CATALYZING OPPORTUNITIES FOR CITIZEN SCIENCE THROUGH iNaturalistGR

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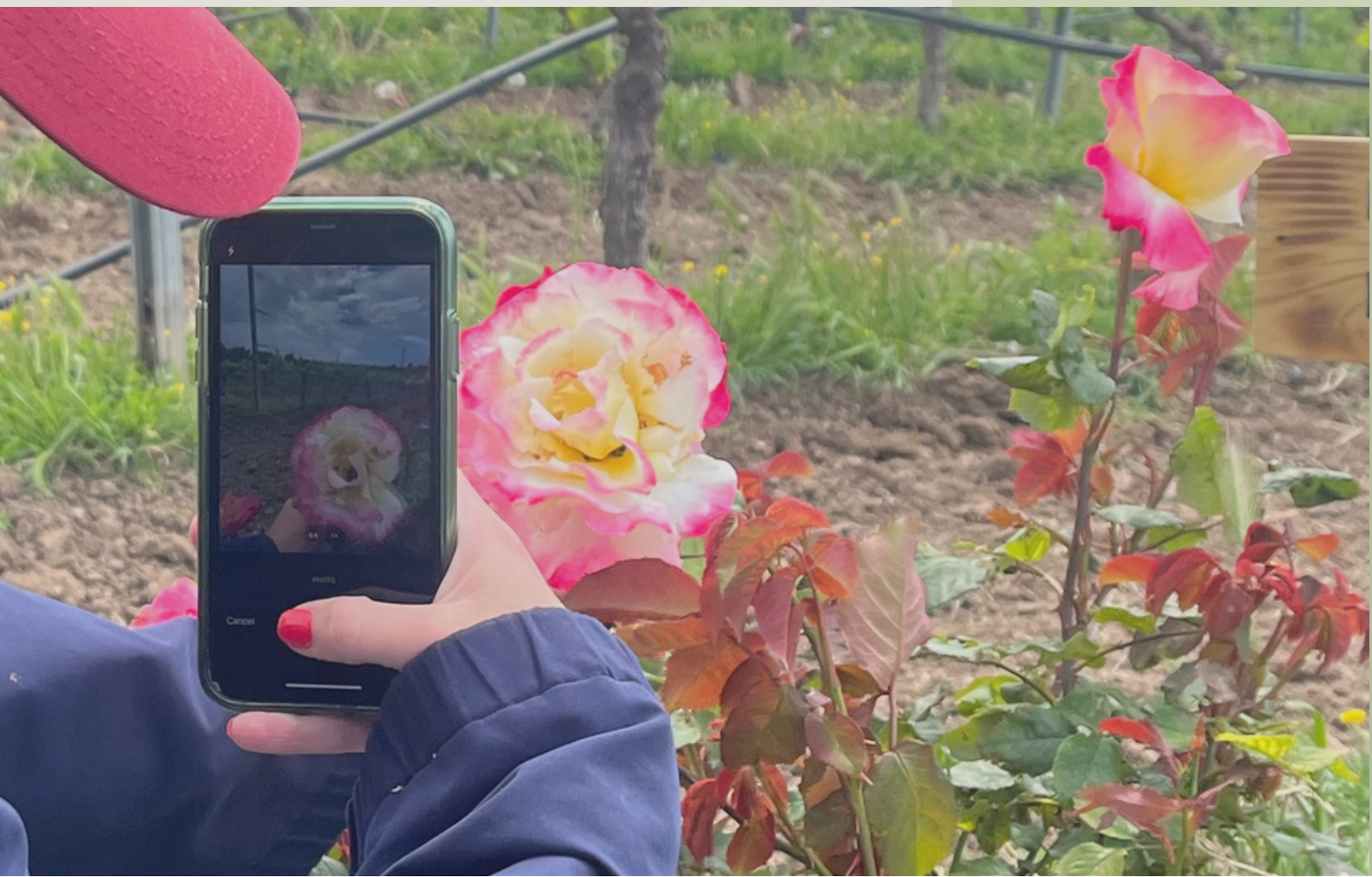Robert Hersh &
Darko Volkov

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CATALYZING OPPORTUNITIES FOR CITIZEN SCIENCE THROUGH INATURALIST

*An Interactive Qualifying Project
submitted to the Faculty of
Worcester Polytechnic Institute
in partial fulfillment of the
requirements for the degree of
Bachelor of Science*

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ABSTRACT

Protecting biodiversity is critical due to the ecosystem services it provides that are threatened by industrial impacts. Working with iSea, an ENGO in Greece, we sought to increase biodiversity monitoring through use of an online platform: iNaturalist. Our goal was to assess stakeholder interest in iNaturalist and identify how the application can enhance biodiversity monitoring initiatives. The team conducted interviews with iSea staff, NGOs, research institutions, educational programs, and designed educational activities with iNaturalist. From this research, we found that social interactions are imperative to citizen science success, the scientific community is hesitant about data reliability and propriety, and that iNaturalist has potential as a powerful active learning tool.

EXECUTIVE SUMMARY

Background

Biodiversity, the variability of all living things, is a critical aspect of life on Earth. Maintaining biodiversity is essential for the provision of ecosystem services such as food, water, and nutrient cycling. The Earth's changing climate, habitat loss and fragmentation due to human actions has led to disastrous effects on global ecosystems. It is estimated that 41% of amphibians, 27% of mammals, 13% of birds, and 21% of reptiles are under threat of extinction, a staggering 28% of all assessed species (The IUCN Red List of Threatened Species, 2022). Greece, a country known for its high level of biodiversity, is currently under siege as it becomes increasingly urbanized and agricultural practices intensify (Valavanidis, 2021).

The prospect of citizen science presents itself as a possible solution to the incessant need for a mass quantity of modern environmental data. Citizen science (CS) is the process of data collection conducted by the general public rather than professional scientists (CitizenScience.gov, 2023). iSea is one ENGO that has had a key role in promoting Greek citizen science, especially in the realm of marine biodiversity monitoring and conservation. The goal of iSea is to preserve and protect Greek biodiversity through raising environmental awareness, encouraging the adoption of sound protection policies, and promoting ecological scientific research (iSea, 2016). Our project aimed to assist iSea in promoting biodiversity monitoring throughout Greece using iNaturalist: a citizen science species-tracking application that is managed by iSea in collaboration with the Goulandris Natural History Museum.

Approach

The goal of our project was to assess stakeholder interest in iNaturalist and identify how biodiversity monitoring initiatives could be enhanced through the use of iNaturalist. We utilized a mixed-methods approach consisting of a variety of interviews as well as creating and user testing educational materials to achieve this goal. The objectives of this project were as follows:

- Examine iSea's past citizen science projects to identify strategies that can be implemented in future iNaturalist-based initiatives to increase success.
- Develop iNaturalist training and educational materials and evaluate opinions on these materials from the public and conservation entities.
- Identify a diverse set of interested organizations that could incorporate iNaturalist into their operations to expand the biodiversity monitoring network in Greece.
- Determine how iNaturalist can be incorporated into these Greek organizations' projects.
- Evaluate how beneficial iNaturalist is to educational institutions in practice through case studies.

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We conducted interviews with iSea staff and researched their past citizen science initiatives. We were also able to conduct a handful of interviews and determine the interest of NGOs and research institutions. A qualitative survey was sent to the top iNaturalist users in the world to gain user-feedback. Finally, case studies on selected education institutions were conducted to determine the compatibility and feasibility of the implementation of iNaturalist. Several deliverables were produced and tested, including flyers, a pamphlet, and an iNaturalist-based game.

Results

Social interaction fosters more participation in citizen science

Through interviewing six iSea staff with roles in planning and maintaining the NGO's citizen science initiatives, we developed a detailed understanding on the strengths and weaknesses of their past efforts. Interacting with end users to develop connections and sense of trust helped to decrease user hesitations and increase project participation. Furthermore, attention to end users strengthened their relationship to iSea and encouraged long-term participation. These findings confirm the importance of social connections in facilitating successful citizen science projects.

iNaturalist presents both superior data organization and social capabilities

iSea has experience with several platforms for users to record citizen science observations, one of which is custom-made Facebook groups. Facebook proved to be user-friendly and excellent in facilitating social interaction among users, but is limited by its informal nature. For iSea's MECO project, an outside software titled SEAlly was used. SEAlly required less administrative efforts to record data than Facebook, however, it significantly lacked a social component as observations were not available for public viewing, comments, or peer reviews. iNaturalist presents itself as a middle ground between the two data collection formats, offering superior data organization while fostering social interaction between observers.

iNaturalist users appreciate the inclusive, extensive database and social aspects

To gain an understanding of what features of iNaturalist were valued the most, we asked the application's top ten users in the world for their opinions. The most frequently mentioned aspect is that it is an extensive dataset, where information can be collected about various species, not just one taxon. Also highly valued is the ability to receive feedback about identifications and

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correct others. When asked specifically about the social aspect of iNaturalist, the majority of the respondents had a positive reaction, with an overall appreciation of the focused conversation topics and safe community guidelines iNaturalist provides.

Revisions on the pamphlet were needed to clearly communicate how to use iNaturalist

The pamphlet we made and had translated into Greek by Sofia Litsiou for general iNaturalist instruction was tested by residents of Greece for how effectively it communicated how to use the application. Through this activity, we found that the participants, after downloading the app on their mobile phones, did not realize initially that they should make an account or how to access the AI feature. It was also brought to our attention that the screenshots of the app that we included in our materials were not very useful for those who did not speak English. Our conversations revealed that the pamphlet served its purpose of communicating instructions, but was revised according to the aforementioned feedback.

The scientific community is hesitant about using citizen science data

We conducted two key informant interviews to explore how researchers at Arcturos and professors in the Biology department of Aristotle University of Thessaloniki (AUTH) regard citizen science

and the iNaturalist platform. A distrust of data collected through citizen science was reported in both interviews as they are currently not considered accurate by Greek researchers, mostly because of concerns regarding false or inaccurate observations. Another main concern with the usage of such platforms is that the data collected on applications such as iNaturalist is freely available to any user and is therefore not proprietary.

Advancing AFS Middle School curriculums with iNaturalist

While assessing iNaturalist interest in schools and educational centers, we found one of the most prominent engagement features of iNaturalist is its ability to be used actively in the classroom on a digital device. Our team conducted a debrief with Despoina Avramidou: one of the biology and STEM teachers present during the presentation. We learned that Avramidou is interested in organizing a school hiking field trip to a nature park that combines species identification so students can learn more about biodiversity. Similarly, she expressed interest in creating an environmental biology club for middle schoolers to learn more about topics that are not extensively covered in the Greek national curriculum.

An iNaturalist-based game engages students in city nature

Our team accompanied the Environmental Education Centre on two of their educational city tours to test the interactive nature game that we designed.

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During the game, we found that the challenge aspect of obtaining the most points on the worksheet made the children excited to record the most observations on iNaturalist. Each of the groups were given an opportunity to share what they learned about the nature in their city where multiple groups informed us that they do not usually take notice of the greenery in the city because of the various distractions that come with living in an urban environment.

Recommendations

We recommend that iSea highlights the social capabilities of iNaturalist as a focal point of their public marketing strategies in addition to interacting with users to foster participation.

In order for citizen science platforms to be used more frequently, it is important for the Greek scientific community to understand how reliable the data is and the limitations regarding citizen science. We recommend conducting a study using Greek volunteers to evaluate how much of the data collected using iNaturalist is unreliable and factors that increase and decrease quality of observations.

A discovery that was made during the interview at the Aristotle University of Thessaloniki was the creation of a new citizen science hub for students. As this hub may be a step towards a greater acceptance of citizen science in the scientific community, we recommend that iSea follows updates on this organization's progress and events. Pursuing a collaboration with the citizen science hub at AUTH could easily aid in the expansion of iNaturalist users and mutually support their goal of encouraging citizen science.

From the interview with an AFS faculty member, it was determined that an avenue for iNaturalist use that has been previously unexplored is within the agricultural sector. We recommend that efforts be made to reach out to members of the community to inform them of the potential benefit of using iNaturalist for weed and pest identification, as it offers a free and simple avenue to do so.

The education sector holds many opportunities for citizen science to be used as a learning tool. As seen in our findings from the EEC tour, student engagement soars when a game element is used in learning. We encourage iSea to take advantage of our iNaturalist-based game as well as the relationship we created with the EEC. There are a number of other educational centers and public schools throughout Greece, and the EEC may have the ability to distribute game worksheets to these organizations.

Due to the educational value of iNaturalist seen by this teacher, we recommend that an environmental biology club as well as planned outdoor excursions be implemented in AFS so students have the ability to utilize the application with teacher supervision. We believe that iNaturalist's educational value should be recognized by schools throughout Greece; we encourage iSea to continue reaching out to educational institutions for its further implementation.

ACKNOWLEDGEMENTS

MEET THE TEAM

Kenneth Niemiec is a third-year mechanical engineering major with hopes to work in thermal-fluid engineering.

Kyra Robinson is a third-year Biology and Biotechnology major who hopes to work in cellular and molecular research.

Clare Nargi is a third-year Biology and Biotechnology major with aspirations of working in the pharmaceutical industry.

Alana Lue Chee Lip is a third-year Biology and Biotechnology major who hopes to work in microbiology research.

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Engage students using an iNaturalist-based game	Clare
Expand the use of iNaturalist Through after-school activities	Clare
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Although primary authors are listed for each section, our team extensively collaborated in creating this report. All interviews, field work, and research activities were conducted jointly, as well as the analysis of results. Additionally, all members took responsibility in reviewing and editing the writing of their three partners. Dividing the authorship of particular sections allowed us to work efficiently in drafting our paper. Each member provided their unique thoughts and knowledge throughout the project, while contributing an equal amount of effort and prioritizing teamwork.

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1. INTRODUCTION

Biodiversity, the variability of all living things, is a critical aspect of life on Earth. Maintaining biodiversity is essential for the provision of ecosystem services such as food, water, and nutrient cycling. The Earth's changing climate, habitat loss and fragmentation due to human actions has led to disastrous effects on global ecosystems. It is estimated that 41% of amphibians, 27% of mammals, 13% of birds, and 21% of reptiles are under threat of extinction - a staggering 28% of all assessed species (The IUCN Red List of Threatened Species, 2022). These human action issues are prevalent in Greece, a country known for its high level of biodiversity, which is currently under siege as the region becomes increasingly urbanized and agricultural practices intensify (Valavanidis, 2021).

iSea is a Greek environmental non-governmental organization with the goal of preserving and protecting Greek biodiversity through raising environmental awareness, encouraging the adoption of sound protection policies, and promoting ecological scientific research (iSea, 2016). Our project will assist iSea in promoting biodiversity monitoring throughout the region using iNaturalist: a citizen science species-tracking application that is managed by iSea in collaboration with the Goulandris Natural History Museum.

The goal of our project was to assess stakeholder interest in iNaturalist and identify how biodiversity monitoring initiatives can be enhanced through the use of iNaturalist. Through this we supported iSea's goal of using iNaturalist to increase the scope of biodiversity monitoring in Greece. The objectives of this project can be seen on the right.

We conducted interviews with iSea staff and researched their past citizen science initiatives. We were also able to conduct a handful of interviews and determine the interest of NGOs and research institutions. A qualitative survey was sent to the top iNaturalist users in the world to gain user-feedback. Finally, case studies on selected education institutions were conducted to determine the compatibility and feasibility of the implementation of iNaturalist. Several deliverables were produced and tested, including flyers, a pamphlet, and an iNaturalist-based game.

