CITIZEN SCIENCE:
THEORY AND PRACTICE

Engagement in a Citizen Science Project in the Amazon Basin

CASE STUDIES

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ABSTRACT

Citizen science is a growing field that has the potential to better integrate citizens' demands and concerns into research projects through participatory methods, and its approach can contribute to large-scale monitoring projects. In this case study article, we share and discuss methods used to promote participant engagement in a pilot initiative of the Citizen Science for the Amazon Project (CSAP). The overall project collects information on fisheries through an app and its upload tool. The pilot initiative was implemented in the main stem area of the Amazon River in Brazil from 2018 to 2019. We worked with 26 target groups, engaging participants in sessions to use and evaluate the app. Participants are residents of local communities, riverine people (*ribeirinhos*), with rich knowledge of natural resources and with specific conservation concerns. Fishing is an important source of income and nutrition, and fishery management strategies are a way to access and strengthen land rights. Engaging local communities in citizen science requires specific approaches to promote dialogue between different types of knowledge systems. We present an overview of our participatory strategies and use qualitative data from our monitoring to analyze outcomes. Our key recommendations include: recognizing traditional knowledge holders, including local interests, and upgrading tools according to these interests; using communication strategies to promote equitable dialogues; and stimulating and fostering networks between citizen scientists. By sharing this experience, we aim to contribute to future citizen science projects, especially in rural areas in the Global South.

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INTRODUCTION

The Amazon Basin is the largest river basin in the world, interconnected by swaths of rivers and rainforest and home to a large diversity of migratory fish (Venticinque et al. 2016; Goulding et al. 2019). Fishing is one of the most important socioeconomic activities in Amazonia. A large portion of the rural and peri-urban population depends on fishing as a primary food source; this is especially true for indigenous and traditional peoples (Santos and Santos 2005; Isaac and Almeida 2011).

Since the 1960s, the intensification of commercial fisheries has increased pressure on Amazonia's fisheries (McGrath et al. 2015). Currently, the main stem area harbors some of the most productive fisheries in the Brazilian Amazon (Barthem and Goulding 2007). Within the context of increasing pressure on fisheries, many communities express an interest and need to develop fishery management systems, which are also opportunities to develop participatory conservation initiatives.

Aquatic conservation in Amazonia has often focused on floodplain fisheries, developing cooperative management at the local level (Goulding et al. 2019). These efforts have been successful for some species, such as *Arapaima* spp. (Castello et al. 2011); however, a lack of more transnational cooperation for fisheries management is observed. The scale of the Amazon requires an integrated approach, more adequate to the life histories of migratory species, as they use multiple spaces over the basin throughout their life cycles (Goulding et al. 2019; Faber and Barthem, 2005).

Citizen science projects are a potential solution to those concerns. Using replicable technologies, many projects work over large spatial scales to account for migration patterns and to collect and analyze crucial information for conservation (Lasky et al. 2021; Wood et al. 2011; Bonney et al. 2014; Bonney et al. 2009b; Gouveia et al. 2004). Citizen science projects can also encourage broad participatory processes, expanding knowledge and promoting learning (Hecker et al. 2018). Yet citizen science is not a common concept in Amazonia. Experiences in participatory management or monitoring are more common (Pocock et al. 2018; Danielsen et al. 2009). Projects in this region, and their participants, have specific demands and characteristics different from citizen science initiatives in Europe or North America (Constantino 2020; Ostermann-Miyashita et al. 2021).

In Amazonia, participatory projects are commonly implemented in indigenous or traditional communities. Local knowledge systems are key to enhancing understandings of the environment—in such a way that indigenous and traditional communities can determine their own futures (Hill et al. 2020; Malmer et al. 2020; Tengö et al. 2021, 2014). Through their ways of knowing and cosmologies, they maintain relationships with humans and other-than-human beings, as part of complex webs in which relations are expressed more in terms of kinship than property (Blaser 2013).

Intersections with conservation initiatives also highlight the need to overcome colonialist practices that do not account for the social costs of losing access to land and resources owing to conservation policies or inadequate participatory processes (Trisos, Auerbach, and Katti 2021; Tironi, Vega, and Antileo 2021; Staddon, Nightingale, and Shrestha 2015). Even in Amazonia, where indigenous, *Quilombola*, and traditional peoples have a long and recognized presence in the socioenvironmental movement, an instrumentalist perspective to conservation prevails (Lima 2019). In this sense, when implementing participatory projects in Amazonia, including citizen science projects, the relationship between different knowledge systems, natural resource access and land rights, and income generation are key elements that must be considered in conservation strategies.

Considering the potential of participatory approaches for fisheries management in the Amazon Basin, the Wildlife Conservation Society (WCS) led the Citizen Science for the Amazon Project (CSAP). The CSAP employs a citizen science approach to generate information on different fish species, their habitats, and migratory paths across the Amazon Basin, involving citizen scientists as informed and empowered agents. The main scientific question guiding the CSAP is: "How do fish migrations work in the Amazon Basin, and what environmental factors influence them?".

An app and a database were developed to record fishery activities. The app, named Ictio, is available for Android mobile phones. It allows people to record fishing activities or observations made at markets, and provide information on species, the number of individuals, total weight, market price, location, date, and photographs. The database includes information shared by app users and historic monitoring data from existing datasets, shared by different institutions through an upload tool.

Initiatives related to CSAP have been implemented in 15 different areas in Brazil, Bolivia, Colombia, Ecuador, and Peru. In 2017, the Mamirauá Institute for Sustainable Development (IDSM) joined the project. IDSM conducted a pilot initiative from 2018 to 2019, in the main stem area of the Amazon River in Brazil (Venticinque et al. 2016).

Most of the participants in the pilot initiative live in rural areas inside the Mamirauá and Amanã Sustainable Development Reserves. Local community participation has been key to the success of conservation strategies and management practices in this area (Franco et al. 2021; El Bizri et al. 2020; Lima and Peralta 2017).

Participants are riverine people (*ribeirinhos*). This Brazilian Amazonian social group came into formation in the aftermath of Portuguese colonialism and comprises people from a mixed cultural background whose main economic activities include agriculture and fishing (Lima and Peralta 2017). As experienced fishers, many have deep knowledge of trophic chains and feeding, and reproductive, migratory, and parental care behaviors. To fish, they develop mechanisms of ecological control and species conservation, based on their daily interactions with and observations of nature. Ecological and cosmological knowledge is passed down from generation to generation, yet at the same time, new information is learned from multiple sources, and innovations continually emerge (Estorniolo, Ferreira, and Rainho 2021).

