state of the archipelago. It is therefore crucial to find a compromise between the use of this natural space and the preservation of its ecological values, for which it is necessary to "raise environmental awareness" with respect to the property, ensuring the involvement of the various stakeholders (administrations, companies, academia and society) with the candidacy process and the conservation of the inheritance of these natural values for future generations. It is for this reason, that the city council of Vigo has pointed the candidacy of Cies through a participatory approach, that has defined the candidacy of the Cies Islands since its inception and has become more significant as the different working programs have been developed, among which is the Citizen Science Program: "Cies Islands, Awakening Environmental Consciences". This Program develops actions that integrate science and society in a reciprocal relationship promoting the association between groups based on mutual benefit, through the disposal of integration processes that facilitate the communication, working to strengthen the candidacy from the environmental, social and academic-scientific perspective. Through the Citizen Science Program, we aim at generating valuable information that will result in a better understanding of the natural space. At the same time, it will support the compliance with the UNESCO Guidelines, allowing citizens to work in the service and for the benefit of Science, with a deep personal and social involvement, therefore, sharing the responsibility with the State Party on the candidature and the conservation of the space.

KEY WORDS: Cies islands, citizen science, scientific diving

RESUMEN

Las Islas Cíes son reconocidas como un espacio de gran belleza natural y riqueza en biodiversidad y patrimonio cultural, que reúne unos valores excepcionales tales, que las convierte en el elemento central dentro del contexto de las Islas Atlánticas de Galicia. Entre otros, destacan las características geomorfológicas de sus ecosistemas (acantilados, playas y los sistemas dunares...), la singularidad de sus hábitats marinos, o el anidamiento de diferentes colonias de aves marinas. Se constituyen además como un territorio de gran valor patrimonial y cultural, que se integra con el valor ambiental.
Todas estas características las convierten en un lugar de enorme atractivo para el desarrollo de actividades científicas, pesquerías, de turismo y de ocio, lo que, a priori, podría constituir un potencial riesgo para el mantenimiento del estado natural del archipiélago. Es por ello crucial encontrar un compromiso entre el uso de este espacio natural y la preservación de sus valores ecológicos, para lo que es necesario “despertar conciencias ambientales” con respecto al bien, asegurando la implicación de los diversos grupos de interés para con la conservación de este espacio natural: administraciones, empresas, academia y sociedad civil.

Es por ello, que el ayuntamiento de Vigo ha orientado la candidatura de las Islas Cíes desde un enfoque participativo, lo que ha definido esta candidatura desde sus inicios y han ido tomando más peso conforme se han ido desarrollando los diferentes programas de trabajo, entre los que se encuentra el Programa Ciencia Ciudadana: “Islas Cíes, Despertando Conciencias Ambientales”.

En dicho Programa se desarrollan acciones que integran ciencia y sociedad en una relación de reciprocidad y acercamiento entre colectivos. La relación que se plantea se basa en el beneficio mutuo, a través de la disposición de procesos integradores que facilitan la comunicación y que trabajan por el fortalecimiento de la candidatura desde la perspectiva ambiental, social y académico-científica.

A través del Programa Ciencia Ciudadana, se trabaja en la generación de nueva cultura científica que redundará en un mejor conocimiento del espacio natural desde diversas dimensiones. A la vez, sustentará el cumplimiento de las Directrices UNESCO, permitiendo a los ciudadanos trabajar al servicio y en beneficio de la ciencia, con un grado de implicación personal y social muy importante para la candidatura.

**PALABRAS CLAVE:** Ciencia ciudadana, islas Cíes, buceo científico

1 **GEOGRAPHICAL CONTEXT OF THE CÍES ISLANDS**

The archipelago of the Cíes Islands (Figure 1) is an insular coastal system, located on the Atlantic coast of Spain. Specifically, on the south-eastern coast of the Autonomous Community of Galicia, outside the Ria de Vigo. It is located at a distance of 14.5 km from the municipal district of Vigo (Pontevedra), to which it belongs.

The archipelago is composed by the Islands of Monteagudo, Faro and San Martiño and the adjacent islets of Boeiro, Penela dos Viños, Carabelos and Ruzo. The islands of Monteagudo and Faro, are currently artificially linked by a dam and naturally by an isthmus of
sand (Rodas beach) that forms the beach-lagoon system. While Faro and San Martiño are separated by a strait, known as Freu da Porta, 560 m. These islands have the status of National Park since 1980 and National Park since 2002 (Costas et al., 2002).