OBJECTIVES

- Examine iSea's past citizen science projects to identify strategies that can be implemented in future iNaturalist-based initiatives to increase success.

- Develop iNaturalist training and educational materials and evaluate opinions on these materials from the public and conservation entities.

- Identify a diverse set of interested organizations that could incorporate iNaturalist into their operations to expand the biodiversity monitoring network in Greece.

- Determine how iNaturalist can be incorporated into these Greek organizations' projects and identify common characteristics in compatible entities.

- Evaluate how beneficial iNaturalist is to conservation organizations in practice through case studies.

2. EXPLORING BIODIVERSITY & CITIZEN SCIENCE IN GREECE

2.1 An Introduction to Biodiversity

A critical aspect of life on Earth is biodiversity, the variability of all living things. This diversity can be ecological, organismal, or genetic, but in all ways it is crucial. Ecological diversity encompasses all habitats, ecosystems, and biomes that support different lifeforms. Organismal diversity refers to all the various taxonomic groups, from prokaryotic bacteria to large mammals. Genetic diversity is the individual genetic differences across a species. Together, biodiversity creates rich and stable communities of organisms while also providing ecosystem services to the humans that rely on them, such as purified air and water, nutrient recycling, food, medicine, and more (Sodhi and Ehrlich, 2010). The delicate relationship we have with nature is dependent on the preservation of biodiversity.

The maintenance of biodiversity is essential for the provision of essential ecosystem services. A key player in the continual production of ecosystem services is pollinators, specifically bees. Pollinators have important roles in the growth and health of both wild plants and agricultural crops. The predominant pollinator that enhances production in agriculture is the honey bee, which increases the yield in 96% of animal-pollinated crops. However, domestic honey bee stocks have declined 59% in the USA (from 1947 to 2005) and 25% in Europe (from 1985 to 2005). There are thought to be several drivers of this loss that can ultimately be grouped into environmental stressors (habitat loss, climate change, pesticides, etc.),

pests and pathogens, and a lack of genetic diversity. These factors work synergistically, not independently. For example, fragmentation of wild populations decreases genetic diversity, which then makes these populations more susceptible to pathogens. The issue of pollinator decline also creates a positive feedback loop where there is then a decline in wild plant populations, further impacting pollinators as their resources are depleted. Not only is this environmental balance disturbed, but so is agriculture, as 75% of all crops worldwide are dependent on pollinators. This presents a clear economic risk and emphasizes the need for protection programs to ensure pollination services remain to support biodiversity and its ecosystem services (Potts et al., 2010). The example of pollinators is just one of many that exemplify the current biodiversity crisis. It has been put forward that the world is rapidly approaching a sixth mass extinction, however, unlike other mass extinction events, this will not be caused by environmental factors, but by human actions (May, 2011). The main driver for biodiversity loss is land use change, mainly for human agriculture, which is estimated to be responsible for 30% of global biodiversity decline. This is followed by overexploitation of nature, climate change, pollution, and invasive species (Royal Society, n.d.). These factors have led to a sharp increase in the extinction rates of species across the globe (see Figure 1) that is predicted to continue increasing unless drastic actions are taken to reduce humanity's further deleterious impact on the planet and its ecosystems.

Accelerating Biodiversity Loss in Greece

Greece is a diverse country with 6,600 taxa of flora, 23,130 animal species and 3,500 species of marine animals that were recorded in 2014 (National Biodiversity Strategy & Action Plan, 2014). A great number of these species, however, are under threat of extinction due to the
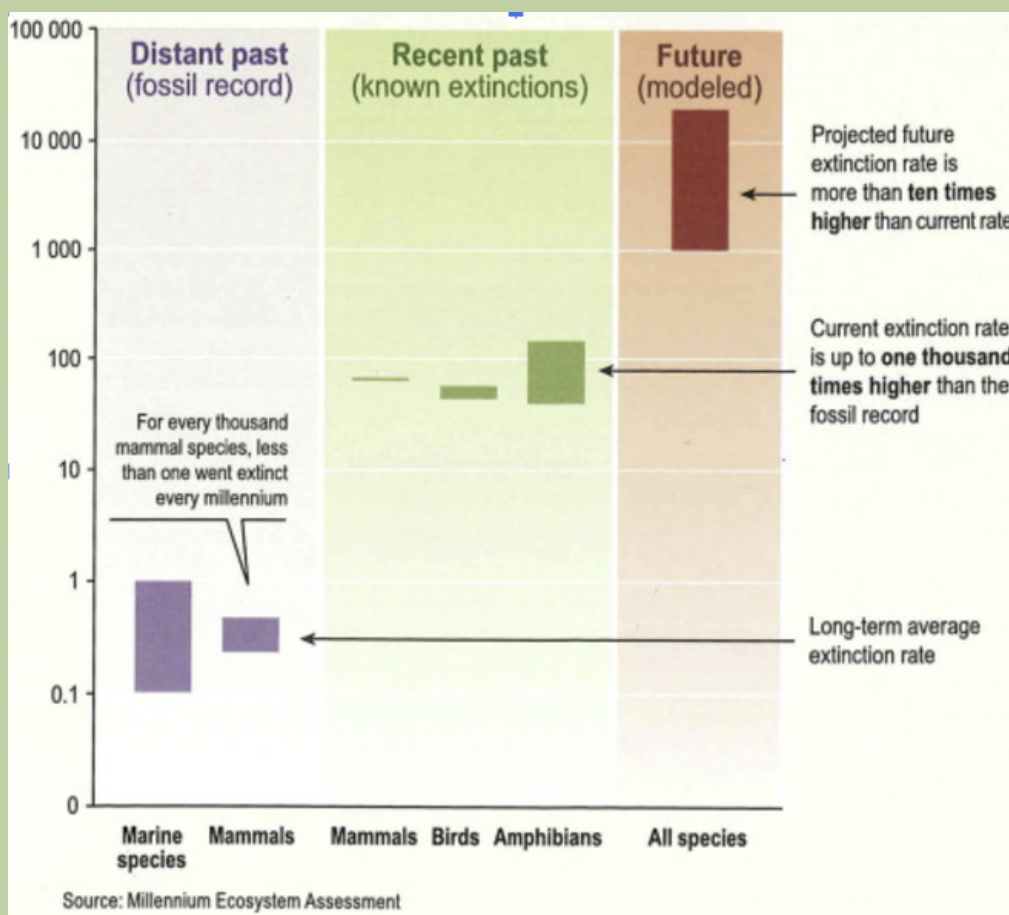
Figure 1. The base extinction rate in the distant past, near past/present, and projected future (May, 2011).

pressures Greek ecosystems are facing, such as intensifying agricultural practices and rapid urbanization (Valavanidis, 2021). The Convention of Biological Diversity (CBD) also lists unsustainable production practices, climate change, pollution, and invasive species as pivotal factors in biodiversity loss in Greece. An underlying cause of this issue is the lack of knowledge on biodiversity trends in Greece. This is mainly due to the poor implementation and maintenance of conservation efforts and sustainability programs, such as species and habitat monitoring or the integration of environmental considerations into the national policy framework, which ultimately stem from administrative delays and a lack of financing (CBD 5th National Report of Greece, 2016). As outlined in Greece's 2007 National Strategic Reference Framework (NSRF), a major existing conservation effort that needs to be acted upon is the strengthening of the participatory process of the public regarding the importance of biodiversity for the quality of life (NSRF, 2007). The Greek economic crisis and austerity measures have made it increasingly hard for environmental measures to be accepted by Greek citizens. For example, there are limited employment opportunities for individuals who reside near protected areas due to the vast area they take up– ultimately creating a negative connotation associated with legislative conservation and environmental protection (CBD 5th National Report of Greece, 2016). An inability to correct this biodiversity loss could lead to negative human health impacts, changes in local migration patterns, and loss in ecosystem services (World Health Organization, 2015).

In a study done by Kougioumoutzis, a professor of Biodiversity and Endemism, as shown in Figure 2, Greece was mapped in terms of endemic species richness in an area weighted by the number of species that have a narrow range size,
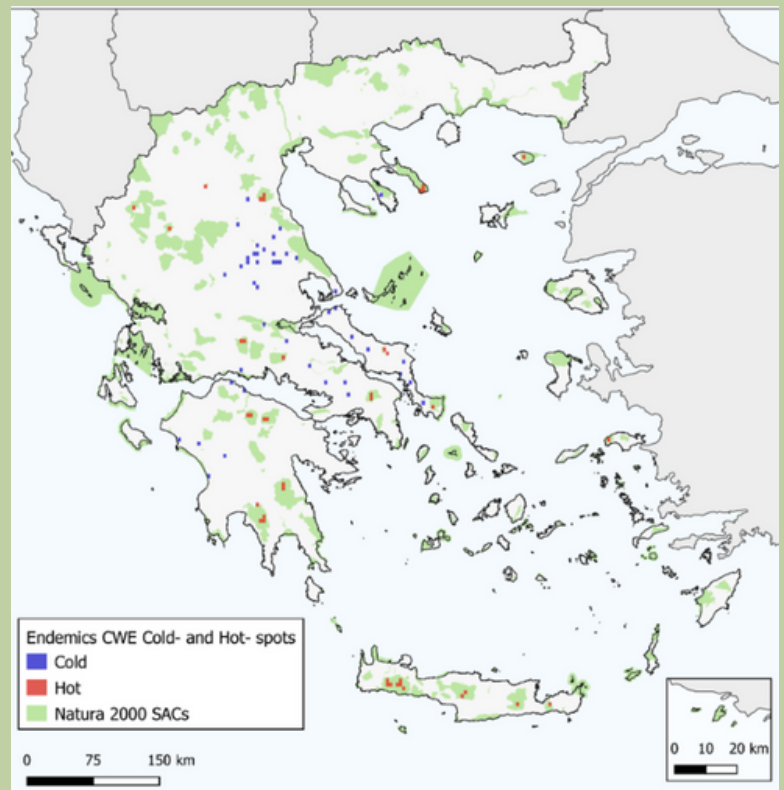
Figure 2. Mapping of species richness in Greece (Kougioumoutzis et al., 2021)

indicating higher demand for conservation. This data allowed them to highlight biodiversity hotspots, affirming that Crete had the highest number of endemic species, with the runner-ups being located in the Greek Mountains and Aegean Islands. This map allowed for an increase in identification of important areas for conservation, as well as confirmed interest in regions that have already been designated as priority areas (Kougioumoutzis et al., 2021).

2.2 Greek Attitudes Toward the Environment

According to a survey in 2004, Greeks value the environment to an extent that surpasses other surrounding countries (Korfiatis et al., 2004). Konstantinos Korfiatis, an associate professor at the University of Cyprus, conducted a study to examine attitudes toward the environment in five European countries: Greece, Bulgaria, Romania, Ukraine and

Georgia. Of these five countries, "on average, the Greek subsample expressed the most environmentally friendly dispositions"(Korfiatis et al., 2004). In regards to ecological policies, Greece received the highest scores by a significant amount in both "local frame of reference" and "global frame of reference" scales. This indicates that Greek individuals respond well to environmental policies that dictate everyday life and the future of the Earth as a whole. The Greek subsample received the highest scores on the "active ecological behavior scale", which suggests they are more apt to active and involved environmental citizenship (Korfiatis et al., 2004). The Greek public's appreciation of the environment can further be supported by Kolimenakis, a public health expert who works with international health organizations. He examined the importance of urban green areas across Greece and found that they are highly valued by residents. A subset was even willing to accept an increase in taxes dedicated to creating green areas when the purpose was for environmental conservation or to combat climate change (Kolimenakis et al., 2022). ccording to research, Greeks support environmental policies and appreciate green spaces in urban areas (Korfiatis et al., 2004; Kolimenakis et al., 2022). The marine environment is an especially well-appreciated realm, with Greeks acknowledging the important ecosystem services, intrinsic existence, and bequest values (Gkargkavouzi et al., 2019; Gkargkavouzi et al., 2020; Halkos and Matsiori, 2017). They also recognized threats to marine biodiversity such as pollution, climate change, and farming (Gkargkavouzi et al., 2019; Gkargkavouzi et al., 2020). However, this appreciation of the environment does not directly translate to participation in environmental activism, such as citizen science.

2.3 Introduction to Citizen Science

As the mass threat to the planet's biodiversity and ecosystems continues to grow, the demand for data collection and research of our natural environment compounds with every passing year. The prospect of citizen science presents itself as a possible solution to the incessant need for a mass quantity of modern environmental data. Citizen science (CS) is the process of data collection completed by the general public rather than professional scientists (CitizenScience.gov, 2023). The method has grown increasingly popular with researchers since the term's coinage in 1995. Data collected via citizen science efforts has steadily translated into publishable research over the past few years (Gura, 2013). There are both advantages and disadvantages to the use of citizen science as a formal data collection tool.

Benefits of citizen science

Encouraging members of the public to collect valuable data points brings about numerous benefits for the scientific and local community. Citizen science amplifies the results obtained from traditional environmental research as there is a much larger pool of observations on the conditions of specific ecosystems. The resultant database will thus be better developed and have a multitude more data points than a small team of researchers would be capable of collecting. Additionally, getting the public involved in the process of conservation increases local knowledge and awareness of ongoing environmental issues. Thus making citizens more likely to support and follow policies for the purpose of environmental management and conservation (CitizenScience.gov, 2023).

Joachim Langeneck, a professor of biology at the University of Pisa, analyzed the impacts of using citizen science as a data collection method for tracking the expansion and distribution of certain aquatic species in the Mediterranean Sea. He notes a particular invasive fish species, L. argentimaculatus, commonly known as the mangrove snapper, went virtually undetected by professional fishery studies conducting species tracking in the Mediterranean. However, through citizen science initiatives, the species has been identified on several occasions in photographs submitted by divers and fishermen (Langeneck et al., 2022).Academic researchers did not encounter these species due to the low population density of the species and resource constraints, but hundreds of marine workers or enthusiasts had the opportunity to randomly encounter this species and the ability to record an observation.

Having a large pool of observers in citizen science initiatives makes CS an especially powerful tool for identifying outlier species within a particular area. As an example, a CS project based on investigating the spread of alien mollusk species within the Mediterranean has proved immensely effective at quickly identifying invasive species. Out of "...the 43 validated marine alien Mollusca in Greece, it appears that only 12 (~ 28%) taxa have been found during formal research projects or by institutional researchers, whilst the remaining 31 (~ 72%) Mollusca have been first found by amateurs" (Crocetta et al., 2017, p. 428). Invasive species often start at low population levels and researchers begin thorough examination for these species when they are already identified as a possible threat (Crocetta et al., 2017). By facilitating data sharing with SCUBA divers, fishers, underwater photographers, and other marine based individuals, potential threats can be recognized on a much shorter time line than traditional research methods.

Limitations of citizen science

Although an extensively developed data set is helpful for analysis of modern conditions, academic researchers have argued that data from citizen science initiatives may be of low quality and lack accuracy. Many CS initiatives operate with no minimum requirement of training or knowledge to submit observations as these requirements may act as de-motivating factors, intimidating potential participants, and decreasing the pool of potential observers (Rotman et al., 2014).

Allowing members of the public to record data, however, brings a significant margin of error as it opens up the possibilities for misidentification, improper data, and incorrect location reporting. As an example, the above-mentioned CS efforts tracking

invasive mollusk species have seen a multitude of misidentification and report inflation. Some tourists who have little knowledge of local ecosystems and species have shown eagerness to record CS observations on their travels (Crocetta et al., 2017). The result is misidentification of shells, with individuals inaccurately reporting mollusks as ones they recognize from their home ecosystem, thus creating several false reports of present alien species (Crocetta et al., 2017).