In this case study, we present the methods developed to promote participant engagement during the pilot initiative, and lessons learned from this experience. Our results are based on the early stages of the CSAP, specifically related to the pilot initiative undertaken by IDSM, and could be relevant to other projects in planning stages. Our goal is to contribute to citizen science projects and to the expansion of this type of initiative, especially in rural areas in the Global South. First, we describe the strategies used to implement the pilot initiative; then we analyze our results in terms of promoting participation. We work with information gathered through the monitoring process, which includes qualitative data from regular reports, interviews with participants, and an exercise entitled Most Significant Change**.** Finally, we share key recommendations based on the lessons we learned through this collaborative process.

DESIGN OF PILOT INITIATIVE AND STRATEGIES

The pilot initiative was developed in 21 months; we spent 15 months with the target groups and nine months working with versions 1.0 and 2.0 of Ictio (see Figure 1). During the pilot initiative, we implemented educational activities, promoted Ictio app use, and discussed participatory monitoring and use of collected data, using diagnosis and communication strategies to support and guide these activities. We developed the pilot with 26 target groups (see Table 1) that included local communities and local organizations considered important as fishers and as participants of civil society- in other words, key citizens. With some groups (Fisher Organizations and Communities),

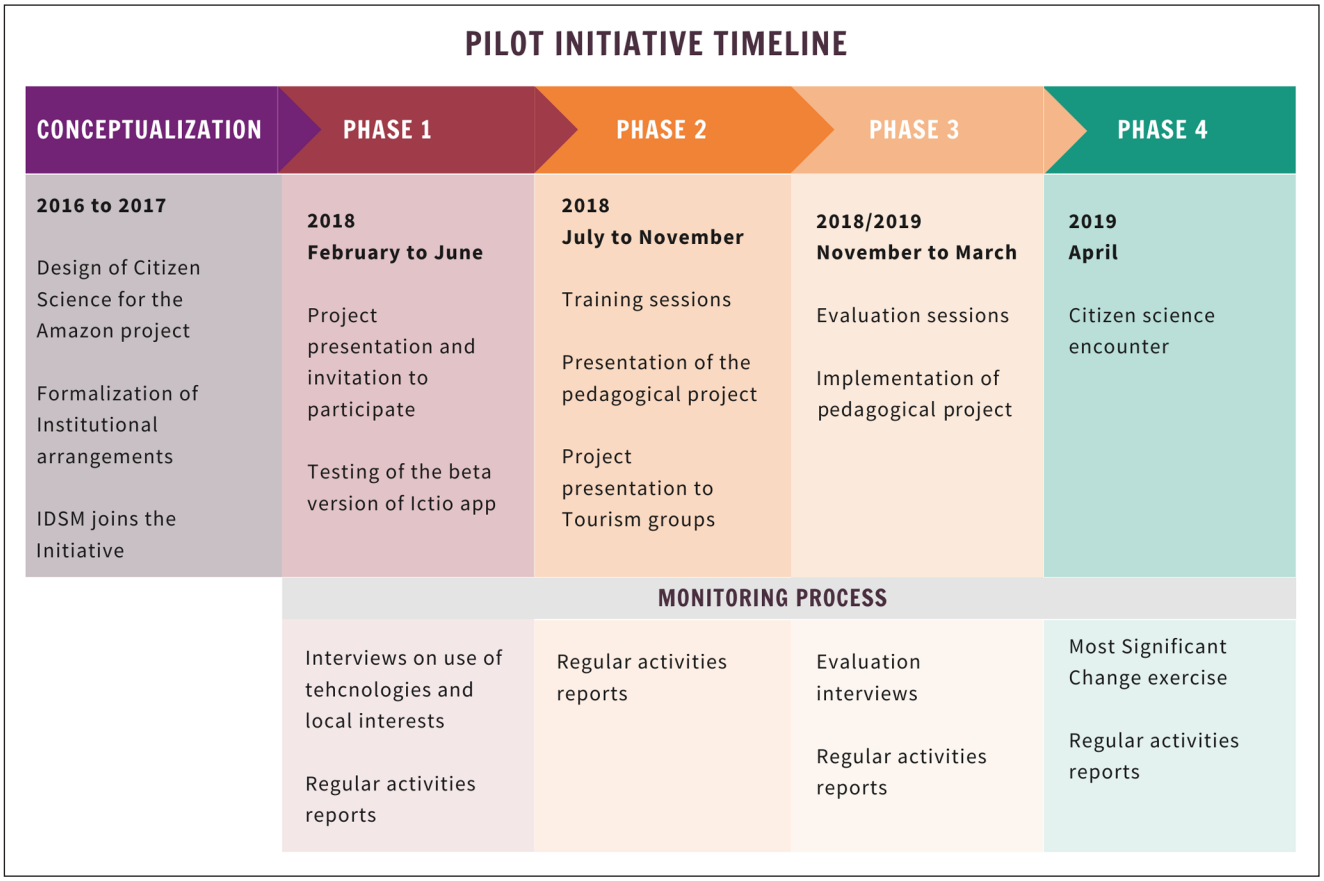

Figure 1 Timeline of the pilot initiative and monitoring process. Most Significant Change: MSC.

TYPE OF TARGET GROUP	APPROACH	INTERNET ACCESS	TOTAL
Fisher Organizations	Continuous work Activities related to presenting the app and project; training and evaluation	Provided by users	9
Communities (from rural areas)	Continuous work Activities related to presenting the app and project; training and evaluation	IDSM's institutional internet	4
		Provided by users	4
Tourism (community-based enterprises)	Selected presentations and communication material	IDSM's institutional internet	1
		Provided by user	1
Regular Schools (public schools)	Pedagogical project	Not applied	6
Technical School (educational project for adults from rural areas placed in Tefé city)	Continuous work Pedagogical activities and app testing and training	IDSM's institutional internet	1

Table 1 Groups involved in the pilot initiative, their characteristics, and the approaches we took with each**.**

Note: IDSM: Mamirauá Institute for Sustainable Development.

we developed continuous work, including presentations on the overall project and the Ictio app, training sessions on the use of the app, and evaluation sessions. With two Tourism groups, we promoted a few presentations and provided communication materials. With Regular and Technical Schools, we developed pedagogical activities, with or without Ictio's training. Internet access was provided by an institutional connection or by users themselves.