THE OUTSTANDING UNIVERSAL VALUE OF THE CÍES ISLANDS

The archipelago of the Cies Islands is located in a biogeographic border and immersed in a highly productive system forced by processes of large spatial scale and, therefore, vulnerable to the impacts of global change. The location of the archipelago in the north limit of a highly productive system has allowed the development of important traditional activities related to the use of marine resources such as fish, molluscs and crustaceans.

The unique values of this archipelago fall mainly in the complex interactions between oceanographic phenomena, productivity of the marine ecosystem and the ecological processes that are framed in these islands. These processes are related to the transfer of matter from the productive coastal system to higher predators, which, in turn, can modify the terrestrial physical environment and the consequent flora that develops in it. In this system, seabirds act as landscape shaping agents with deep effects on terrestrial ecosystems. The high density of these birds in the Islands, create unique environmental conditions, in which the contributions of faeces and other organic debris, create particular microhabitats in which high concentrations of biolimiting elements are given for plant production. This type of vegetation, dependent on the contribution of nutrients from birds, establishes, in turn, mutualistic relationships of exceptional intensity with birds.

This ecosystem stands out for the diversity of habitats, associated with the heterogeneous mosaic of geomorphological features, plurality of substrates and different degrees of exposure, which coexist in a relatively small and scarcely altered space (Figure 2). Its border situation between the bioregions of the "boreal" at north and the "lusitanian" at south, allow the coexistence of species of boreal distribution and species of temperate distribution in this ecosystem. This scenario is characterized by an exceptionally diverse mosaic of landscape units, whose singularity lies in the configuration of a landscape of contrasts, with a high heterogeneity of physiographic elements in a reduced spatial dimension.

Figure 2. Landscape of the Cies islands. Source: Adolfo Cordero
THE CANDIDACY OF THE CÍES ISLANDS

In 2012, the City Council of Vigo, convinced of the necessity to improve the protection and preservation of the Cíes Islands and its potential to be recognized as a UNESCO World Heritage, leads the initiative of the candidacy of the Cíes Islands.

During these years, the City Council of Vigo has been developing several actions since the fulfilment of three key aspects considered by UNESCO, the definition of a solid and structured work team, the compilation and analysis of all the information published in scientist journals, official reports, inventories, etc about the good and the development inclusive actions that enhance the participation of local people.

Therefore, the work has been articulated under 4 main points:

- **Technical work actions**

  The first step was to define a work team of specialists and coordinators for each group (Figure 1), that support the scientific and technical justification to meet the UNESCO criteria and the conclusions of the Exceptional Universal Value of the Cies Islands.

  These actions include several meetings among these groups to identify and bring together all the existing information on the property and identify the gaps of knowledge to plan future research projects. This equipment was also responsible of the validation of the justification of the UNESCO criteria. These works conclude with the elaboration of the report for the World Heritage nomination.

Figure 3 organization chart of the work team
- Institutional coordination actions

A collaboration agreement was reached between the City Council of Vigo and the University of Vigo, signed by the Mayor, Abel Caballero and the rector of the University, Salustiano Mato. In this agreement, the University of Vigo, through the Campus Do Mar, has provided the scientific support that ensures accuracy of the candidature proposal. Though this agreement the candidacy got the support of the three Universities of Galicia and the Investigation Centres (CSIC and IEO).

The main objective was to establish collaborations and agreements with other institutions, joining efforts for the common goal of declaring the Cíes Islands as a UNESCO World Heritage site.

- Communication-dissemination actions

Several dissemination activities have been developed that have achieved significant social support through events such as the presentation of the project at the Fitur Fair (2015, 2016, 2017 and 2018), dissemination of the project through different communication means (press, radio, television), promotion agreement with transport means, such as airlines (Ryanair, Airnostrum), buses (Avanza) or Madrid Underground, or the signature collection campaign. The promotion of the nomination also included sport events (regattas, football matches ...) and cultural events such as festivals, concerts.

The main objective of this actions was to reinforce the candidature from the maximum participation, at all levels, including administration, business, scientific and academic sector and civil society, in general.

- Conservation and awareness campaigns

The main goal was to reinforce the conservation of this archipelago and develop a shared responsibility for its future.

This campaign includes several actions aimed at improving the conservation of this place, such as environmental monitoring programs, cultural heritage recovery project (cemetery of the Cies Islands), environmental volunteering actions designed to recover native species, elimination of invasive species and waste collection among others. This volunteering program have involved more than 1,200 people and more than 19,000 hours of work. In the field of awareness, several activities directed to schoolchildren have been developed, such as writing and drawing competitions under the frame of the Cíes Islands, but also the creation of an interpretation centre of the values strengths and weaknesses of this archipelago and the production of reports and documentaries.