Report inflation, the other issue occurring in the above study, occurs when multiple observations are submitted about the same specimen. The unfortunate result is that the population of that given species in an area is vastly overestimated (Crocetta et al., 2017). There exist methods to correct this inflation, such as eBird, an avian citizen science program, having a maximum number of reports for every species in a given region. The program is more focused on tracking alien or outlier species distribution, so imposing this maximum helps prevent an overinflation of reports on native species (Wood et al., 2011). Additionally, efforts such as peer-review systems among users and AI processes are being implemented into many softwares, such as eBird, to increase data quality by recognizing and removing misidentifications, while also praising high accuracy submissions. However, although there are methods to try to minimize the impact, errors in reporting such as misidentification and improper data greatly reduce the quality of citizen science results, causing researcher's initial hesitations of CS.

Another notable drawback to implementing an effective citizen science program is the financial and time requirements. A large staff is necessary to establish a citizen science initiative, to develop the project, support participants, and program softwares. The Cornell Lab of Ornithology notes that its citizen science

budget exceeds one million dollars every year to keep their programs running (Bonney et al., 2009). Bonney, Cornell's director of the public engagement in science programs and co-founder of the international Citizen Science Association, qualifies this drawback however, highlighting that once the institutional and computer infrastructure is fully initialized, the project proves more cost effective for the amount of data collected compared to professional data collection. Additionally, new projects can often reuse planning and programming from previous ventures, creating diminishing required costs as more citizen science initiatives are created within an organization.

Motivators for participation in citizen science

Much research has been done on the best ways to motivate people to participate in volunteer initiatives such as citizen science projects. Most scientific organizations base the promotion of their CS activities on the Information Deficit model, which assumes that humans are largely rational and filling deficits in public understanding on a topic will drastically alter their actions. For example, this mode of thinking suggests that the solution to vaccine hesitancy is to provide parents with information on vaccines, thus overcoming their lack of understanding so that they will make the rational decision to vaccinate their children. However, this strategy of providing the public with sound scientific findings has been found to be insufficient in generating action.

Christiano and Neimand (2017, 2018), researchers at the University of Florida's Center for Public Interest Communications, represent the sharply contrasting opinion that simply raising awareness of a project is not enough to incite action. They propose that maximizing community engagement hinges on understanding the

community values, appealing to these values with a combination of facts and emotional appeals and, most importantly, providing actionable steps for them to complete once they have become invested in the cause (Ann Christiano & Annie Neimand, 2018).

In terms of environmental initiatives, Niemiller et al. (2021) posit that current low levels of individual participation in environmental citizen science (ECS) projects is partially due to 'biodiversity naivety', which they define as "the lack of experience and awareness regarding the identification and importance of life on the planet" (p. 2) due to decreasing access to natural spaces caused by increasing urbanization. Many researchers have concluded that this biodiversity naivety prevents people from developing close

personal connections to nature which in turn result in an inability to perceive the value of biodiversity and conservation activities (Bonney et al., 2016; Dickinson et al., 2012; Novacek, 2008).

The research of motivators that drive participation in CS projects are often categorized in terms of affecting initial or long-term participation (see Table 1). A main factor that has been identified as promoting initial participation is the perceived benefit of the social interactions involved in CS projects (Van Der Berg et al., 2009; Newman et al. 2012), while long-term volunteer retention is commonly attributed to publicly recognizing the contributions of participants and allowing volunteers the opportunity to manipulate and compare the data that has been collected (Bonney et al., 2009; Rotman et al., 2012).

Motivator	Aspect of participation affected by motivator		Sources
	Initial participation	Long-term engagement	
Allowing volunteers to manipulate the data collected	✗	✓	Bonney et al. (2009)
Allowing volunteers to compare results among themselves	✗	✓	Bonney et al. (2009)
Recognizing the contributions of volunteers to the project	✗	✓	Rotman et al. (2012)
Social interactions connected to participation	✓	✗	Van Den Berg et al. (2009); Newman et al. (2012)

Table 1: Motivators for participation in CS.

2.4 Citizen Science in Greece

Citizen science in Greece is still in its infancy when compared to other countries. However, that does not mean that it is nonexistent, Galanos and Vogiatzakis (2022) identified over 100 citizen science (CS) projects in the country, most of which were concerned with biodiversity and the environment. This is not surprising since Greece has a large number of endemic species (that is, species that are only found in one country) and its citizens tend to have a favorable attitude towards the environment (Georghiou and Delipetrou, 2010). Of these environmental citizen science (ECS) projects identified by Galanos and Vogiatzakis (2022), the majority were run by environmental non-governmental organizations (ENGOs). Galanos and Vogiatzakis (2022) posit that this could be due in part to the recent economic crisis in Greece that forced the national environmental administration to limit their spending, which in turn decreases the funding that can be put towards environmental surveillance programs hosted by governmental organizations. Thus, ENGOs have set out to fill this void.

Encouragingly, the number of European CS projects with Greek participants is currently increasing, which further suggests that CS is becoming more prevalent in Greece (Galanos and Vogiatzakis, 2022). Galanos and Vogiazakis' (2022) survey of key stakeholders in Greek ECS initiatives (including scientists, public servants whose occupations related to conservation, and ENGO employees) determined that the majority (65.2%) of such stakeholders are familiar with the concept of citizen science, with 41.6% recognizing the term "citizen science" in particular. Interestingly, they found that Greeks are more familiar with citizen science being referred to as "public participation in scientific research" or PPSR.

iSea's role in developing Greek citizen science

iSea is one ENGO that has had a key role in promoting Greek citizen science, especially in the realm of marine biodiversity monitoring and conservation. The organization was founded in 2016 in Thessaloniki with the goal of "preserving the aquatic habitats, including the fauna and flora, which inhabit them through research, raising awareness and the promotion of conservation policies" (iSea, 2016). This mission is especially important as there are currently large gaps in knowledge regarding marine bioinvasions (such as the introduction of invasive species) in the Mediterranean, which is one of the most impacted regions (Giovos et al., 2019).

iSea's first large-scale CS project, called "Is it Alien to you? Share it!!!" was launched in May 2016. Its main objective was to "collect information on the occurrence, distribution, and expansion of marine NIS [non-indigenous species] in Greece and Cyprus" (iSea, 2016). This first-of-its-kind large-scale CS initiative aims to disseminate information to participants as well as the general public about NIS (iSea, 2016). Since its inception, it has facilitated the gathering of vast amounts of data that have allowed researchers to identify several novel NIS in addition to filling gaps in the knowledge of species distribution in the region (Giovos et al., 2019; Kaminas et al., 2022; Langeneck et al., 2022).

iSea's second CS project was similarly successful. Beginning in July of 2017, its "Sharks and Rays in Greece and Cyprus" initiative began collecting data on sharks and rays in the region using Facebook, iNaturalist, and a proprietary app called SeaAlly as avenues to receive photographic

submissions from volunteers. It has since been a valuable tool for researchers interested in the occurrence and distribution of these organisms in the Mediterranean (iSea, 2016).

Limitations of citizen science development in Greece

As discussed above, on a global scale the most commonly cited concern regarding CS projects is that volunteers will not always produce reliable data that can be used to draw accurate results and possibly be used as the foundation for scientific publications (Alabri & Hunter, 2010; Dickinson et al., 2010; Leocadio et al., 2021; Riesch & Potter, 2014).

Galanos and Vogiatzakis (2022) found that, contrary to this common concern, key stakeholders in Greek ECS projects generally believed that citizens are capable of collecting accurate environmental data, provided that they received adequate training beforehand. However, there are a number other obstacles to the development of CS in the region that have been identified by researchers (Burgess et al., 2017; Galanos and Vogiatzakis, 2022; Lyberaki and Paraskevopoulos, 2002; Riesch and Potter, 2014). These include:

- Lack of cooperation culture.
- Lack of trust between Greek citizens and institutions.
- Ignorance about the existence of citizen science.
- Uncertainty regarding implementation of citizen science.
- Lack of incentives for volunteers and institutions.
- Fears that data gathered by citizen scientists will not be well-received by professional scientists.

2.5 Introduction to iNaturalist

Our sponsor throughout this project is the environmental NGO, iSea, mentioned in section 2.4. iSea recently began to manage the Greek portal of iNaturalist– an unstructured citizen science platform in which volunteers can upload observations of species digitally to aid in biodiversity monitoring. The photos or recordings uploaded are then identified using a community identification process (Callaghan et al., 2021). This process allows observations on iNaturalist to move up a quality scale when the identification of an upload is confirmed by multiple members. The highest quality grade that can be obtained is known as "research grade" (Arazy and Malkinson, 2021).

iNaturalist as an interactive activity for biodiversity research

iNaturalist is used as an educational tool for monitoring biodiversity around the world. Many schools and universities implement the CS platform into biology course curriculums as an active learning exercise. Shem Unger, a professor from the biology department at Wingate University, led a study in which undergraduate students participated in aquatic and terrestrial activities to identify different species using iNaturalist (Unger et al., 2020). During this study, students found that iNaturalist successfully validated the identification of specific organisms, such as the trees and insects they encountered, and further stimulated the students' interest in nature (Unger et al., 2020). Similarly, a secondary school in Navarre, Spain developed an outdoor field activity for biology students which incorporated species tracking using iNaturalist (Echeverria, 2021). After the activity, the Navarre students filled out a questionnaire which highlighted positive aspects of iNaturalist: innovation, technology in
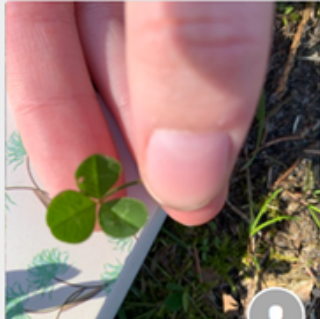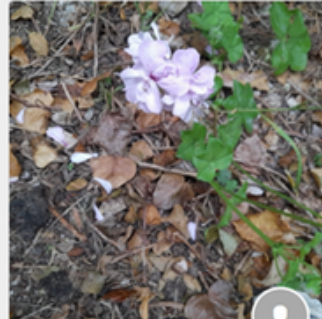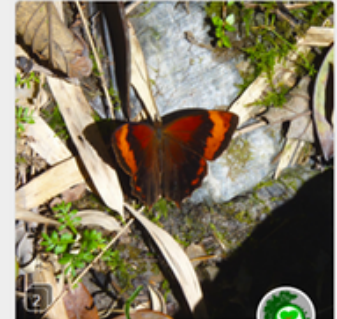
Figure 3. iNaturalist's global observation totals (iNaturalist, 2023)

education, use of investigation, and interactivity (Echeverria, 2021).

iNaturalist also acts as a social network for amateur and expert naturalists from all across the world; users are connected through their passion for biodiversity and conservation efforts. The bio-tracking application allows individuals to form a stronger connection with nature as the species mapping tools enhance their knowledge and everyday nature practices (Altrudi, 2020).

Since 2007, there has been a 12-fold increase in species occurrence records in the Global Biodiversity Information Facility, an international biodiversity organization that assists in data tracking. A large part of this increase is attributed to growing citizen science platforms such as iNaturalist, which has over 133 million species observations to date (see Figure 3) (Heberling et al., 2020). Professionals in global ecology from the University of Florida, state in a 2022 research article that if individuals invest merely 30 minutes per month to iNaturalist, the understanding of biodiversity can be improved substantially (Callaghan, 2022).

Case studies associated with iNaturalist

Maria Aristeidou from the Institute of Educational Technology used variations of data analytics, visualizations, and correlations to assess iNaturalist activity among children and adolescents over the span of approximately six years (Aristeidou, 2021). Aristeidou concluded that there was asymmetric participation among the young participants as the majority had merely one or two contributing days on the application. As referenced by Aristeidou, her previous article from 2017 eludes that the design factor of iNaturalist explains the lack of systemic contribution, for iNaturalist requires its users to spend time outdoors which raises questions on individual's preference and availability when engaging in a citizen science activity. This study found that young volunteers who have more active days possess a higher average daily contribution to iNaturalist observations. It was recommended that researchers explore new strategies for improved engagement of young people in online citizen science applications– such

such as the Bowser et al's (2013) CS project (as referenced in Aristeidou, 2021) which introduced game elements into an online application for entertainment purposes. iNaturalist has the correct framework and motive to be a popular educational tool for children and adolescents, but lacks the engagement element that young people need to stay entertained. With that being said, it is recommended that future online CS studies combat low participation by analyzing the target audience's behavior and retention span to fit their personal preferences in application and project design (Aristeidou, 2021).

iSea and iNaturalist

iSea is hoping to connect with other environmental organizations, biology and environmental science departments at local universities, and science museums in the area to gauge interest in using iNaturalist for possible citizen science projects and/or for its immense biodiversity tracking data that can be used for research purposes. iSea uses iNaturalist for its project-collaboration features as iNaturalist allows individuals to create and join projects. These projects may focus on a specific species that a community of people have a shared interest in monitoring its global global recognition sites. Specifically, iSea created a project– known as the Prosfero Project– on iNaturalist that aims to record the marine biodiversity found at their regularly scheduled beach-clean ups that take place all over Greece. The focus of Prosfero is for iSea to better understand which organisms are inhabiting polluted areas and the impact that these conditions are having on the species. Another project that iSea has created on iNaturalist is an extent of their "Is it Alien to you? Share it!!!" project as mentioned in section 2.4– this project was first started as a Facebook community group for monitoring invasive

species in the Thermic Gulf region, but transitioned to an iNaturalist project for its additional benefits of species recognition tools and vast species-tracking database.

Assessing the use of iNaturalist by organizations in varying sectors may help us identify how biodiversity monitoring initiatives can be enhanced through increased citizen science engagement. In order to fill the research gap of how iNaturalist can be used to increase the scope of biodiversity monitoring in Greece, our team mapped out the approaches we deemed necessary in section 3.

3. OUR APPROACH

The goal of our project was to assess stakeholder interest in iNaturalist and identify how biodiversity monitoring initiatives could be enhanced through the use of iNaturalist. We utilized a mixed-methods approach consisting of a variety of interviews as well as creating and user testing educational materials to achieve this goal.

OBJECTIVES

- Examine iSea's past citizen science projects to identify strategies that can be implemented in future iNaturalist-based initiatives to increase success.

- Develop iNaturalist training and educational materials and evaluate opinions on these materials from the public and conservation entities.

- Identify a diverse set of interested organizations that could incorporate iNaturalist into their operations to expand the biodiversity monitoring network in Greece.

- Determine how iNaturalist can be incorporated into these Greek organizations' projects and identify common characteristics in compatible entities.

- Evaluate how beneficial iNaturalist is to conservation organizations in practice through case studies.

Figure 4. Flowchart of methods used to reach each objective towards the final goal.

3.1 Inquiry and Analysis of iSea's Citizen Science Activities

As described in Section 2.4, iSea has developed and executed multiple successful citizen science projects where volunteers submit photos of organisms they encounter. The expertise iSea has developed for engaging the Greek public in citizen science was valuable to us, so interviews with iSea employees were conducted to gain a better understanding of how a successful citizen science project is run. We also inquired about challenges that have arisen during the implementation of iSea's projects and ways that these issues were mitigated. The information gathered from these interviews helped us to anticipate issues that may arise during iNaturalist implementation in addition to giving us a comprehensive understanding of what makes iSea's citizen science projects successful.

To remain on topic and ensure all our desired information was collected in these interviews, we followed the interview protocol detailed in Appendix Item B.