Before starting the work with the app itself, we gave presentations in communities and fisher organizations, inviting them to participate in the pilot initiative (Phase 1). Our presentations were designed to stimulate conversation on topics, such as fisheries management and local knowledge. With the beta version of Ictio released in April 2018, we held a test training with two Fisher organizations, with one Community group, and with the Technical School (Phase 1). Ictio was officially released in July 2018. In August, we started training sessions focused on the Ictio app and its functionalities, practical exercises, and policy for sharing and using data (Phase 2). Evaluation sessions (Phase 3) entailed participants' evaluation of the app after training. Data collected through Ictio was also presented and discussed.

We facilitated a citizen science encounter as our last evaluation session (Phase 4). We invited organizations, researchers, and participants from target groups and participants from other regions in Brazil also involved in the project, like Porto Velho, Santarém, and Manaus. During a two-day workshop, we promoted discussions on how data could be used for local interests and in conservation strategies. We also conducted an exercise based on the Most Significant Change (MSC) method. We asked participants to share their experiences, promoting dialog between different groups and with researchers. We also held a discussion on the future of the Ictio app.

For Tourism groups, few project-dissemination activities were undertaken. We presented the project to guides, and printed materials were left at two tourist lodges located in the Mamirauá Sustainable Development Reserve (Phase 2).

The target groups of schools, has distinct characteristics. Six Regular Schools used a pedagogical project named Amazonia Basin: Connectivity, Migrations, and Citizen Science. The teachers were introduced to the material (Phase 2) and used it in their classrooms (Phase 3).

The Technical School group was the IDSM Vocational Technological Center (CVT).[1] CVT students are fishers or come from fishing families. Therefore, they were considered potential users of Ictio. We developed specific activities with these students, including testing the app, developing educational activities, and promoting evaluation discussions (Phases 1, 2, 3, and 4).

A CLOSER LOOK AT PARTICIPATORY STRATEGIES

Participatory strategies are a crucial element for citizen science initiatives. We planned to promote participation and multi-way dialogues, therefore including local interests in the conversation. Importantly, a citizen science project related to Amazonian fisheries needs to recognize fishing as a crucial economic activity and also consider its importance to territorial and natural resource management and cultural identity. In this context, respectful and equal participation is imperative.

When introducing the project to the different target groups, we discussed local historical efforts to manage fisheries, local environmental and fisheries knowledge, and the basin-wide scale of the project. We used a specific question to jump-start the discussion, focusing on sharing

information as equals (Gazenvoort et al. 2017; Vitos et al. 2017; Stevens et al. 2014). Specifically, "Have you ever seen a catfish (*Brachyplatystoma rousseauxii*) ovulate?" This allowed us to start the conversation based on fishers' knowledge and techniques because it is not common for the *Brachyplatystoma rousseauxii* to reproduce in our study region (Barthem et al. 2017; Duponchelle et al. 2016).

To better understand local interests and the scenario in which the pilot initiative would be implemented, we also performed interviews during Phase 1. We investigated how people use specific technologies (email, internet, and smartphones) and if they might be interested in using an app to register information on fisheries management.

Communication was key during the implementation of the pilot initiative; our general goal was to promote an open dialogue between target groups and researchers. A broad selection of communication materials was elaborated for use during sessions—in addition to other products to keep participants informed and motivated. For instance, we developed news articles and reports, regular radio programs, calendars, folders, information packets, digital presentations, banners, and videos on how to use Ictio and/or share data.

Users' testimonies and photos were included in communication materials, so that participants could see themselves represented. Testimonies were directly related to Ictio use and fish species, and also included fishing stories, or even jokes, fisheries management concerns, and messages for other users. Since many of our participants have different education levels, we preferred visual language techniques to both capture users' attention and promote understanding.

We produced materials to be shared offline, considering that participants do not regularly access online information. For training materials, we chose to print most of our resources, because most communities do not have regular access to electricity.

During the sessions, we used visual registration techniques, such as using posters that could be built as interactive figures to analyze work completed; we also showed printed photos and data from Ictio, thereby creating opportunities to discuss the information and to decide how to proceed with future work.

LESSONS LEARNED AND BEST PRACTICES

In general, citizens' participation in a citizen science project can be done at different levels (Haklay 2018; Schrögel and Kolleck 2018; Singh et al. 2014; Bonney et al. 2009a). Engagement can be evaluated considering various dimensions such as motivations, what is learned, affection, participation in broader activities, and social connections (Phillips et al. 2019). We considered the use of the Ictio app itself as a level of involvement, but also analyzed participation in general discussions, and the capacity of the project to adapt itself to local demands (Staddon, Nightingale, and Shrestha 2015; Vitos et al. 2017). The latter is crucial, since our work was developed with traditional communities, on their territories and related to fisheries, which is a central activity in their lives.

In this section, we present what we learned with regard to the initiative's implementation strategies. By evaluating monitoring information, we were able to understand the outcomes and limits of the proposed strategies, pointing to the best practices for potential use in other projects (see Table 2).

INTRODUCING THE PILOT INITIATIVE

Introducing the project to participants beginning with a question was a good way to stimulate dialogue. It allowed us to start the discussion on the basis of fishers' knowledge, as opposed to scientific evidence, creating space for fishers to talk about their experiences. During these conversations, we heard that many fishers had never captured an ovulating *Brachyplatystoma rousseauxii*. One fisher told us that about 20% of the *Brachyplatystoma rousseauxii* he caught were ovulating. Others had never seen *Brachyplatystoma rousseauxii* ovulating at all. For another fisher, species like the *Calophysus macropterus* are a mystery because he had never caught one ovulating. During the presentation, fishers also pointed out how the project's main scientific question is also the basis of their work. Fishers know local migration processes well; they know when fish are passing through, and fish according to this information.