The participatory approach has defined the candidacy of the Cíes Islands since its inception and has become more significant as the different working programs have been developed, among which is the CITIZEN SCIENCE PROGRAM: "CÍES ISLANDS, AWAKENING ENVIRONMENTAL AWARENESS".

4 THE CITIZEN SCIENCE PROGRAM

What is Citizen Science

The concept of "Citizen Science" has been defined as the "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions" in the Oxford Dictionary. By "Citizen Science" are understood actions that are carried out by a sum of collaborators, among which
are researchers and scientists, along with citizens in general, so that a relationship of mutual benefit and closeness occurs between both groups. Volunteers, while adding value to research, acquire new knowledge or skills, and a better understanding of the scientific method framed in the topic under study, in an attractive way. As a result of the interactions between science and society, conduct under the principles of the citizen science, leads to more "social" research.

The relevance of the Cíes islands as Natural heritage is unquestionable, they illustrate in an exceptional way the ecological and evolutionary processes that frame them. These processes derive from the interaction between the marine and terrestrial systems, in a historical context of years of economic development, linked to the exploitation of natural resources, through traditional fishing gears. One of the most outstanding ecological values of the archipelago of the Cíes Islands is the presence of subtidal benthic communities characteristic of the relatively unimpacted Atlantic ecosystems (Figure 2). That is why, in the face of the aspiration to achieve the declaration as a World Heritage of this natural space, it is necessary to obtain a high-resolution cartography of these communities.

**Awakening environmental awareness**

The main objective of the UNESCO World Heritage Program is to ensure the safeguarding of the outstanding values that characterize goods already declared, or whose declaration is intended. This requires establishing a compromise between the use of the resources and their conservation, for which it is necessary to "raise environmental awareness" with respect to the property, ensuring the participation of the various stakeholders in the process: administrations, companies, academia and society, what is usually called "quadruple helix". ("Such participation should be a priority from the start of the process and all the way through the preparation of a nomination", Document Preparing World Heritage Nominations, Second Edition, 2011).

This Program develops actions that integrate science and society in a reciprocal relationship promoting the association between groups based on mutual benefit, through the disposal of integration processes that facilitate communication and work to strengthen the candidacy from the environmental, social and academic-scientific perspective.

Through the Citizen Science Program, we aim at generating valuable information that will result in a better understanding of the natural space from various dimensions: natural, scientific, social, cultural, economic, management and conservational. At the same time, it will support the compliance with the UNESCO Guidelines, allowing citizens to work in the service and for the benefit of Science, with a deep personal and social involvement to enable them to have a shared responsibility with the State Party on the candidature. From the academic field, the available information is analysed and areas that require a deeper knowledge are identified to ensure a rigorous fulfilment of the UNESCO requirements. In these processes of knowledge generation, social agents are incorporated from a double perspective:

- Acquiring scientific knowledge about the Cíes Islands, through an understandable and comprehensible language.
- Being an active part of the processes of generation of technical and scientific information that allow improving knowledge on the property.

The ultimate aim of this program is aligned with the goal of the Cíes Islands Candidature project: to bring to light the property’s value from the international recognition under the premise of the commitment to its preservation and conservation; something that is difficult to achieve without the implication of local people and a global understanding of its universal natural value.
In the Citizen Science Program: “Cíes Islands, Awakening Environmental Awareness”, several actions are designed to strengthen the candidacy. In particular, the Vigo City Council develops the Action "Scientific diving for the Characterization of Submarine Communities of the Cíes Islands", whose objective is to generate information of the benthic communities, that allows mapping the grounds at a high resolution, thereby exhaustively characterizing the biological communities inhabiting them.

**ACTION 1: CHARACTERIZATION OF SUBMARINE COMMUNITIES OF THE CÍES ISLANDS**

In the subtidal zone, four main types of grounds have been described in the seabed of this islands: rocky reefs, gravel beds, maërl substrates and sand (Kersting et al., 1999) (Figure 4).

Of these substrates, the rocky reef dominates the subtidal coverage of the archipelago, mainly on the west side. These grounds are distributed on the island of Martiño from Cabo dos Bicos, on the southeastern tip of the island to Punta da Bandería, at the north of the island (Figure 3). In turn, the rocky substratum of the Islands of Faro and Monteagudo, is distributed from Punta do Carracido, at the southern end of the island of Faro, to the Costa do Bufardo, on the eastern face of the Monteagudo island.