3.2 Understanding the iNaturalist User Experience Through a Survey

In order to gain a better understanding about what the users of iNaturalist value, we sent a short qualitative survey to the top ten users in the world as listed on the website. This included questions about their thoughts on the AI feature, social aspects, possible improvements, and best features (see Appendix O). We analyzed the responses for trends and popular features in order to pinpoint areas of importance that could be highlighted to increase iNaturalist use.

Figure 5. Interviewing Sofia Litsiou at the iSea office.

3.3 Development and Evaluation of Educational Materials

To successfully relay the educational value that iNaturalist has to offer, our group designed iNaturalist educational materials. These materials included three flyers, a pamphlet, and an FAQ document (see Appendices G-L). We developed these by adapting information from existing public iNaturalist infographics and video tutorials, as well as our first-hand exploration of the application. We used the online software Canva to design these deliverables and make them attractive. Once developed, we tested the clarity of the pamphlet with a small group of Greek residents that were sampled through a volunteer with iSea, Dimitra Ioannidou, who contacted her friends. We hosted an activity (see Appendix F) with nine of these individuals to observe how easily they were able to use the application with help of the pamphlet. This allowed us to gauge their understanding of the training material. To conclude, the participants were led as a group through a short debrief to gather feedback on the delivery of the information and iNaturalist itself (see Appendix F). We led a conversation that included questions on the clarity of the materials, confidence in using iNaturalist, and the most difficult features to use. Overall, our goal for this user testing exercise was to refine our pamphlet on iNaturalist in order to present it in an engaging but informative way.

Figures 6A-C. Personal exploration with iNaturalist around the American Farm School campus.

3.4 Identifying Stakeholders

To successfully incorporate iNaturalist into the Greek biodiversity monitoring community, we determined which groups would be most benefited by the platform. We worked with our sponsors at iSea to research Greek organizations and educational institutions associated with biodiversity and conservation. Our sponsors, Anastasia Charitou and Sofia Litsiou, had connections with Greek environmental organizations from past collaborations that leveraged in the hopes of increasing our response rate. We wanted a diverse perspective on iNaturalist, so we looked for groups that concentrate on different aspects of biodiversity and conservation. We then stratified the stakeholders into categories of NGOs, educational institutions (particularly primary schools), and environmental research groups to ensure that we contacted organizations across a wide variety of specialties and missions.

3.5 Identifying iNaturalist-Compatible Organizations Through Interviews

Through interviews we determined which features of iNaturalist appeal to Greek organizations and identified which of these stakeholders were receptive to future integration of iNaturalist. Emails served as our first point of contact to schedule meetings with these individuals. To ensure relevant and on topic discussion, we followed unique interview protocols, as described in Appendix Items C-E, for the three organization categories based on our previous stratification.

Each interview began with a description of the features and functions of iNaturalist, with a focus on possible benefits to the organization and the scientific community. Additionally, we showed our educational materials to several interviewees, both for their benefit in learning about iNaturalist and to propose further distribution of the materials through their organization. Meetings with NGOs questioned their requirements for a biodiversity data collection tool, such as what particular species they are interested in, their opinions on citizen submitted observations, and what species information they collect like color, weight, or location. We additionally discussed how critical program details such as user-friendliness or social media components are to them. Research interviews concentrated on similar material, but with a more in-depth focus on their requirements for data quality and using the data for detailed scientific analysis. Using the general thought process diagrammed in Figure 7, we were able to collect a suitable amount of information on each NGO and research institution to determine whether iNaturalist matches their needs and could prove useful to them.

Educational program interviews investigated the possibility of using iNaturalist as a tool for active learning. We proposed that students could use the application in an organized activity to gain an understanding of their local ecosystem through iNaturalist's identification and informational features. In these interviews, we assessed whether the educational institution was receptive to this program by investigating how important environmental education is to them, how receptive they are to collaboration with outside groups, and if there would be any limitations in integrating this program such as technology access barriers.
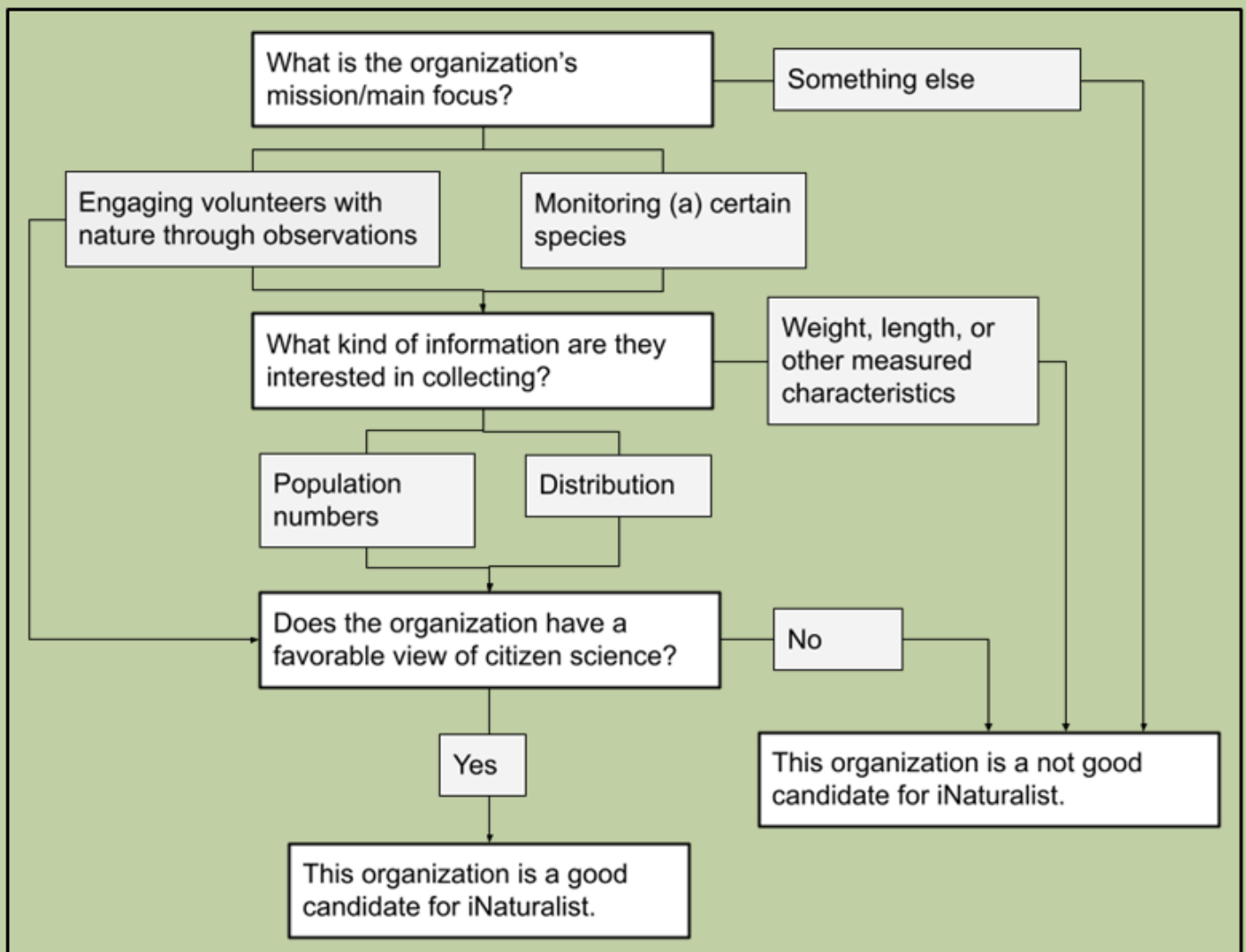
Figure 7. Decision tree used when structuring the NGO/research institution interview process (see Appendix Items C and D).

At the end of each interview, we asked the interviewee if they had any recommendations for other organizations they believe could benefit from the use of iNaturalist to pursue contact with and increase our outreach.

3.6 Assessing Feasibility of iNaturalist Implementation Through Case Studies

Next, we hoped to evaluate the benefits of having organizations incorporate iNaturalist into their operations using a comparative case study method. This type of case study involves the analysis and synthesis of patterns across two or more cases that share a common goal (Baxter and Jack, 2008); allowing us to explore this complex issue in a real-world setting.

Our team originally planned to work with at least two organizations to employ a comparative case study approach wherein the organizations incorporate iNaturalist into one of their programs so that we could evaluate its utility based on their unique experiences. In order to capture a range of perspectives, our team sought to collaborate with at least one NGO, an educational institution, and a research team in the fields of conservation biology or biodiversity. For the NGOs and research teams we wanted to participate in the case study, we hoped to emphasize the application's biodiversity monitoring and project features as well as convey how those tools could help guide the mission of the organization or research team. . Due to lack of responses from NGOs and research groups, our team was unable to perform a case study in these two organization types. For the educational

institutions participating, our team anticipated to make clear iNaturalist's value as an active learning tool for biology and environmental science courses. We gathered the most interest in iNaturalist from educational institutions as we had two organizations participate in this case study approach: the American Farm School Middle School (AFSMS) and the Environmental Education Centre (EEC). We provided both the AFSMS and EEC with our training materials (described in Section 3.4) for internal usage and public distribution.

Our team had a positive response after introducing iNaturalist to Principal Slavoudis of the AFSMS which ultimately led our group to pursue a case study to incorporate the platform into their science course. We were then given the opportunity to conduct three iNaturalist presentations to seventh, eighth, and ninth grade students as well as their respective teachers. In order to gauge their interest in the app, we proposed a project for the students to complete over the Easter holiday: we challenged them to make at least ten iNaturalist observations.

After the Easter break, our team reconvened with the AFSMS to hold a debrief with one of the biology-STEM teachers present during the iNaturalist presentation. We hoped to get the teacher's perspective on the application to see if it is of interest to incorporate iNaturalist into their science curriculums at the school.

Furthermore, our team was able to work with the Environmental Education Centre of Eleftherio Kordelio and Vertiskos (EEC): one of fifty-three environmental education centres in Greece supported by the Ministry of Education. While working with the EEC, we designed an educational game using iNaturalist. The EEC aims to educate Greek students to be active and think critically about the world around them. The educators at the EEC create worksheets related to the urban environment for their tours of Thessaloniki for students in primary and secondary school. We met with one of the educators, Giorgos Yfantis, to get a better understanding of what the game design should look like.

Figure 8. Introducing iNaturalist to the AFS Middle Schoolers through a presentation.

Our team designed a nature scavenger hunt worksheet where students could use iNaturalist to identify the nature in their city; there was a point system for the various plants and animals that could be found in Thessaloniki parks (see Appendix M). We tested the worksheet during an EEC tour where students used our phones to access iNaturalist and complete the scavenger hunt. After the tour, we conducted a debrief with the students to assess their interest in the game and iNaturalist in general (see debrief questions in Appendix N).
 This case study approach demonstrated the positive impacts iNaturalist can have on the education sector, and helped us focus primarily on schools and educational centers rather than multiple entity types. We shared that the AFSMS and EEC were most receptive to iNaturalist and issued outreach plan recommendations to iSea– ultimately encouraging them to engage primarily with educational institutions for future success in growing iNaturalist. Through having the AFSMS and EEC actively use the platform through case studies, we were able to evaluate whether iNaturalist was a suitable platform for them to advance their curriculums and tours.

4. WHAT WE FOUND

Following the methods outlined in section 3, we interviewed six members of the iSea staff to learn more about the strengths and challenges of their past citizen science projects. We also sent a short qualitative questionnaire to top iNaturalist users in the world to evaluate the user experience. Additionally, we requested to interview many NGOs, research institutions, and educational institutions to gain diverse perspectives on citizen science and iNaturalist. We were able to interview one NGO and one research institution on using citizen science data. We had the most success with educational institutions as we were able to conduct two case studies to evaluate how iNaturalist can be implemented as a learning tool. Finally, we analyzed user testing feedback on the iNaturalist pamphlet we made in order to find sections in need of clarification or revision.

4.1 iSea's Experience with Citizen Science

Social interaction fosters more participation in citizen science

Through interviewing six iSea staff with roles in planning and maintaining the NGO's citizen science initiatives, we developed a detailed understanding on the strengths and weaknesses of their past efforts. One of iSea's largest projects, "Is it Alien to you? Share it!!!", sought to "collect information on the occurrence, distribution, and expansion of marine NIS [non-indigenous species] in Greece and Cyprus" (iSea, 2016). In planning the project, Nikos Doumpas, the project manager, anticipated difficulty encouraging their target audience of fishers and divers to record observations. To address this potential problem, iSea made frequent comments on users' posts containing helpful information on the marine species recorded, such as recipe recommendations for edible species and warnings or safety tips for venomous species. This strategy had two main benefits. First, participants had an increased incentive to upload observations as iSea then provided them with useful information on the species. Second, iSea's responses made users feel that the data they provided was seen and appreciated; giving them a stronger sense of community and the satisfaction of contributing to a project. These responses emphasize the benefits of recognizing and interacting with users, a sentiment which was experienced frequently in our background research (Rotman et al., 2012).

Another obstacle several staff reported was that fishers were wary to contact researchers for observations out of fear they may be fined or otherwise penalized for accidentally catching a protected species; a unique challenge for CS not encountered in our background research. To address this, Doumpas joined numerous Facebook groups for fishers and divers in addition to forming connections with target audiences through field work. Doumpas stated it is important,

> ❝ *to be one with the audience"*

highlighting the necessity of developing trust and emphasizing common interests to increase project participation (Doumpas, March 15th, 2023).

Developing a sense of trust and connection helped to decrease these hesitations and increase uploads from these users.

Roxani Naasan Aga-Spyridopoulou, a senior iSea team member, seconded the importance of a personal connection in encouraging responses. She explained that a majority of data uploaded to the project "Sharks and Rays in Greece and Cyprus", also known as the MECO project, were uploaded by individuals who formerly had personal interactions with iSea. This includes previous volunteers for citizen science initiatives or environmental cleans ups and members of diving centers iSea has maintained close relations with. She also mentioned that personal connections increased data quality as the likelihood of responses is higher when iSea contacts observers for customized information on a species encounter such as a time or location (Naasan Aga-Spyridopoulou, March 24th, 2023). Giorgos Rallis, who also worked on the MECO project, added that sending personal messages thanking observers for recording an observation, providing information on the species, or requesting additional details assured participants that their voice and data matter.

This attention to end users strengthened their relationship to iSea and encouraged long-term participation. These findings confirm the importance of social connections in facilitating successful citizen science projects as discussed in our background research.

iNaturalist presents superior data organization and social capabilities

One platform iSea has used to record citizen science observations is custom-made Facebook groups. As a large portion of the population has experience with the social media platform, using Facebook removed the intimidation first time users typically experience when learning an unfamiliar scientific software. "Is it Alien to you? Share it!!!" was based primarily on Facebook (see Figure 9) and thrived due to its social capabilities; each unique photo could be posted to the project's dedicated group for others to then identify or comment. Through these comments, iSea was able to interact with observers, offer helpful information on recorded species, and strengthen the bond between users and the NGO. The benefits of the ease of

Figure 9. Cover of iSea's "Is it Alien to you? Share it!!!" Facebook group.

use and social connections on Facebook were reflected in the project's success. There were "15,000 members in the project and a majority were active at the project's height" through iSea's efforts to connect with fishers and divers, advertising, and word of mouth recommendations (Doumpas, March 15th, 2023).