PHASE 1 INTERVIEWS

Interviews during this phase highlighted local concerns and allowed us to better prepare for planned activities (see Appendix A). In the study area, smartphone use is not universal and internet access can be difficult and sporadic, even in urban centers. Younger citizens tend to make a greater use of these technologies. But even among younger participants, email is not a commonly used tool, and by default, neither is Google Play (See Figure 2).

During interviews we asked participants about their interest in using an app to register fishery records. Interests in nature conservation and in learning are commonly cited as factors that motivate citizens' participation (Phillips et al. 2019; Gazenvoort et al. 2017). These interests were also mentioned by our interviewees. For example, someone mentioned that "the app could help decrease predatory actions, such as illegal fisheries and excessive extraction."

TYPE OF TARGET GROUP	OUTCOMES	RECOMMENDATIONS
Fisher Organization	Administrative staff are not users, but they can advertise Ictio Groups with more contact with IDSM had more availability to promote Ictio	Project agenda needs to be in line with group availability Organizations have regulatory roles and we need to make it clear that Ictio data is private to users Continue working with administrative staff to promote Ictio
Communities	Different levels of Ictio use General interest in discussions promoted by the project Test of functionalities and recommendations for app updates Evaluation of potential uses of Ictio's data	Project agenda needs to be in line with group availability Phase 1 interviews allowed us to better prepare and respond to local interests Participants should recognize themselves in communication materials Communications materials could discuss local interests App needs to address local interests in data collection Login and app updates need to be adapted local specificities Discuss data collected through Ictio and information from different places Create a network of users
Tourism	No use of Ictio; Low interest in the initiative	Sport fishers need some specific functionalities in the app Create an iOS version for Ictio
	No use of Ictio; Low interest in the initiative	
Regular Schools	High interest in the initiative. The pedagogical project was adapted by teachers. Students were able to share their knowledge on fisheries.	Work with teachers to encourage them to be protagonists and implement the project according to their interests and ideas Consider and work with students' knowledge of fisheries
	With adult students, low interest in the initiative	Work with the teacher to adapt the pedagogical project to adult classes
Technical School	With the CVT, we had high-use level use of Ictio	Produce communication materials with groups in response to their interests Students could promote Ictio in their communities

Table 2 Outcomes and recommendations organized by target group.

Note: IDSM: Mamirauá Institute for Sustainable Development, CVT: IDSM Vocational Technological Center.

Fishing as an important source of income also appears among participants' desire to engage with the technology (as mentioned, "It's a way to know and control the quantity and the quality of the fish we caught," and "To the association [of fishers] and to the Flona's [Conservation Unity] Fishery Arrangements, it will be very important"). This makes it clear that we are working with an activity that is central to participants' lives, and is not a hobby or volunteer activity.

Informants were further motivated by the opportunity to be a part of a group. For them, the use of the app could help create relationships with fishers from different places (as mentioned, "To learn about the fish from Bolivia and other places," and "To improve knowledge exchange between other fishers").

Information from Phase 1 Interviews made us aware of technological challenges and the risks of marginalizing participants (Pateman et al. 2021). It also showed us how important the citizen science encounter (Phase 4) might be. We used this phase to create the following specific strategies.

How to address local questions

Because Ictio mainly registers information about where fish are caught and in which quantities, some information of local interest can be entered in the app as notes. During training with target groups, the potential of the note field was highlighted. However, notes alone could not be the only way to address this interest. Using the note function requires that people input information, which could be difficult in cases of low literacy, and could also present challenges when systematizing data. Thus, we also addressed and discussed local interests outside the app, using videos, radio programs, maps, folders, etc;

How to involve senior citizens

Senior participants had less contact with technologies like smartphones and the internet, but they are very