The rest of the coast is mainly made up of sand and mèarl banks. Although these grounds contain a significant wealth of species, the organisms of these substrates are dominated by endo-fauna (organisms that live buried in the substrate) and therefore their characterization requires an invasive sampling, that allows the collection of samples through corers or dredges and their subsequent analysis in the laboratory, with specific teams and personal with a consolidated experience in taxonomy.

![Figure 4. The main types of grounds described in the Cies islands: rocky reefs, gravel beds, maërl substrates and sand. Source: Vigo City Council](image-url)
The elaboration of this type of work requires a high level of scientific knowledge given the difficulties inherent to the reliable identification of the species. In addition, it represents an important effort in terms of workload and, consequently, its economic cost is very high. As consequence, the information available about the composition and distribution in the space of these communities is scarce. During the process of bibliographic compilation, the following references have been found focused on the characterization of grounds of the Islands: Acuña-Castroviejo et al. (1984), carried out several surveys to study the macrobenthos of the infralittoral rocky shore, of which, the coast of Cies Island was only used as a collection station for algae and invertebrates. This work was followed by the study carried out by Kesting et al, (1999), whose results provide information of the species and communities of the four characteristic habitats represented on the Cies Islands (sand, rock, gravel and maërl). Subsequently, Besteiro-Rodríguez, (2004) quantitatively studied the benthos of the rocky intertidal environment in isolated areas of the North Island of the Cies archipelago, as part of a study to evaluate the impacts of the "Prestige" oil spill. Sibaja-Cordero, & Troncoso, (2011), conducted a qualitative study of rocky benthos to assess the variability of organisms across the intertidal zone, comparing protected and exposed areas within the framework of the Cies. In turn, Ourens et al. (2010) provides a characterization of the benthic substrate types of the archipelago. This characterization, was elaborated from interviews held with the fishermen of the Rías of Vigo and Pontevedra. We have also found studies focused on specific communities, such as Peña & Bárbara (2007), who characterized the communities of the maërl grounds of the Cies Islands and García-Redondo et al., (2011) that provide a cartography of the seagrasses of the National Park of Atlantic Islands of Galicia. The characterization of the seabed of the islands through the citizen science system would, unlike the previous works, make a temporal (interannual) monitoring of the rocky areas at a high spatial resolution. Studies through direct observation allow "in situ" annotations in order to transpose with the greatest possible fidelity the characteristics of the grounds to the resulting cartographies, facilitating identification analysis of the digital images. With the added value of being able to involve citizens in an enjoyable field work of the scientific research, promoting environmental awareness in society.

Sampling design
The methodology of this programme has been scientifically designed, based on the existing information. The observation and sampling campaigns are planned according to the characteristics of the study area, selecting subareas to be covered in relation to their representativeness and the limitations of the temporality of the dives, with an inter-annual replication, which will allow to assess patterns of inter-annual variability. The campaigns are developed in a collaborative way, under the science-society formula. The participants, a total of 24 volunteers for each of the diving campaigns, had to prove the fulfillment of minimum training and experience requirements of diving skills, while attending at specific training on scientific methodology for data collection, thus ensuring skills and knowledge and the achievement of high quality results. The mapping of the subtidal macrobenthos will be carried out biannually, during several years. The first sampling campaign will be carried out in 2018, in winter and summer, so that the composition of the grounds is studied in the pre-recruitment and recruitment period.

The aim of this project, in the long-term perspective, is to obtain the coverage and seasonal pattern of the subtidal zonation of the rocky bottoms of the Cies, from the upper subtidal zone up to 25m of depth, at a spatial resolution of 500 m between transects (Figure 5).
The integration of the data collected is directly assumed by scientist from the University of Vigo, who, in collaboration with representatives of citizen volunteers, will elaborate a final report and an interactive ebook showing the characterization of the seabed ecosystems of the Cíes Island.

Therefore, the Citizens Science Program: “Cíes Islands, Awakening Environmental Awareness”, is presented as the distinguishing element of the Cíes Islands World Heritage Candidature, demonstrating that working within an open, collaborative and transversal scenario, where the interaction between science and citizens prevail, will undoubtedly benefit the conservation of the Cíes Islands.

6 Conclusions

The final product of the actions will be a book (ebook) of the submarine communities of the Cies. This publication will nominally recognize the work of volunteers.

The secondary results of this project are:

1. Improve the knowledge about the Cies Islands in a critical aspect to strengthen their candidacy to World Heritage: the cartography of the subtidal benthic communities of the archipelago.
2. Involve citizens in the generation of high quality research that result in an improvement of the knowledge of this natural space.
3. Generate a sufficient critical mass of young researchers involved in this natural space.
4. Communicate the knowledge generated to the general public.
REFERENCES