Facebook, however, was not an ideal citizen science software, despite these benefits. Most notably, an iSea employee had to personally review and enter the details of each observation into its records to construct the final database as Facebook had no automatic capabilities to process entries. Additionally, "Is it Alien to you? Share it!!!" had an aquatic scope, but the informal nature of the Facebook group led observers to upload unrelated content such as certain plant or terrestrial species. Due to this loss of focus, the target audience of fishers and divers felt as though the project was no longer specialized to their interests. This led to a steady decline in project participation, where today the page mainly persists via the distribution of created deliverables and an iNaturalist project being created in the program's name.

For iSea's MECO project (see Figure 10), an outside software titled SEAlly was used. This application had observers fill out a detailed form as its submission system rather than posting their images to a public group. With this software, data was automatically formatted for iSea's database, requiring only minimal verification by a staff member, allowing data to be processed faster than when using Facebook. SEAlly, however, significantly lacked a social component as observations were not available for public viewing, comments, or peer reviews. Additionally, the software proved difficult to navigate, which hindered its utility for new users, as well as time consuming,

proving tiresome for repeat users. As such, divers, especially those older or less technologically able, frequently opted to report their observations to iSea directly via instant message rather than using the application. This process created an administrative burden for iSea as these observations had to be manually entered into the database, nullifying SEAlly's data processing abilities, which was the primary advantage of using the software for this project.

Figure 10. M.E.C.O Project Logo.

iNaturalist presents itself as a middle ground between the two data collection formats, offering superior data organization while fostering social interaction between observers. Sofia Litsiou, who manages iNaturalist's Greek portal, shared that she believes iNaturalist's ability to collect data through an intuitive, user-friendly form and automatically format those entries for easy data analysis is a main incentive for organizations to use the application in their projects. Filters can be applied to the global database on specific species, areas, timeframes, and many other criteria, allowing desired data to be exported within minutes. Additionally, these

records are not only available to specific organizations, but all users, allowing individual users to see the distribution or diversity of species in their area (Litsiou, March 20th, 2023). As all observations are public, anyone can comment to offer information or a possible identification, fostering healthy social interactions and a sense of community. Katerina Katsaouni, who works with iSea's Prosfero project (see Figure 11) collecting data with iNaturalist, shared that despite being a unique software, the app has proven user-friendly and participants effectively recorded observations after briefly reviewing printed materials (Katsaouni, March 29th, 2023). Many staff also mentioned that iNaturalist's AI capabilities are unlike anything the NGO has used before and are a highly appealing aspect of the software. These AI capabilities combined with iNaturalist's social peer review system greatly increase the accuracy of observations, without any required effort from NGO staff members, thus relieving a large quantity of administrative burden.
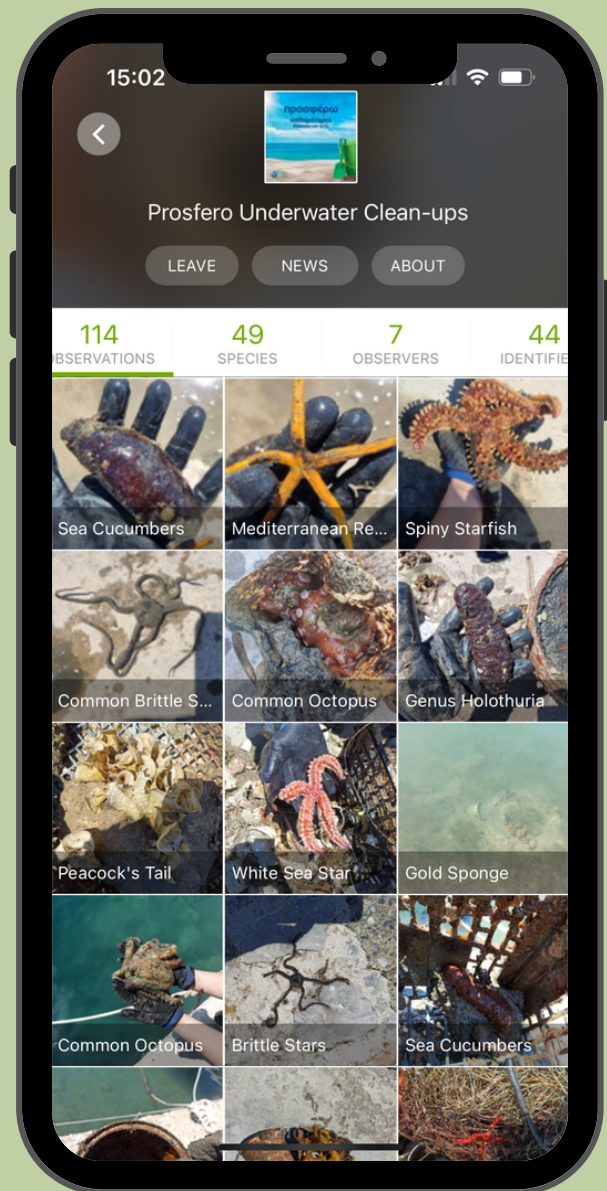
Figure 11. iSea's Prosfero project page in iNaturalist.

4.2 iNaturalist User Experience: The Positives and Pitfalls

iNaturalist users appreciate the inclusive, extensive database and social aspects

To gain an understanding of what features of iNaturalist were valued the most, we asked the application's top ten users in the world for their opinions. This survey placed specific emphasis on the perceived importance of the social aspect, as this was a large contributor to iSeas past successful platforms. However, the results are limited, as only seven of these individuals responded to our questions. All the respondents have used iNaturalist for at least 4 years, with each having a wealth of experience using the platform. As shown in Figure 12, the individuals learned about the application through friends and family, environmental organizations, or social media. In addition, four out of the seven individuals have used applications similar to iNaturalist, three of which listed eBird as one of those apps.

They noted that in regards to these two apps, iNaturalist is better for photos and offers more verified data, whereas eBird is better for giving an idea of the abundance of birds in particular. Bugguide was another application that was mentioned and described as being more difficult for novice individuals to use.

We found that the users valued varying aspects of iNaturalist, which is represented as a word-cloud in Figure 13. The most frequently mentioned aspect is that it is an extensive dataset, where information can be collected about various species, not just one taxon. Also highly valued is the ability to receive feedback about identifications and correct others. This was commented on in response to another question, in which we found all respondents thought this feature was critical to the utility of the app. Generally, the appreciation for the overall concept was commented on by several respondents, with one saying, "Being able to take a picture or upload a picture and immediately have a way to share it to a larger database, especially one that's friendly to everybody, is simple and inclusive" (Respondent 6).
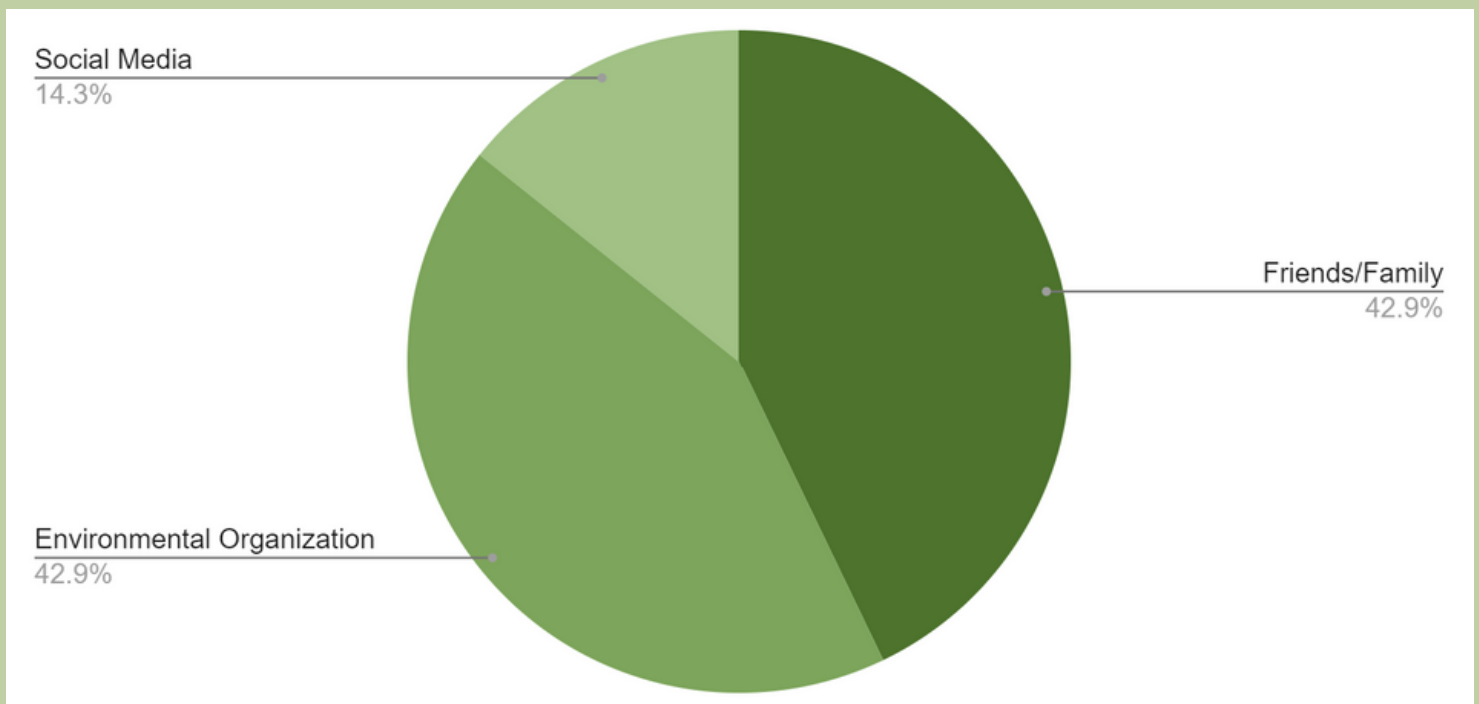
Figure 12. Pie chart representation of how top iNaturalist users learned about the app (n=7).

Figure 13. Word cloud of the benefits of iNaturalist as mentioned by top users.

When asked specifically about the social aspect of iNaturalist, the majority of the respondents had a positive reaction, with one having nothing to comment on the topic. One individual said,

> *I find the social aspect very helpful – I have got to know many great local naturalists that way"*

(Respondent 3). Another compared it to Facebook by saying,

> *But unlike FB [Facebook], there is a strong culture of respect for all users"*

(Respondent 2). There was also an overall appreciation of the focused conversation topics and safe community guidelines iNaturalist provides.

All seven respondents suggested improvements they would make to the platform. Two people suggested the general design and bugs on the iOS app needed work, while others delved into more specific issues. A particular surprise to us was an issue with iNaturalist use in schools and the "research grade" component, where observations move up a quality scale when the identification of

an upload is confirmed by multiple members. This user said, "Some schools use iNat for class credit and require students to post "research grade" observations, which leads other students to come and "confirm" the original ID whether or not they know anything about the species in question. This can be a source of a large number of misidentified observations" (Respondent 4). A similar idea was echoed by another user who suggested that there should be a ranking system for identifications confirmed by experts versus novice users.

4.3 Testing the Clarity of Our iNaturalist Pamphlet with the Greek Public

Revisions on the pamphlet were needed to clearly communicate how to use iNaturalist

The pamphlet (see Appendix G) we made and had translated into Greek by Sofia Litsiou for general iNaturalist instruction was tested by residents of Greece for how effectively it

communicated how to use the application (see Figure 14). The sample was not an accurate representation of the whole Greek population as the group consisted of nine young adults, eight of whom were female. They were all contacted directly from a friend who volunteers with iSea, Dimitra Ioannidou. Through this activity, we found that the participants, after downloading the app on their mobile phones, did not realize initially that they should make an account. This was evident when we began collecting their usernames and only one participant had one. Another point of confusion was when first accessing the AI feature. The participants were unsure of how to do this as the instructions were not specific about which button needed to be pressed. It was also brought to our attention that the screenshots of the app that we included in our materials were not very useful for those who did not speak English. However, they unanimously expressed

that the application was easy to use after making an initial observation, but one participant said that they "would not be able to use iNaturalist for the first time without the pamphlet." This indicates that the pamphlet served its purpose of communicating instructions, but was revised according to the aforementioned feedback (see Figure 15 and Appendix H).

We considered this user testing event to be successful since each first-time user submitted at least 7 observations in the Pedion Areos park of both the flora and fauna. In total, 25 different species were identified using iNaturalist as a part of this user testing event. In regard to the application itself, the participants valued the ability to identify species and when asked how likely they were to recommend the app on a scale of 1-5 (with 5 being highly likely), the average answer was a 4. Despite this, many commented that they would likely not use iNaturalist again as they do not see the personal benefit of it.

Figure 14. Debrief with the pamphlet testing participants.

What is iNaturalist?

iNaturalist is a social networking platform for citizen scientists and biologists that aims to map biodiversity.

Observations that are submitted to iNaturalist are added to the app's database. From there, users can validate each other's observations to increase the confidence rating of the observation. Once a post has reached "research grade", scientists can then use it in their research.

Who can use iNaturalist?

Anyone! iNaturalist's power comes from the fact that anyone can upload and verify observations.

iNaturalist acts as a social network for amateur and expert naturalists from all across the world!

Device requirements

iNaturalist can be accessed on most iPhones, computers, and Android devices that are able to take pictures and connect to the internet.

The application can be downloaded to mobile devices on the Google Play Store and Apple App Store, or accessed via web browser at https://www.inaturalist.org/observations.

For iPhone   **For Android**

Want to know more about incorporating iNaturalist into your organization?

Contact iSea by email!
info@isea.com.gr

greece.inaturalist.org

Introducing

iNaturalistGR

Why use iNaturalist?

iNaturalist serves as a helpful personal tool and aids conservation efforts in data collection

Species Occurrence Records

By contributing to iNaturalist, you will be contributing to the 12-fold increase in global species observations that has resulted since the implementation of citizen science platforms. This increase in data allows researchers to better construct necessary environmental policies and conservation efforts.

Species Identifcation

Gain access to a useful tool for quick identification of plant or animal species from photos using AI and peer review methods.

Social Networking

Connect with *biodiversity organizations* and projects to learn more about *conservation efforts* in your area and connect with like-minded people.

Active Learning Exercise

Many schools and universities have implemented iNaturalist into biology *course curriculums* to gauge *students interest* in biodiversity.

HOW TO POST AN OBSERVATION

1 Make an account

2 Tap the observation icon

3 Take or upload a photo or audio recording

4 Click "What did you see?" to view AI suggestions

5 Pick the species that matches closest

6 Enter additional information and notes

7 Share and scroll!

Figure 15. The final version of the iNaturalist pamphlet.

4.4 Perceptions of iNaturalist in Varying Organizations

The scientific community is hesitant about using citizen science data

We conducted two key informant interviews to explore how researchers at Arcturos (a Greek NGO that broadly aims to protect the wildlife of Greece but currently focuses on bears and wolves) and professors in the Biology department of Aristotle University of Thessaloniki (AUTH) regard citizen science and the iNaturalist platform. We initially contacted a total of 34 NGOs, conservation groups, and universities, but received very limited responses to our interview requests. Thus, we cannot claim that the views of our two interviewees are representative of all conservation entities in Greece.

Our interviewee at Arcturos, Lampros Krampokoukis, is one of the organization's main researchers. He noted that its main method of collecting species observations was through phone calls they received from the public. The information obtained from these phone calls (such as date and time of observation, species observed, and location) is then recorded in an internal database and used to track the distribution of species. One benefit of this method that was cited is that less follow-up is needed as detailed questions can be asked during the initial phone call. It is also low-cost, which is useful as the interviewee explained that costs are prohibitive to large-scale data collection. Another low-cost method Arcturos uses to collect data for their internal species distribution database is by scanning Facebook groups centered on photographing Greek wildlife for observations of species of interest. When discussing the data collection methods used, Mr. Krampokoukis emphasized the importance of keeping costs low due to budgetary constraints the NGO faced.