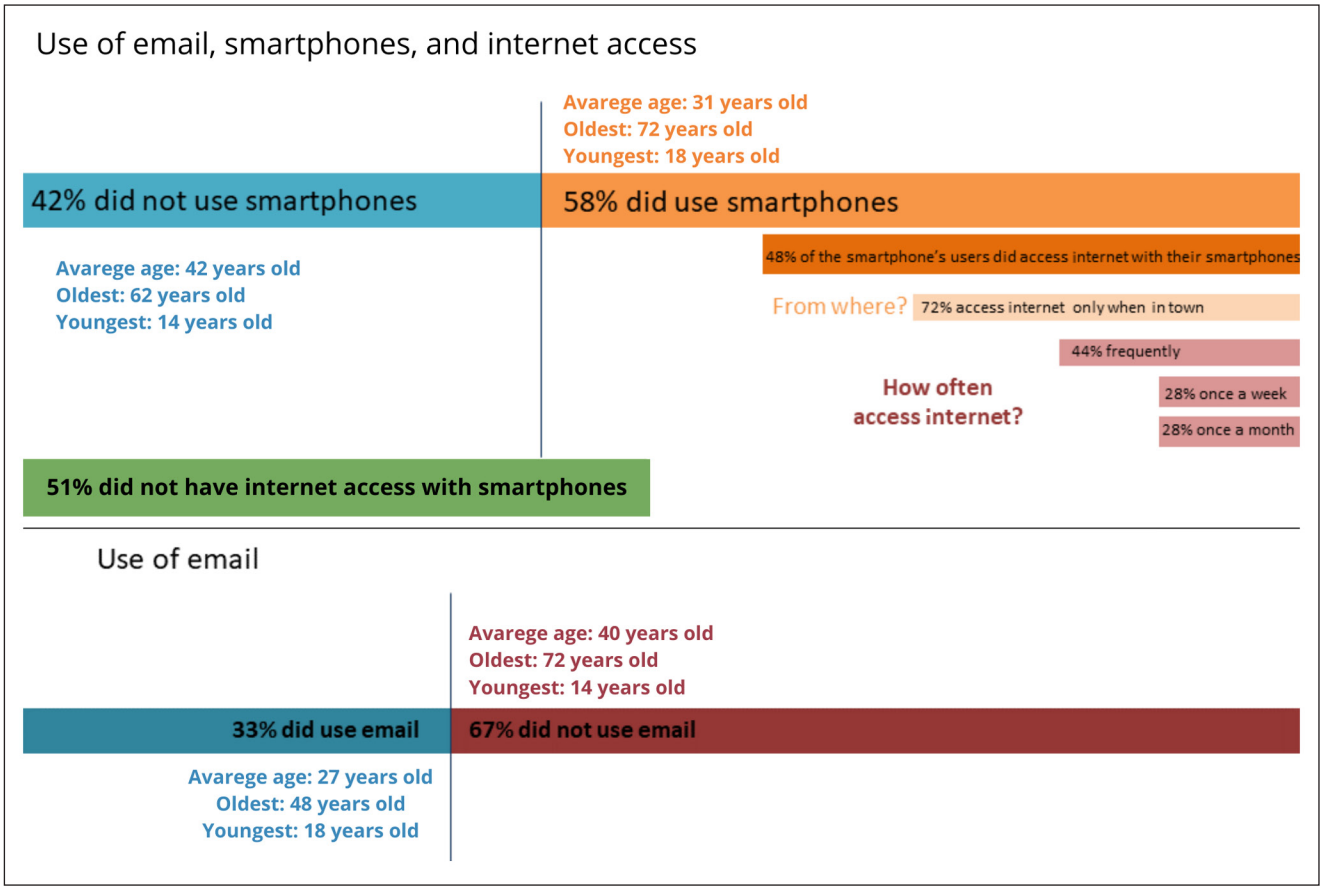

Figure 2 Use of email, smartphones, and internet access, related to participants' average age.

experienced fishers. To overcome this limitation, younger people could be encouraged to use Ictio with older relatives or neighbors (Vitos, et al. 2017); this would also promote interactions between people of different age groups in collaborative work. Meetings could thus be planned as an opportunity to engage people who are not directly using the app. At the same time, communication materials could also involve seniors by sharing their stories;

How to facilitate participant login

Since an email account is required to log into Ictio, we created general email accounts for most target groups. Logging into the app requires an internet connection, and it was often difficult to connect during training sessions, as in many communities the internet is not available. During training sessions, we generally had at least one smartphone already logged into Ictio (using the general account per group) so people could begin inputting fishery data.

COMMUNICATION

Communication materials played an important role in discussions, helping to share information about the project and to motivate participants (Crall et al. 2017; Hood-Nowotny et al. 2019). Long-term citizen science projects need ongoing collaboration and quality communication to inform, motivate, and engage participants (Hecker et al. 2018). Communication materials produced rendered positive results. These materials consolidated information from all the sites where the Ictio app was also being used, thus increasing users' perception of belonging to a larger network. They also highlighted that the accomplishments are possible only through the work of each participant, reinforcing the importance of cooperation among all groups. We also used communication materials to address local demands not met through the app itself, such as providing complementary information on fish and data sharing (on a basin-wide scale and at regional and local levels).

We acknowledge that communication materials should privilege participants' voices. In our case, participants spoke positively about being able to recognize themselves and their contributions in the materials, through recorded testimonies, stories, and photos. Some participants mentioned that, through this material, people from their communities now give them more recognition for their work (Phase 3 interviews).

TRAINING AND EVALUATION SESSIONS

The strategies used during training and evaluation sessions (with Fisher Organizations and Communities) also had good results. The practical exercises proved fun and important, helping to clarify details regarding Ictio use. They provided an opportunity to understand user difficulties and to present app functionalities. The use of printed materials allowed people to interact with course materials (see Figure 3). These techniques helped to increase the sense that we were building discussions together (Vitos et al. 2017; Evens et al. 2014; Evens and Guariguata 2016). Participants were also interested in the general discussions promoted by the project; of particular interest were themes like fish behavior, fishing techniques, monitoring, and management strategies.

Some technical problems occurred during the sessions. Many times, participants with an interest in Ictio could not log in. They had to wait for an opportunity to go to the nearest place with internet access to log in, which was inconvenient. Another problem related to login was the email requirement—something our participants generally do not use. As a consequence, participants do not commonly use Google Play to download/update apps. People use generally alternative offline transfer apps (like ShareIt), which requires that someone has the newest app version to share it with others. Groups ended up mainly working with the general accounts, and we were not able to create an alternative login process. In this context, if we want to promote an autonomous use of the app, we recommend that the Ictio login be adapted to local contexts. As a secondary solution, we could promote internet literacy activities or even look for ways to improve communities' access to the internet, a very complex process.

Once logged in, Ictio users did not have difficulties using the app, mainly because they were younger participants. Senior representatives took part in the activities and shared their data, which were recorded in Ictio by younger friends or family members.

After at least one training and one evaluation session (Phase 3), we conducted evaluation interviews (see Appendix B). Our results showed that the main challenge for users, after logging into Ictio, was related to poor internet connectivity (either a poor connection or no connection at all), which made it difficult or impossible to upload data, particularly photos. This is a sensitive issue that directly impacts the amount of data able to be shared. Participants also mentioned that they expected Ictio's new versions to be more interesting. They wanted to have access to a wider range of information through the app, including statistics related to their data. They also wanted the opportunity

Figure 3 Activities with selected target groups. Photos: Vanessa Eyng.

to learn more about other parts of the Amazon and suggested more interaction between users. Version 2.5 of Ictio fulfilled some of these expectations owing to the feedback between app developers and users; however, this version was released after the implementation of the pilot initiative and thus we did not evaluate it.

The citizen science encounter promoted interaction among different target groups, and some mentioned that they had learned about different places. Some participants commented on how they appreciated the presentation of a researcher who brought information on fisheries from across the Amazon Basin. They were impressed by the lack of monitoring data and the potential to collect information on a basin-wide scale.

The MSC exercise pointed to some key elements for understanding local engagement, as well as to the different relationships participants maintained with the project (see Table 3). It is interesting to note that participants' stories range from issues of youth engagement (mainly using the Ictio app) to local organization, perceptions of a users' network, and potential monitoring and scientific outcomes of the project.

As of June 2019, there were 11 active users with group Ictio accounts out of the 17 groups expected to use Ictio (Fisher Organization, Communities, and the Technical School). Most were from Community groups; the average age was 27 years, and eight were men and three were women. These numbers are positive given the short period of time (only nine months) dedicated to the use of the Ictio app, especially considering the context of technology development and constant app updates. After 2019, we did not conduct additional engagement activities, in part due to the COVID-19 pandemic, which restricted in-person activities. During 2020, seven users were still active. They shared 12% of the total lists exchanged through the Ictio app during the year.

In regard to Fisher Organizations, involvement was more restricted to supporting the pilot initiative. We worked mainly with administrative staff. In a few cases they used Ictio, but they are not necessarily fishers. We participated in regular meetings, advertising Ictio to associated fishers. Additionally, constituents of this target group have their own agendas that require an approach to engagement on a political level, beyond what our training or evaluation sessions could do. Since information on fisheries can often be sensitive data, with these groups it is important to emphasize the difference between personal data from the Ictio app, and data from the database, not shared on individual levels.

OTHER GROUPS

The teachers involved in the Regular School group evaluated the pedagogical project positively.[2] The most critical point was the presentation given to teachers in the middle of the Brazilian school year. The teachers had to reorganize some of their usual activities to include our initiative. Despite this difficulty, using project materials allowed students to share their knowledge on fisheries Some teachers mentioned that they have learned a lot from their students. In the case of adult classes, our results show a low level of engagement. Closer work with teachers working with this age group could improve future results.

The work with the Technical School CVT was conducted over the course of one year, which allowed us to build a relationship with students, who provided a very detailed evaluation of Ictio's functionalities. During activities, students insisted on more information about fish in Ictio. To address this demand, an educational brochure was created, with information on fish species, recreational activities, and recipes. The students themselves researched the content and shared their knowledge on fish behavior

THEMES OF THE STORIES	EXAMPLES
Youth engagement	Young people engaged themselves in scientific research
	Incentive for children to help record information gathered by their parents
Network between users (at different levels)	Learning about fish from other places and knowledge exchange
	Learning other fishers' realities
Local organization	Greater community member involvement
	Recognizing the value of fishers' work
	Environmental education activities
Monitoring information and scientific research	Monitoring the community's fish consumption
	More organized information
	Fishers becoming researchers

Table 3 Outcomes of the Most Significant Change exercise elaborated during the citizen science encounter.

and fishery techniques. They also used the brochures to support educational activities in their communities.

Regarding the Tourism groups, the strategy we developed was unsuccessful. In general, tourists were not interested in the materials we left at the lodges. In the case of a sport fishery tourist package, the guides mentioned that for these tourists, Ictio was not an effective way to register their fishing activities (same species more than once, with size measurements). Also, foreign tourists normally use smartphones with the iSO system, not compatible with Ictio.

CONCLUSIONS

Based on our findings, we understand that continued engagement, in the medium and long term, is related to the capacity of Ictio to respond to user expectations, to consolidate a user network, and to make tools available for data visualization across different scales. Ensuring better internet connectivity is important to the future of the initiative.

In terms of fisheries management, Ictio data (from the app and from the database) needs to be more politically relevant; this requires stakeholder mobilization and database consolidation (more information, from broader watersheds). However, efforts to work on a basin-scale are worthwhile. A broader reach could bring key information to manage fisheries on this scale, and at the same time, guarantee local communities' access to natural resources to sustain their ways of life.

In future projects, which involve traditional communities in conservation strategies, we recommend some general principles, including working alongside citizen scientists as equals, including them in the conceptual stages of projects and in data collection and analysis. We also recommend the dissemination of initiatives and their evaluation and the elaboration of future phases, according to their interests.

Considering participants as key knowledge holders should be a mainstay of Citizen Science projects, particularly involving indigenous and traditional communities who are experts in this regard. This needs to be addressed in an equitable and adequate way throughout the entire process. In Amazonia, and even in other contexts, these relationships open up to a vast range of opportunities for citizen science projects to engage with different knowledge systems.

We hope that the lessons obtained through our pilot experience, and the best practices described in this paper, are useful to other projects, especially those involving traditional communities in the Global South. We recognize the importance of truly understanding the local context, so that strategies are not prescribed, but are flexible, leaving space for local adaptation.

DATA ACCESSIBILITY STATEMENT

The Ictio dataset is available on Ictio.org. Translated Phase 1 interviews data is available in Appendix A and translated Phase 3 interviews data is available in Appendix B. Personal data has not been made public to preserve interviewees' privacy.

NOTES

1 The CVT is program supported by the Brazilian Ministry of Science, Technology and Communications, and was implemented by IDSM in 2014. The CVT was conceived to provide training to youth representatives from rural communities working with the sustainable management of Amazonian natural resources. More information is available here: https://www.mamiraua.org.br/centro-vocacional.

2 The receptivity of the pedagogical project was so positive that we chose to expand the work to other schools. We signed a Cooperation Agreement with Tefé City Hall to develop training sessions with teachers, working with the same project. Activities with teachers started on April 17, 2019 and were developed until July 2019.

SUPPLEMENTARY FILES

The supplementary files for this article can be found as follows:

- **Supplemental File 1.** Appendix A. DOI: https://doi.org/10.5334/cstp.453.s1
- **Supplemental File 2.** Appendix B. DOI: https://doi.org/10.5334/cstp.453.s2

ETHICS AND CONSENT

This study gained approval from the Mamirauá Institute Ethics Committee (process number CAAE 04008318.4.0000.8117), which includes proper procedures to guarantee free, prior, and informed participation. Groups in the pilot initiative were present and informed about the work and freely decided to participate in the project.

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

VE and MCG made substantial contributions to the conception and design of this case study, to the analysis and interpretation of the data, and wrote the manuscript; VE and LMFC made substantial contributions to data acquisition; APH and LMFC contributed to the drafting of this manuscript.

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REFERENCES

Barthem, R and **Goulding, M.** 2007. *Um Ecossistema Inesperado – A Amazônia Revelada pela Pesca*. Lima: ACA/Sociedade Civil Mamirauá.

Barthem, R, Goulding, M, Leite, RG, Cañas, C, Forsberg, B, Venticinque, E, Petry, P, Ribeiro, MLB, Chuctayay, J and **Mercado, A.** 2017. Goliath catfish spawning in the far western Amazon confirmed by the distribution of mature adults, drifting larvae and migrating juveniles. *Scientific Reports*, 741784. DOI: https://doi.org/10.1038/srep41784

Blaser, M. 2013. Notes towards a political ontology of 'environmental' conflicts. In: Green, L (ed.), *Contested Ecologies: Nature and Knowledge*, 13–27. Cape Town: HSRC Press.