Despite these financial considerations, Mr. Krampokoukis did not have a favorable view of free citizen science platforms such as iNaturalist. His main concern with the usage of such platforms is that the data collected on applications such as iNaturalist is freely available to any user and is therefore not proprietary. He explained that this competitive nature of Greek research entities is mostly driven by the desire to publish and be credited for their findings in scientific literature, especially since having more publications is correlated with more funding. As such, his organization favors other methods of data collection (such as phone calls), even though they are more labor-intensive.

Furthermore, a distrust of data collected through citizen science was reported in both interviews, a finding that is discussed in studies such as Dickinson et al. (2010). Our interviewee at the Aristotle University of Thessaloniki (AUTH) is a biology professor interested in the prospect of using data collected through citizen science channels such as iNaturalist, especially since a citizen science hub is being developed at the university. This hub will be partially funded by Horizon Europe, a funding program for projects in the European Union that support research and innovation (Horizon Europe, 2021). Our interviewee at AUTH noted that data collected through citizen science is not currently highly regarded in the Greek scientific community due to concerns of data ownership and reliability, so he is cautious about using CS data in his own research despite his personal positive feelings towards it. However, he was cautiously optimistic that the development of the CS hub at AUTH could be the beginning of a more positive attitude towards CS in Greek academia.

Mr. Krampokoukis echoed the view that citizen scientist observations are currently not considered accurate by Greek researchers, mostly because of concerns regarding false or inaccurate observations. (For instance, a large dog may be misidentified as a wolf by an untrained observer.) Our interviewees were also concerned that observers uploading data to citizen science platforms after the initial observation may skew the metadata of the observation (such as the date and time), making the data incorrect and unsuitable for research.

Advancing AFS Middle School curriculums with iNaturalist

While assessing iNaturalist interest in schools and educational centers, we found one of the most prominent engagement features of iNaturalist is its ability to be used actively in the classroom on a digital device. This was supported by an interview with Dimitris Slavoudis, the principal of the American Farm School Middle School, who shared that

> *things are changing with technology, and we have to be more open to using it in the future"*

(Slavoudis, April 4th, 2023). Slavoudis' interest in the platform led our group to conduct multiple presentations to AFS middle schoolers and faculty in order to introduce them to iNaturalist and its learning benefits (see section 3.5). When we opened the floor for questions as each presentation ended, we found that the ninth graders had the most inquiries pertaining to iNaturalist use and its AI features. Similarly, the seventh grade students had a number of questions about the application including how to download the app, how to upload pre-existing photos, and how to collaborate

with their peers. We found that the eighth grade students were the least engaged during the presentation and contributed little feedback at the end; these students asked questions such as if they could upload a picture of a ball to the app or if iNaturalist can help them find Pokémon. The positive outcome from ⅔ of the presentations matched up with our literature findings discussed in section 2.6 – especially Echeverria et al.'s 2012 study of iNaturalist usage in a secondary school in Navarre, Spain. The ninth grade students' questions pertaining to the machine learning software highlighted the "innovation" and "technology in education" aspects of iNaturalist found in this paper, while the noted interest in the projects feature among multiple grades underlined the "investigation" and "interactivity" aspects associated with the application.

After the Easter break when students and faculty returned to AFSMS, our team conducted a debrief with Despoina Avramidou: one of the biology and STEM teachers present during the presentation. Avramidou enlightened us on her perception of iNaturalist and whether the application would fit in a classroom setting– she took it upon herself to browse the website to get a better gauge of the projects feature and educational value iNaturalist offers. We found that Avramidou

> *loved that there were links to other websites about the organisms as you take pictures of different things".*

She further went on to explain the usefulness of the app if more time was allocated to the biology course curriculum. Avramidou informed us that due to limitations of strict, nationally-set curriculums for teachers in Greece, the possibility of having iNaturalist implemented in classes may be difficult.

Further concern was posed as she explained that although there is some flexibility for teachers, the lack of outdoor accessibility and issues surrounding cellphone use can generate problems. When our team brought up our Easter project proposal during the debrief, Avramidou informed us that she had not gotten a chance to ask students if they attempted iNaturalist over the break (Avramidou, April 26, 2023).

We learned that Avramidou is interested in organizing a school hiking field trip to a nature park that combines species identification so students can learn more about biodiversity. Similarly, she expressed interest in creating an environmental biology club for middle schoolers to learn more about topics that are not extensively covered in the Greek national curriculum. Avramidou mentioned that for both of these new projects, iNaturalist could be a great tool for the students as it's a "user-friendly, easy app" (Avramidou, April 26, 2023).

During the debrief, we also mentioned the nature game we designed for the EEC in order to assess if the school would be interested in learning more about it for possible use by their students. Avramidou was excited about the idea of a game that used iNaturalist to get students interested in biodiversity– especially because the American Farm School campus would be a perfect environment to use the application. She followed up her interest by asking questions such as the duration of the game, where we had the EEC tour, and the age range of students we worked with. We ultimately learned that Avramidou would like to stay in contact with iSea for possible implementation of the game into the AFSMS as she provided us with her email for distribution.

An iNaturalist-based game engages students in nature in the city

Our team accompanied the Environmental Education Centre on two of their educational city tours to test the interactive nature game that we designed (described in section 3.5). Our first tour with the EEC was with a class of sixteen-year-old students from a school in Thessaloniki – of this class, eight students participated in our game. We introduced a team element to the game by dividing the students into groups of two; this gave students the opportunity to collaborate with a partner and share their ideas for the scavenger hunt list (see Figure 16). Among all the groups, roles were assigned so that one partner would be actively using iNaturalist on a cellphone to record observations while the other partner would handle the worksheet and write

Figure 16. Students working together to complete the scavenger hunt worksheet.

Worksheet 3: Nature in the City Scavenger Hunt

Use iNaturalist to make observations that fulfill the requirements listed below and write the species it is in the table. You can have multiple observations for each category, but only if they are two distinct species (ex. two different trees). You do not need to find every item. You can only use each observation once, so an orange flower could count for an orange plant OR a flower, but not both. Each type of observation is worth a different amount of points, so compete with your friends to see who can get the most!

Item	Point Value	Species Found	Total
A tree	1		
A bush	1		
A flower	2		
A weed	2		
A bug that crawls	3		
A bird	4		
A plant with fruit	5		
A snail	6		
A plant with thorns	7		
A bug that flies	8		
A mushroom	8		
An animal with fur	9		
A plant with an orange part	9		
A plant with a purple part	9		
A non-native species	10		
Final Total			

HINT: For larger organisms, try taking multiple pictures of the same organism and uploading them under one post to make it easier to identify!

Example: If you are trying to identify a tree, take close up pictures of one of its leaves, its bark, and then a picture of the entire tree.

Figure 17. Blank version of the scavenger hunt worksheet.

Figure 18. Debriefing with game participants on an EEC tour.

down the species' names for each observation. This was accomplished through the iNaturalist AI feature as once an observation is uploaded on iNaturalist, the AI recognition would reveal the species name, as well as additional facts about said species, so the students could easily record each upload in the worksheet. The partners had to work together to ensure fluidity when observing and recording the observations; communication was a key component when the students were playing the game. Each team was given fifteen minutes at two tour stops to record as many observations as they could pertaining to the categories on their scavenger hunt worksheet (see Figure 17 and Appendix M). During the game, we found that the challenge aspect of obtaining the most points on the worksheet made the children excited to record the most observations on iNaturalist. All eight of the students expressed their interest in winning the competition, thus influencing them to actively participate during the entirety of the tour. One pair of students were so competitive that they would run around the tour sites looking for the items that matched those on the worksheet. At the end of the two fifteen minute periods, each team counted their total number of points; any observations that accurately fit the description of the items in the

worksheet were considered valid. Three of the teams had a total between forty and fifty points while one team had a total of ninety points.

Afterwards, we conducted a debrief with the students to gauge their opinion of the game and iNaturalist in general. During this time, the students informed us that iNaturalist is "helpful", "easy to use" and "gives a lot of information about species and plants" (Students, April 25, 2023). Each of the groups were given an opportunity to share what they learned about the nature in their city. Multiple groups informed us that they do not usually take notice of the greenery in the city because of the various distractions that come with living in an urban environment. One pair of students mentioned that they enjoyed iNaturalist because it helped feed their curiosity of what the species are around them. Another student informed us that they "did not know that there were so many species of plants present in Thessaloniki" (Student, April 25, 2023). One of the teachers accompanying the students entered the discussion to emphasize that we

> **"** *made them observe the city differently"*

(High school teacher, April 25, 2023).

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After the debrief with the students, our team briefly followed up with an educator from the EEC, Giorgos Yfantis, where he expressed his fondness of using iNaturalist for educational purposes. One of the EEC educators, Giorgos Yfantis, was also present during the entirety of the debrief with the students, and thus mentioned his fondness of the students' perspectives on the game. We followed up with Yfantis after the debrief where he then expressed interest in using our iNaturalist game in their nature program.

We next asked the students what they specifically enjoyed about the game (see Figure 18), and we found similar responses amongst all four groups: each pair expressed the thrill of participating in a competition with their peers. Furthermore, students conveyed that they enjoyed the collaboration aspect of the game as most groups dedicated one person to using the phone for making iNaturalist observations, while their partner would fill in the worksheet as new species were recorded. When our team asked for suggestions on ways we could improve our game, the students provided us with good feedback suggestions for the scavenger hunt categories.

To begin, some of the items listed on the worksheet were seen as too difficult to find in an urban setting– the major items being a mushroom and a non-native species. Students also expressed that they wished they had longer than fifteen minutes in each stop to make observations. Our team finished the first tour's debrief by asking the groups if they would ever use iNaturalist on their own or if they would recommend it to their peers. One student had already downloaded the application after the first stop and the other students mentioned their interest in using the platform again in a more rural environment.

5. RECOMMENDATIONS AND CONCLUSIONS

5.1 Recommendations for iSea

Promote social connections in iNaturalist

Social connection has proven a powerful feature in influencing the success of past iSea projects and as a primary motivator for iNaturalist users. With these evident benefits, we recommend that iSea highlights the social capabilities of iNaturalist as a focal point of their public marketing strategies in addition to interacting with users to foster participation. In iSea's current advertising efforts, the primary assets presented to the users are the value of iNaturalist as a tool to gain knowledge of local ecosystems as well as the improvement of current biodiversity records for scientific gain. Although occasionally mentioned, the social features of iNaturalist are often not highlighted to the potential user despite being a critical component of the application.

Throughout the project, participants continuously emphasized the positive experiences they had using iNaturalist's social features. We recommend sharing their opinions and experiences through iSea's advertising efforts as it may pique the interest of potential users, thereby increasing participation. In discussions with iNaturalist's top users, many said the application served as an ideal platform for them to meet like-minded naturalists in a welcoming and subject-focused environment. Also, in working with

students, the ability to see other's observations facilitated friendly competition among users and was repeatedly mentioned as making the program more engaging. Additionally, iSea's strategy of making personal connections and interacting with the target audience has proven effective in past projects. We encourage iSea to pursue similar efforts in the promotion of iNaturalist, expanding beyond aquatic centered organizations to form in person connections with other naturalists, such as hiking groups, for increased participation.

Further research needs to be pursued for citizen science to reach its full potential

The interviews with the AUTH Professor and Mr. Krampokoukis from Arcturos revealed there was hesitancy in using citizen science data due to a lack of reliability. Our interviewees stated that for this reason, the use of citizen science platforms, including iNaturalist, is avoided in many formal scientific studies. In order for citizen science platforms to be used more frequently, it is important for the Greek scientific community to understand how reliable the data is and the limitations regarding citizen science. We recommend conducting a study using Greek volunteers to evaluate what portion of data collected using iNaturalist is

unreliable and identify factors that increase and decrease quality of observations. This study could be conducted by iSea or a partner organization, in which they consider all research-grade observations recorded in a set region and time. These observations can then be analyzed by an expert for accuracy to develop an understanding of how frequently the observations that reach research-grade are inaccurate. This analysis should also take into account when photos are not detailed enough to make a proper identification, or when individuals upload observations with no photos. Should this study be successful, it could give the scientific community the opportunity to fully understand the degree of risk regarding data quality that comes with using a platform like iNaturalist so they can make an informed decision about using it in their own research. Depending on what this research reveals, it may expand potential users for the application and citizen science in general.

Expand the use of iNaturalist by targeting new groups

A discovery that was made during the interview at the Aristotle University of Thessaloniki was the creation of a new citizen science hub for students. As this hub may be a step towards a greater acceptance of citizen science in the scientific community, we recommend that iSea follows updates on this organization's progress and events. If possible, they should attempt to organize an event with the members of this organization in the form of a bioblitz using iNaturalist or presentation on their past and current citizen science initiatives. Information about iNaturalist could also possibly be made available to people through this hub in the form of one of our digital flyers.

Pursuing a collaboration with the citizen science hub at AUTH could easily aid in the expansion of iNaturalist users and mutually support their goal of encouraging citizen science.

From the interview with an AFS faculty member, it was determined that an avenue for iNaturalist use that has been previously unexplored is within the agricultural sector. We recommend that efforts be made to reach out to members of the community to inform them of the potential benefit of using iNaturalist for weed and pest identification, as it offers a free and simple avenue to do so. This can also be done through the distribution of the flyer designed for them (see Appendix J). From these initial connections, it could then be possible to establish a specific community for farmers using the projects feature so that agricultural observations could be collected in one convenient place for researchers and farmers alike to share their observations, providing a place for the exchange of information and ideas. This would not only help increase biodiversity monitoring of unwanted pests and plants, but would also potentially aid the agricultural community by giving them a free platform where they can discuss these plights.

Engage students using an iNaturalist-based game

The education sector holds many opportunities for citizen science to be used as a learning tool. As seen in our findings from the EEC tour, student engagement soars when a game element is used in learning. The competitive aspect and collaboration opportunities our game offered made students excited to learn more about the nature in Thessaloniki. Additionally, the children were encouraged to use the species-specific

facts from the additional information feature iNaturalist offers. We learned from the debrief that being able to readily see facts about the organisms uploaded helped the students better understand the greenery in their city. Multiple students specifically put an emphasis on their fondness for the map of where an organism is naturally found in the world, ultimately demonstrating the educational value the application holds. We encourage iSea to take advantage of our iNaturalist-based game as well as the relationship we created with the EEC. There are a number of other educational centers and public schools throughout Greece, and the EEC may have the ability to distribute game worksheets to these organizations. If our game can get more recognition in the education sector, there is promise for a stronger student user base on iNaturalist. This will ultimately aid in increasing student knowledge on local biodiversity while simultaneously assisting researchers in monitoring species globally.

Engage students using an iNaturalist-based game

During a debrief with Despoina Avramidou of the AFS Middle School, it was revealed that teachers are limited by nationally set curriculums. Although there is some flexibility in the classroom, the use of iNaturalist requires access to outdoors spaces with ample time for making observations. Due to the educational value of iNaturalist seen by this teacher, we recommend that an environmental biology club as well as planned outdoor excursions be implemented in AFS so students have the ability to utilize the application with teacher supervision. Avramidou informed us that creating an environmental club will aid in connecting

like-minded, nature-loving students who see the potential in an application such as iNaturalist; this kind of club for students is something that Avramidou specifically expressed interest in pursuing at AFS. Additionally, we encourage the AFS Middle School to take advantage of the nature scavenger hunt that we created for the EEC to get students excited about biodiversity monitoring through the game's competition and collaboration aspects. We believe that iNaturalist's educational value should be recognized by schools throughout Greece; we encourage iSea to continue reaching out to educational institutions for its further implementation.

5.2 Concluding Remarks

Our team determined that the education sector shows promise in utilizing iNaturalist in their practices. The application encourages students to connect with nature in an active and collaborative format, while the open-access and user-friendly aspects of iNaturalist ultimately make it an appealing platform for educators. Furthermore, the competitive nature of an iNaturalist-based game and the application's social capabilities drive student engagement. On the other hand, research institutions and NGOs were less likely to utilize iNaturalist in the future due to their distrust of citizen science observations and the lack of data ownership. These findings will allow iSea to specialize their outreach strategy and increase biodiversity monitoring in the area through increased iNaturalist participation. Ultimately, expanding the user base for iNaturalist will support iSea's goal to preserve and protect biodiversity by contributing to species tracking research and engaging interested citizens.

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APPENDICES

Appendix A: Biases Surrounding iNaturalist

Although the educational application iNaturalist demonstrates a lot of benefits in the areas of biodiversity tracking and conservation, sampling and taxonomic biases are still associated with the platform (Di Decco et al., 2021; Arazy and Malkinson, 2021; Callaghan et al., 2021). Di Decco, a macroecology and global change biologist with a PhD from UNC Chapel Hill, discusses spatiotemporal patterns in iNaturalist observations; she specifies that the application's uneven records of daily use throughout the year may be detrimental to scientists studying biodiversity (Di Decco et al., 2021). Specifically, iNaturalist is used disproportionately in respect to the time of year as well as the day of the week: more observations are made during the spring and summer months (i.e. April to September) and there is a much higher usage pattern on weekends compared to weekdays. Species observations on iNaturalist are also not very well-dispersed globally, for the majority of uploads are concentrated in developed areas and deciduous forests of the United States (Di Decco et al., 2021).

University of Haifa Professors Arazy and Malkinson, from the departments of information systems and environmental studies, reveal the biases associated with recordability of species on the iNaturalist platform. The recordability of species influences the observations that end up in the tracking database used for biodiversity monitoring. The University of Haifa researchers led a citizen science study which revealed observers' perceptions of what species they deem "important to record" as well as their likeness to put in the effort associated with uploading the observation– their results concluded that iNaturalist users recordability are most often articulated at the taxon and species level, ultimately revealing the taxonomy and recordability biases associated with the application (Arazy and Malkinson, 2021).

Observer-based biases can be illustrated when comparing semi-structured and unstructured CS projects as performed in a study by researcher Corey Callaghan from the University of Florida (Callaghan et al., 2021). Callaghan and his colleagues specifically analyzed bird observations recorded on iNaturalist (unstructured program) and an application known as eBird (semi-structured program). The team concluded that larger and more common species, as well as species that are found in larger flocks, are all over-represented on iNaturalist (Callaghan et al., 2021). This ultimately sheds light into the detectability biases that iNaturalist holds.

GENERAL CONSIDERATIONS:

- Interviews can take place wherever is most convenient for the interviewee - Zoom, their workspace, or a neutral public setting would all be possible.
- We will likely interview either iSea employees Sofia Litsiou or Anastasia Charitou given their in-depth knowledge of iSea's past projects.

SAMPLE INTERVIEW FORMAT

Interview with:
Date:
Time:
Location:
Attendees:

INTRODUCTION:

Hello [interviewee],

[Team introduces themselves.] As you know, we're going to be working with iSea for the next few months on increasing Greek participation in iNaturalist. As part of our research, we thought it would be useful to gain insight on some of iSea's past citizen science projects since they have been so well-received. Our main goal of this conversation is to gain an understanding of strategies that help make a citizen science project successful so that we can have a better idea of what other NGOs may be considering when planning their own initiatives. This information will hopefully help us better understand both iSea's needs and those of potential partner NGOs.

Given that this is for our research project, we have a few initial things to address before we get started.

1. Would you be comfortable if we recorded this interview so we can review your answers later for our research? If not, we can just take written notes.
2. Do we have your permission to use this interview in our report? Would you like to be named if we decide to quote one of your answers or remain confidential? Our report will contain a summary of all our interviews since they are such an important part of our research. It will be available online when it's finished, and we can email it to you if you'd like.
3. If there are any questions that you don't want to answer, just let us know and we'll move on.
4. Before we begin the interview, do you have any questions for us?

NOTE 1: The interview will be conducted based on the following outline. If the conversation happens to flow in a way that does not follow the order of the questions, the facilitator will skip around as necessary while ensuring that we still address all the questions.

INTERVIEW QUESTIONS

NOTE 2: Assuming that this interview is with Sofia, our primary contact at iSea, some introductory questions such as those regarding her history and role at iSea have already been answered. Thus, this interview is more targeted to our goal of gathering information regarding successful strategies for developing citizen science projects.

1. In your time at iSea, have you had a favorite project that you worked on? Could you tell us about it?
2. We've read a lot about iSea's past citizen science projects, but we'd love to hear more about your personal experience with them. Could you tell us about what working on these projects was like and what your role was?
3. Have you been involved in the planning of any of iSea's citizen science projects?
   a. **IF YES:** Could you tell us about what types of considerations go into planning these projects in terms of promotion as well as executing the project itself? (In other words, what does the planning process look like when deciding how you want to promote the project and when planning how you want to execute the project's goal - whether that's collecting data, raising awareness, or something else?)
      i. Are there any things that you avoid when designing a project and planning how to market it?
      ii. What are some common issues that iSea's citizen science projects have experienced (e.g. low volunteer participation)?
         1. How have you mitigated these issues?
4. With regards to the citizen science platforms you use currently, what aspects of them do you think are most beneficial to your work?
   a. Are there any aspects you think still need to be improved upon? If so, what is it and how would you improve it?
5. Do you have any ideas on how the use of iNaturalist could be improved or expanded? Any suggestions for our project?

CONCLUSION:

Thank you so much for taking the time to chat with us today! Was there anything you think that we missed or that you'd like to talk more about?

If there's anything you think of that you'd like to add, you can always reach us at gr-GPC23_iSea@wpi.edu, or by phone at [phone number].

Appendix C: NGO Interview Protocol

GENERAL CONSIDERATIONS:

- When organizing the interview we will reach out to institutions that we have found online and determined to be both active and possibly interested in using iNaturalist data. Alternatively, we may also reach out to institutions as recommended by our partners at iSea.
  - In our initial interaction, we will frame our proposed interview as an opportunity for the interviewee to tell us more about their organization's mission and needs with regard to data collection for biodiversity monitoring in return for the potential to take part in launching an exciting and powerful citizen science database in Greece.
- Interviews can take place wherever is most convenient for the interviewee - Zoom, their workspace, or a neutral public setting would all be possible.
- We would ideally like to interview someone relatively high up in the research institution who would be able to potentially coordinate hosting a project that incorporates iNaturalist into the organization's activities.
  - This person should also be aware of the needs of the institution with regards to data collection software such as iNaturalist.
- Addressing bias:
  - We will mostly ask open-ended questions to gauge the interviewee's thoughts on the matters at hand, rather than relying on yes/no questions that lead to the answers we expect.
  - We will welcome dissent and accept if the interviewee is wary of/disinterested in iNaturalist - we want partners that are open to incorporating citizen science into their endeavors and are excited about the platform!

SAMPLE INTERVIEW FORMAT

Interview with:
Date:
Time:
Location:
Attendees:

INTRODUCTION:

Hello [interviewee],

[Team introduces themselves.] We are American students doing research on implementing a new citizen science platform called iNaturalist to Greece. It's a website that allows users to submit images of organisms they come across to a database that validates the organism's identity and adds this observation to a database of submissions that can be used for scientific research and biodiversity monitoring. We are working with iSea, a local non-governmental organization (NGO) that focuses on marine biodiversity conservation and research. Our goal of this interview is to identify NGOs that have projects and missions that could be enhanced by using iNaturalist.

Appendix C: NGO Interview Protocol

Given that this is for our research project, we have a few initial things to address before we get started.

1. Would you be comfortable if we recorded this interview so we can review your answers later for our research? If not, we can just take written notes.
2. Do we have your permission to use this interview in our report? Would you like to be named if we decide to quote one of your answers or remain confidential? Our report will contain a summary of all our interviews since they are such an important part of our research. It will be available online when it's finished, and we can email it to you if you'd like.
3. If there are any questions that you don't want to answer, just let us know and we'll move on.
4. Before we begin the interview, do you have any questions for us?

NOTE: The interview will be conducted based on the following outline. If the conversation happens to flow in a way that does not follow the order of the questions, the facilitator will skip around as necessary while ensuring that we still address all the questions.

INTERVIEW QUESTIONS:

1. How long have you been working at [NGO]?
2. What made you interested in working for [NGO]?
3. How would you describe your role at [NGO]?
4. Can you tell us about some of your favorite projects that you are involved in at [NGO]?
5. In your role at [NGO], have you been able to facilitate any connections with other similar organizations?
   a. **IF YES:** Could you tell us more about how you made these connections?
6. In your own words, what would you say the mission of [NGO] is?
7. Is [NGO] interested in monitoring invasive species, endangered species, or biodiversity monitoring in general?
   a. **IF YES:**
      i. What kinds of information are you collecting? (e.g. population sizes, range of habitat, weight of observed individuals)
      ii. What are the current data collection methods that [NGO] uses?
         1. What are some things you like and dislike about this method?
         2. What do you wish this method could achieve that it currently cannot?
8. Could you explain how important you feel user friendliness is to collecting data? What about ability to collect large amounts of data? Ease of data validation?
9. In your work with [NGO], I'm sure data collection and analysis are very important. Part of our project is to determine which aspects of a data collection software are most important to organizations such as [NGO]. Could you tell us about the importance of user friendliness, the ability to collect large amounts of data, and ease of data validation in your work?

10. Are you familiar with the term citizen science? You may have also heard it referred to as community science or public participation in scientific research.

    a.**IF YES:** Does [NGO] currently participate in any citizen science initiatives?

        i.**IF YES:** Could you tell us more about them? Are you involved in facilitating these projects?

    b.**IF NO:** Citizen science involves large-scale data collection by people who aren't necessarily trained scientists. In the realm of biodiversity, this could be collecting data from the wildlife observations of people like birdwatchers or recreational divers. Given this information, do you think that [NGO] could be interested in implementing a citizen science program in the future?

        i.**IF YES:** Do you have any ideas off the top of your head of potential projects? These don't have to be polished - we're just trying to establish whether this method could be useful to your organization and its mission.

        ii.**IF NO:** Is there a particular reason why [NGO] wouldn't be interested? (For instance, are you wary of collecting data from non-scientists?)

CONCLUSION:

Thank you so much for taking the time to chat with us today! Was there anything you think that we missed or that you'd like to talk more about?

Again, this interview was incredibly valuable for our research. Would you be open to another interview within the next few weeks? [IF YES: What's the best way for us to reach you?] Do you know anyone else that might be interested in using iNaturalist and being interviewed?

If there's anything you think of that you'd like to add, you can always reach us at gr-GPC23_iSea@wpi.edu, or by phone at [phone number]. You can also contact iSea at [email/phone].

GENERAL CONSIDERATIONS:

- When organizing the interview we will reach out to institutions that we have found online and determined to be both active and possibly interested in using iNaturalist data. Alternatively, we may also reach out to institutions as recommended by our partners at iSea.
  - In our initial interaction, we will frame our proposed interview as an opportunity for the interviewee to tell us more about their organization's mission and needs with regard to data collection for biodiversity monitoring in return for the potential to take part in launching an exciting and powerful citizen science database in Greece.
- Interviews can take place wherever is most convenient for the interviewee - Zoom, their workspace, or a neutral public setting would all be possible.
- We would ideally like to interview someone relatively high up in the research institution who would be able to potentially coordinate hosting a project that incorporates iNaturalist into the organization's activities.
  - This person should also be aware of the needs of the institution with regards to data collection software such as iNaturalist.
- Addressing bias:
  - We will mostly ask open-ended questions to gauge the interviewee's thoughts on the matters at hand, rather than relying on yes/no questions that lead to the answers we expect.
  - We will welcome dissent and accept if the interviewee is wary of/disinterested in iNaturalist - we want partners that are open to incorporating citizen science into their endeavors and are excited about the platform!
- Validity of findings

SAMPLE INTERVIEW FORMAT

Interview with:
Date:
Time:
Location:
Attendees:

INTRODUCTION:

Hello [interviewee],

[Team introduces themselves.] We are American students doing research on implementing a new citizen science platform called iNaturalist to Greece. It's a free website that allows users to submit images of organisms they come across to a database that validates the organism's identity and adds this observation to a database of submissions that can be used for scientific research and biodiversity monitoring. We are working with iSea, a local non-governmental organization (NGO) that focuses on marine biodiversity conservation and research. Our goal for this interview is to learn more about your research and to explore whether iNaturalist could be of use to your work.

Appendix D: Research Institution Interview Protocol

Given that this is for our research project, we have a few initial things to address before we get started.

1. Would you be comfortable if we recorded this interview so we can review your answers later for our research? If not, we can just take written notes.
2. Do we have your permission to quote this interview in our report of our findings? Regardless of your answer, we will not quote you by name for your confidentiality. Our report will contain a summary of all our interviews since they are such an important part of our research, but you don't have to allow us to quote you if you're uncomfortable with it. It will be available online when it's finished, and we can email it to you if you'd like to read it.
3. If there are any questions that you don't want to answer, just let us know and we'll move on.
4. Before we begin the interview, do you have any questions for us?

NOTE: The interview will be conducted based on the following outline. If the conversation happens to flow in a way that does not follow the order of the questions, the facilitator will skip around as necessary while ensuring that we still address all the questions.

INTERVIEW QUESTIONS:
1. How long have you been working at [organization]?
2. What is your area of study?
   a. What made you interested in this area of study?
3. Can you tell us about some of your favorite research projects that you've worked on?
   a. What are the data collection methods that you use(d) for these projects?
      i. What are some things you like and dislike about this/these method(s)?
      ii. What do you wish this/these method(s) could achieve that it currently cannot?
4. Are you or any other Professors here interested in monitoring the presence, range, or distribution of species?
   a. **IF YES:** What kinds of information are you collecting? (e.g. population sizes, range of habitat, the weight of observed individuals)
5. Part of our project is to determine which aspects of data collection software are most important to organizations. Could you tell us about the importance of user-friendliness, the ability to collect large amounts of data, and ease of data validation in your work?
6. Are you familiar with the term citizen science? You may have also heard it referred to as community science or public participation in scientific research.
   a. **IF YES:** Does [your department] currently participate in any citizen science initiatives or use citizen science data in your research?
   b. **IF YES:** Could you tell us more about them? Are you involved in facilitating these projects?
   c. **IF NO:** Citizen science involves large-scale data collection by people who aren't necessarily trained scientists. In the realm of biodiversity, this could be collecting data from the wildlife observations of people like birdwatchers or recreational divers. Given this information, do you think that [your department] could be interested in implementing a citizen science program in the future?

      i. **IF YES:** Do you have any ideas off the top of your head of potential projects? These don't have to be polished - we're just trying to establish whether this citizen science data could be useful to your research.

      ii. **IF NO:** Is there a particular reason why [your department] wouldn't be interested? (For instance, are you wary of collecting data from non-scientists?)

CONCLUSION:

Thank you so much for taking the time to chat with us today! Was there anything you think that we missed or that you'd like to talk more about?

Again, this interview was incredibly valuable for our research. Would you be open to another interview within the next few weeks? [**If yes:** What's the best way for us to reach you?]