Bonney, R, Ballard, H, Jordan, R, McCallie, E, Philips, T, Shirk, J and **Wilderman, CC.** 2009a. Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. *A CAISE Inquiry Group Report*. Washington, DC: Center for Advancement of Informal Science Education (CAISE).

Bonney, R, Cooper, CB, Dickinson, J, Kelling, S, Phillips, T, Rosenberg, KV and **Shirk, J.** 2009b. Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience*, 59(11): 977–984. DOI: https://doi.org/10.1525/bio.2009.59.11.9

Bonney, R, Shirk, J, Philips, T, Wiggins, A, Ballard, H, Miller-Rushing, A and **Parrish, J.** 2014. Next steps for citizen science. *Science*, 343(6178): 1436–1437. DOI: https://doi.org/10.1126/science.1251554

Castello, L, Pinedo-Vasquez, M and **Viana, JP.** 2011. Participatory conservation and local knowledge in the Amazon várzea: The pirarucu management scheme in Mamirauá. In: Pinedo-Vasquez, M, Ruffino, M, Padoch, CJ and Brondizio, ES (eds.), *The Amazon várzea: the decade past and the decade ahead*, 261–276. New York: Springer-Verlag. DOI: https://doi.org/10.1007/978-94-007-0146-5

Constantino, PAL. 2020. Challenges of Forest Citizen Involvement in Biodiversity Monitoring in Protected Areas on Brazilian Amazonia. In: Lepzyk, C, Boyle, OD and Vargo, TLV (eds.), *Handbook of Citizen Science in Conservation and Ecology*, 237–247. Oakland: University of California Press. DOI: https://doi.org/10.1525/9780520960473-021

Crall, A, Kosmala, M, Cheng, R, Brier, J, Cavalier, D, Henderson, S and **Richardson, A.** 2017. Volunteer recruitment and retention in online citizen science projects using marketing strategies: lessons from Season Spotter. *Journal of Science Communication*, 16(1): A01. DOI: https://doi.org/10.22323/2.16010201

Danielsen, F, Burgess, ND, Balmford, A, Donald, PF, Funder, M, Jones, JPG, Alviola, P, Balete, DS, Blomley, T, Brashares, J, Child, B, Enghoff, M, Fjeldså, J, Holt, S, Hubertz, H, Jensen, AE, Jensen, PM, Massao, J, Mendoza, MM, Ngaga, Y, Poulsen, MK, Rueda, R, Sam, M, Skielboe, T, Stuart-Hill, G, Topp-Jørgensen, E and **Yonten, D.** 2009. Local participation in natural resource monitoring: a characterization of approaches. *Conservation Biology*, 23(1): 31–42. DOI: https://doi.org/10.1111/j.1523-1739.2008.01063.x

Duponchelle, F, Pouilly, M, Pécheyran, C, Hauser, M, Renno, JF, Panfili, J, Darnaude, AM, García-Vasquez, A, Carvajal-Vallejos, F, García-Dávila, C, Doria, C, Bérail, S, Donard, A, Sondag, F, Santos, RV, Nuñes, J, Point, D, Labonne, M and **Baras, E.** 2016. Trans-Amazonian natal homing in giant catfish. *Journal of Applied Ecology*, 53(5): 1511–1520. DOI: https://doi.org/10.1111/1365-2664.12665

El Bizri, HR, Fa, JE, Lemos, LP, Campos-Silva, JV, Vasconcelos Neto, CFA, Valsecchi, J and **Mayor, P.** 2020. Involving Local

Communities for Effective Citizen Science: Determining Game Species' Reproductive Status to Assess Hunting Effects in Tropical Forests. *Journal of Applied Ecology,* 58(2): 224–35. DOI: https://doi.org/10.1111/1365-2664.13633

Estorniolo, M, Ferreira, JCL and **Rainho, AP.** 2021. Manejo de peixes de água doce e marinhos. In: Cunha, MC, Magalhães, SB, Adms, C. (Org). *Povos tradicionais e biodiversidade no Brasil*. São Paulo: SBPC.

Evens, K and **Guariguata, MR.** 2016. *Success from the ground up* – Participatory monitoring and forest restoration. CIFOR, Occasional Paper.

Evens, K, Larson, A, Mwangi, E, Gronkleton, P, Maravanyika, T, Hernandez, X, Müller, P, Pikitlelt, A, Marchena, R, Mukasa, C, Tibazalika, A and **Banana, A.** 2014. *Field guide to Adaptive Collaborative Management and improving women's participation*. CIFOR.

Fabré, NN and **Barthem, R.** (eds). 2005. *O manejo dos grandes bagres migradores piramutaba e dourada – no eixo Solimões-Amazonas*. Manaus: Ibama – ProVarzea.

Franco, CLB, El Bizri, HR, Souza, PR, Fa, JE, Valsecchi, J, Sousa, IS and **Queiroz, HL.** 2021. Community-Based Environmental Protection in the Brazilian Amazon: Recent History, Legal Landmarks and Expansion across Protected Areas. *Journal of Environmental Management,* 287: 112314. DOI: https://doi.org/10.1016/j.jenvman.2021.112314

Gazenvoort, W, Born, RJG, Halffman, W and **Turnhout, S.** 2017. Sharing biodiversity data: citizen scientists' concerns and motivations. *Biodiversity and Conservation,* 26: 2821–2837. DOI: https://doi.org/10.1007/s10531-017-1391-z

Goulding, M, Venticinque, E, Ribeiro, MLDB, Barthem, R, Leite, RG, Forsberg, B, Petry, P, Silva-Júnior, UL, Ferraz, PS and **Cañas, C.** 2019. Ecosystem-based management of Amazon fisheries and wetlands. *Fish and Fisheries*, 20: 138–158. DOI: https://doi.org/10.1111/faf.12328

Gouveia, C, Fonseca, A, Câmara, A and **Ferreira, F.** 2004. Promoting the use of environmental data collected by concerned citizens through information and communication technologies. *Journal of Environmental Management,* 71: 135–154. DOI: https://doi.org/10.1016/j.jenvman.2004.01.009

Haklay, M. 2018. Participatory citizen science. In: Hecker, S, Haklay, M, Bower, A, Makuch, Z, Vogel, J and Bonn, Al (eds.), *Citizen Science: Innovation in Open Science, Society and Policy*, 52–62. London: UCL Press. DOI: https://doi.org/10.14324/111.9781787352339