If there's anything you think of that you'd like to add, you can always reach us at gr-GPC23_iSea@wpi.edu, or by phone at [phone number]. You can also contact iSea at [email/phone].

GENERAL CONSIDERATIONS:

- When organizing the interview we will reach out to institutions that we have found online and determined to be both active and possibly interested in using iNaturalist data. Alternatively, we may also reach out to institutions as recommended by our partners at iSea.
  - In our initial interaction, we will frame our proposed interview as an opportunity for the interviewee to tell us more about their organization's mission and needs with regard to data collection for biodiversity monitoring in return for the potential to take part in launching an exciting and powerful citizen science database in Greece.
- Interviews can take place wherever is most convenient for the interviewee - Zoom, their workspace, or a neutral public setting would all be possible.
- We would ideally like to interview someone relatively high up in the research institution who would be able to potentially coordinate hosting a project that incorporates iNaturalist into the organization's activities.
  - This person should also be aware of the needs of the institution with regards to data collection software such as iNaturalist.
- Addressing bias:
  - We will mostly ask open-ended questions to gauge the interviewee's thoughts on the matters at hand, rather than relying on yes/no questions that lead to the answers we expect.
  - We will welcome dissent and accept if the interviewee is wary of/disinterested in iNaturalist - we want partners that are open to incorporating citizen science into their endeavors and are excited about the platform!
- Validity of findings

SAMPLE INTERVIEW FORMAT

Interview with:
Date:
Time:
Location:
Attendees:

INTRODUCTION:

Hello [interviewee],

[Team introduces themselves.] We are American students doing research on implementing a new citizen science platform called iNaturalist to Greece. It's a website that allows users to submit images of organisms they come across to a database that validates the organism's identity and adds this observation to a database of submissions that can be used for scientific research and biodiversity monitoring. We are working with iSea, a local non-governmental organization (NGO) that focuses on marine biodiversity conservation and research. Our goal of this interview is to explore the idea of creating a

curriculum for students at [school] to use iNaturalist to help them identify organisms in their environment and help contribute to scientific research in the process.

Given that this is for our research project, we have a few initial things to address before we get started.

1. Would you be comfortable if we recorded this interview so we can review your answers later for our research? If not, we can just take written notes.
2. Do we have your permission to quote this interview in our report of our findings? Regardless of your answer, we will not quote you by name for your confidentiality. Our report will contain a summary of all our interviews since they are such an important part of our research, but you don't have to allow us to quote you if you're uncomfortable with it. It will be available online when it's finished, and we can email it to you if you'd like to read it.
3. If there are any questions that you don't want to answer, just let us know and we'll move on.
4. Before we begin the interview, do you have any questions for us?

NOTE: The interview will be conducted based on the following outline. If the conversation happens to flow in a way that does not follow the order of the questions, the facilitator will skip around as necessary while ensuring that we still address all the questions.

INTERVIEW QUESTIONS:

1. How long have you been working at [school]?
2. What made you interested in working for [school]?
3. **OPTIONAL:** How would you describe your role at [school]?
4. **OPTIONAL:** Can you tell us about some of your favorite lessons that you teach?
5. In your own words, what are some of the core aspects of [school] curriculum that you think lessons should focus on?
6. In your teaching, do you incorporate any hands-on active learning activities?
   a. **IF YES:** Can you tell us about them?
7. Are you familiar with the term citizen science? You may have also heard it referred to as community science or public participation in scientific research.
   IF NECESSARY: Citizen science involves large-scale data collection by people who aren't necessarily trained scientists. In the realm of biodiversity, this could be collecting data from the wildlife observations of people like birdwatchers or recreational divers.

We're interested in potentially helping to create a curriculum for [school] that will allow students to use the iNaturalist app to identify species and contribute to the scientific community in the process.

EXAMPLES of this could include having students identify invasive species and talk about the impacts of these species or identifying weeds and pests in the fields so they can learn more about them and how to prevent their spread.

Given this information, do you think you/[school] would be interested in potentially using iNaturalist as part of a lesson plan?

    i. **IF YES:**
        1. What ages do you think would be most appropriate for an activity like this?
        2. Do you think there would be any barriers to students accessing mobile devices to complete the activity?
        3. Do you have any other ideas for how iNaturalist could be implemented in the classroom?
        4. Do you have any other people at [school] that you think might be interested in learning more about our initiative?
    ii. **IF NO:** Is there a particular reason why [school] wouldn't be interested? (For instance, is there a no-phone policy for students?)

CONCLUSION:

Thank you so much for taking the time to chat with us today! Was there anything you think that we missed or that you'd like to talk more about?

Again, this interview was incredibly valuable for our research. Would you be open to another interview within the next few weeks? [If yes: What's the best way for us to reach you?]

If there's anything you think of that you'd like to add, you can always reach us at gr-GPC23_iSea@wpi.edu, or by phone at [phone number]. You can also contact iSea at [email/phone].

Appendix F: User Testing Protocol

INTRODUCTION:

Hello everyone,

Thank you for participating in our user testing exercise! You will be given the materials, and have a few minutes to review them, download iNaturalist, and make an account. Then we will go into the field and observe you making observations on iNaturalist for twenty minutes, followed by a short debrief.

Go to the field and split into small groups, 10 minutes to make observations and for us to take notes on 1-3 participants, depending on turn-out

DEBRIEF:
1. Did you encounter any trouble when figuring out how to post observations?
    a. What aspects of using iNaturalist did you find difficult or confusing?
2. Did you have to continually consult the pamphlet?
3. Do you think you'd be able to use iNaturalist without any help (including from the pamphlet) tomorrow?
4. Did you find the pamphlet engaging/attractive or distracting?
5. What do you think is the most important benefit provided by iNaturalist?
6. How likely are you to use or recommend iNaturalist in the future on a scale of 1-5?
7. Do you have any recommendations for improvements that could be made to the materials?
    a. Did you find any important information to be lacking or confusing?

What is iNaturalist?

iNaturalist is a social networking platform for citizen scientists and biologists that aims to map biodiversity.

Observations that are submitted to iNaturalist are added to the app's database. From there, users can validate each other's observations to increase the confidence rating of the observation. Once a post has reached "research grade", scientists can then use it in their research.

Who can use iNaturalist?

Anyone! iNaturalist's power comes from the fact that anyone can upload and verify observations.

iNaturalist acts as a social network for amateur and expert naturalists from all across the world!

Device requirements

iNaturalist can be accessed on most iPhones, computers, and Android devices that are able to take pictures and connect to the internet.

The application can be downloaded to mobile devices on the Google Play Store and Apple App Store, or accessed via web browser at https://www.inaturalist.org/observations.

For iPhone   For Android

Want to know more about incorporating iNaturalist into your organization?

Contact iSea by email!
info@isea.com.gr

greece.inaturalist.org

Introducing
iNaturalistGR

Why use iNaturalist?

iNaturalist serves as a helpful personal tool and aids conservation efforts in data collection

Species Occurrence Records

By contributing to iNaturalist, you will be contributing to the 12-fold increase in global species observations that has resulted since the implementation of citizen science platforms. This increase in data allows researchers to better construct necessary environmental policies and conservation efforts.

Species Identifcation

Gain access to a useful tool for quick identification of plant or animal species from photos using AI and peer review methods.

Social Networking

Connect with biodiversity organizations and projects to learn more about conservation efforts in your area and connect with like-minded people.
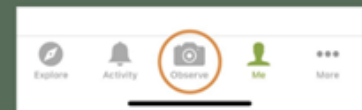
Active Learning Exercise

Many schools and universities have implemented iNaturalist into biology course curriculums to gauge students interest in biodiversity.

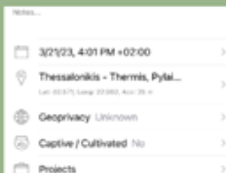## HOW TO POST AN OBSERVATION
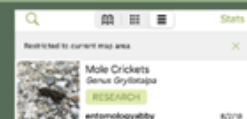
1 Tap the observation icon

2 Take or upload a photo or audio recording

3 Add species identification or use the AI feature to view suggestions

4 Enter additional information

5 Share and scroll!

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For iPhone　　For Android

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info@isea.com.gr

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Introducing

iNaturalistGR

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Social Networking

Connect with *biodiversity organizations* and projects to learn more about *conservation efforts* in your area and connect with like-minded people.

Active Learning Exercise

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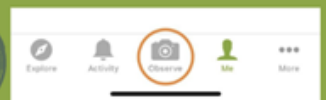
HOW TO POST AN OBSERVATION

1 Make an account

2 Tap the observation icon

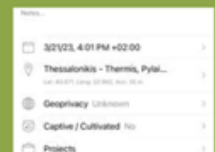**3** Take or upload a photo or audio recording

4 Click "What did you see?" to view AI suggestions

5 Pick the species that matches closest

6 Enter additional information and notes

7 Share and scroll!

iNaturalistGR

iNaturalist is a social networking platform for citizen scientists and biologists that aims to map biodiversity.

Identify Species

- Take pictures of your own observations.
- View AI-generated identification suggestions.

Connect Through Nature

- Start projects with fellow naturalists.
- View other species in your area.
- Comment on others' findings.

Assist Researchers

- Add to a global species-tracking database .
- Allow scientists to inform better environmental policies.

English Website

Want to know more about Projects on iNaturalist?

Contact iSea by email!

info@isea.com.gr

Greek Website

iNaturalistGR

iNaturalist is a free citizen science platform that provides researchers with data for monitoring global species presence and distribution

Create Your Own Project

- Focus on a topic of your choice
- Keep all relevant observations in one location
- View and connect with all the users that joined your project

Collaborate with Others

- See data from other researchers' projects
- View peer-reviewed observations listed as "Research Grade"
- Offer identifications to others
- Reach out to active users

View and Download Data

- Click explore to get access to all global observations
- Filter uploads by quality, range, species, etc.
- Select download to get a spreadsheet of the data

English Website

Questions?

Contact iSea by email!

info@isea.com.gr

Greek Website

iNaturalist FAQs

What is an observation?

- **An observation is a record of an individual organism at a specific time in a specific location.**
- Observations can be images of the organism itself in addition to sounds or proof that an organism was present such as tracks, nests, and recently deceased animals.
- Observations are not required to have photos or sounds attached, but these observations cannot be verified and therefore cannot achieve research grade.
- **Each organism should have its own separate observation post,** but one post can contain multiple pictures of the **same** organism as long as they were taken on the same date at the same location.

What are the different types of observations?

Verifiable observations have a date, location, photo or sounds, and are determined by the community to not be a captive/cultivated organism.	**Casual observations** are considered not useful for research based on community feedback. *Example: the date/location is inaccurate or the organism appears to be cultivated by humans*	A verifiable observation achieves **research grade** when more than ⅔ of identifiers agree on its taxon. This is the most useful kind of observation for researchers!

What does captive/cultivated mean?

The captive/cultivated designation shows that the organism exists in the time and place that it was observed because of human actions. *Example: zoo animals, pets, plants in a garden*	All other organisms are considered wild/naturalized. *Example: weeds in a garden, feral animals*

iNaturalist FAQs

Can I upload old photos?

Yes, as long as you know the correct date and location that the image was taken.

Can I upload videos?

No, but you can take a screenshot from a video and post that as an observation.

How do I add sounds?

On the web, you can add sounds by dragging wav, mp3, or m4a files into the uploader on iNaturalist, or using the import tool. You can also record sounds in the Android and iOS apps.

I have more questions!

There are many online resources that delve deeper into any other questions you might have about iNaturalist. Below is a QR code for a comprehensive iNaturalist FAQ.

More resources

iNaturalist website
(EN)

iNaturalist website
(GR)

iNaturalist FAQs
(EN)

Appendix M: Nature Scavenger Hunt for EEC Use

Use iNaturalist to make observations that fulfill the requirements listed below and write the species it is in the table. You can have multiple observations for each category, but only if they are two distinct species (ex. two different trees). You do not need to find every item. You can only use each observation once, so an orange flower could count for an orange plant OR a flower, but not both. Each type of observation is worth a different amount of points, so compete with your friends to see who can get the most!

Item	Point Value	Species Found	Total
A tree	1		
A bush	1		
A flower	2		
A wild grass (weed)	2		
A bug that crawls	3		
A bird	4		
A plant with fruit	5		
A tree with non-green leaves	6		
A plant with thorns	7		
A bug that flies	8		
An animal with fur	9		
A plant with an orange part	9		
A plant with a purple part	9		
A snail	10		
Final Total			

Appendix M: Nature Scavenger Hunt for EEC Use

HINT: For larger organisms, try taking multiple pictures of the same organism and uploading them under one post to make it easier to identify!

Example: If you are trying to identify a tree, take close up pictures of one of its leaves, its bark, and then a picture of the entire tree.

QUESTIONS

For 5 of your favorite observations, write at least one fun fact about them from the information feature on the website in the space below.

Were you satisfied with the amount of nature/greenery in the city?

What did you notice about the diversity of nature you saw? Was the amount of diversity high or low?

There are many stray cats and dogs in Thessaloniki. How do you think this could affect people and other animals in the city?

Why do we bother planting trees in the city?

Appendix N: Debrief Questions for Students Post Nature Scavenger Hunt

INTRODUCTION:

Hello everyone,

Thank you for participating in our game! We'd love to get your thoughts on it, what you liked, and what you didn't, as well as things you think could be improved.

DEBRIEF:

1. Were you able to download the app and make an account easily?
2. Did you have any problems figuring out how to post observations?
3. In the instructions for using iNaturalist, did you find any important information to be lacking or confusing?
4. Do you have any recommendations that could make our iNaturalist instructions easier to understand?
5. Were the instructions for the game clear?
6. Was the game too easy, too hard, or just right?
7. Did you find iNaturalist engaging as a learning tool?
8. Did you learn anything new or exciting about the nature in Thessaloniki?
9. Do you have any ideas for how the game could be improved?
10. Do you think you would use iNaturalist again?
11. Would you like to see iNaturalist incorporated into your school's science class curriculums?

Any other comments?

Appendix O: Survey to Top iNaturalist Users

Hello! As mentioned in our initial message, we are students from Worcester Polytechnic Institute (WPI) in the United States completing a project in Greece. We are currently working with iSea (an NGO that manages iNaturalist's Greek portal) to increase the usage of iNaturalist in Greece, with the overall goal of improving biodiversity monitoring in the region.

We reached out to you because you are a top user of iNaturalist either globally or in Greece, and we want your feedback! As part of our project, we want to know your opinions on the best and worst things about iNaturalist so that we can identify areas that should be highlighted or need improvement.

Informed consent statement: Participation in this survey is completely voluntary - you can choose to skip any question or completely withdraw your participation at any time. All your responses will be recorded anonymously.

1. I have read and understood the above informed consent statement and am willing to participate in this survey.
2. How did you learn about iNaturalist?
3. When did you join iNaturalist?
4. In your opinion, what are the best features of iNaturalist?
5. What are your thoughts on the social aspects of iNaturalist?
6. Do you think being able to comment on and confirm other people's observations is useful?
7. In your opinion, what are some aspects of iNaturalist that could be improved?
8. Have you used any other applications that are similar to iNaturalist (e.g. eBird)?
   a. **IF YES:** Which applications?
   b. How does this app compare to iNaturalist? What does it do better? Worse?

CATALYZING OPPORTUNITIES FOR CITIZEN SCIENCE THROUGH INATURALIST

Written By:

Alana Lue Chee Lip,
Clare Nargi,
Kenneth Niemiec, &
Kyra Robinson

3 May 2023