Hecker, S, Luckas, M, Brandt, M, Kikillus, H, Marenbach, I, Schiele, B, Sieber, A, Vliet, AJH, Walz, U and **Wende, W.** 2018. Stories can change the world – citizen science communication in practice. In: Heckers, S, Haklay, M, Bower, A, Makuch, Z, Vogel, J and Bonn, Al (eds.), *Citizen Science: Innovation in Open Science, Society and Policy*, 445–462. London: UCL Press. DOI: https://doi.org/10.14324/111.9781787352339

Hill, R, Adem, Ç., Alangui, WV, Molnár, Z, Aumeeruddy-Thomas, Y, Bridgewater, P, Tengö, M, Thaman, R, Adou Yao, CY, Berkes, F, Carino, J, da Cunha, MC, Diaw, MC, Díaz, S, Figueroa, VE, Fisher, J, Hardison, P, Ichikawa, K, Kariuki, P, Karki, M, Lyver, POB, Malmer, P, Masardule, O, Yeboah, AAO, Pacheco, D, Pataridze, T, Perez, E, Roué, MM, Roba, H, Rubis, J, Saito, O and **Xue, D.** 2020. Working with Indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. *Current Opinion in Environmental Sustainability*, 43: 8–20. DOI: https://doi.org/10.1016/j.cosust.2019.12.006

Hood-Nowotny, R, Wawra, A, Watzinger, A and **Ziss, E.** 2019. Combining Lab-Based Analysis and Science Communication with an Experimental Citizen Science Approach: Does Biochar Improve Resilience of Plants to Drought Stress? *Citizen Science: Theory and Practice*, 4(1): 27: 1–9. DOI: https://doi.org/10.5334/cstp.195

Isaac, VJ and **Almeida, MC.** 2011. *El Consumo de Pescado en la Amazonía Brasileña*. COPESCAALC Occasional Paper No. 13. Food and Agriculture Organization (FAO).

Lasky, M, Parsons, A, Schuttler, S, Mash, A, Larson, L, Norton, B, Pease, B, Boone, H, Gatens, L and **Kays, R.** 2021. Candid Critters: Challenges and Solutions in a Large-Scale Citizen Science Camera Trap Project. *Citizen Science: Theory and Practice*, 6(1): 4. DOI: https://doi.org/10.5334/cstp.343

Lima, D and **Peralta, N.** 2017. Developing Sustainability in the Brazilian Amazon: Twenty Years of History in the Mamirauá and Amanã Reserves. *Journal of Latin American Studies*, 49(4): 799–827. DOI: https://doi.org/10.1017/S0022216X17000414

Lima, DM. 2019. Áreas protegidas na Amazônia e o porvir: Por uma composição possível. In: Galúcio, AV, Prudente, AL. (Orgs). *Museu Goeldi: 150 anos de Ciência na Amazônia,* 222–246. Belém: Museu Paraense Emílio Goeldi.

Malmer, P, Vanessa, M, Austin, B and **Tengö, M.** 2020. Mobilisation of indigenous and local knowledge as a source of useable evidence for conservation partnerships. In: Sutherland, WJ, Brotherton, PNM, Davies, ZG, Ockendon, N, Pettorelli, N, Vickery, JA. (Orgs). *Conservation Research, Policy and Practice*, 82–113. Cambridge: Cambridge University Press. DOI: https://doi.org/10.1017/9781108638210.006

McGrath, DG, Castello, L, Almeida, OT and **Estupiñán, GMB.** 2015. Market Formalization, Governance, and the Integration of Community Fisheries in the Brazilian Amazon. *Society & Natural Resources,* 28(5): 513–529. DOI: https://doi.org/10.1080/08941920.2015.1014607

Ostermann-Miyashita, EF, Pernat, N and **König, HJ.** 2021. Citizen science as a bottom-up approach to address human–wildlife conflicts: From theories and methods to practical

implications. *Conservation Science and Practice,* 3: e385. DOI: https://doi.org/10.1111/csp2.385

Pateman, R, Dyke, A and **West, S.** 2021. The Diversity of Participants in Environmental Citizen Science. *Citizen Science: Theory and Practice*, 6(1): 9. DOI: https://doi.org/10.5334/cstp.369

Phillips, TB, Ballard, HL, Lewenstein, BV and **Bonney, R.** 2019. Engagement in science through citizen science: Moving beyond data collection. *Science Education*, 103(3): 665–690. DOI: https://doi.org/10.1002/sce.21501

Pocock, MJO, Chandler, M, Bonney, R, Thornhill, I, Albin, A, August, T, Bachman, S, Brown, PMJ, Fernandes Cunha, DG, Grez, A, Jackson, C, Peters, M, Rabarijaon, NR, Roy, HE, Zaviezo, T and **Danielsen, F.** 2018. A Vision for Global Biodiversity Monitoring With Citizen Science. In: Bohan, DA, Dumbrell, AJ, Woodward, G and Jackson, M (eds.), *Advances in Ecological Research*, 59: 169–223. Academic Press. DOI: https://doi.org/10.1016/bs.aecr.2018.06.003

Santos, GM and **Santos, ACM.** 2005. Sustentabilidade da pesca na Amazônia. *Estudos Avançados*, 19(54): 165–182. DOI: https://doi.org/10.1590/S0103-40142005000200010

Schrögel, P and **Kolleck, A.** 2018. The Many Faces of Participation in Science. *Science & Technology Studies*, 32(2): 77–99. DOI: https://doi.org/10.23987/sts.59519

Singh, NJ, Danell, K, Edenius, L and **Ericsson, G.** 2014. Tackling the motivation to monitor: success and sustainability of a participatory monitoring program. *Ecology and Society,* 19(4): 7. DOI: https://doi.org/10.5751/ES-06665-190407

Staddon, SC, Nightingale, A and **Shrestha, SK.** 2015. Exploring participation in ecological monitoring in Nepal's community forests. *Environmental Conservation*, 42(3): 268–277. DOI: https://doi.org/10.1017/S037689291500003X

Stevens, M, Vitos, M, Alenbuchner, J, Conquest, G, Lewis, J and **Haklay, M.** 2014. Taking Participatory Citizen Science to Extremes. *Pervasive Computing*, 13(2): 20–29. DOI: https://doi.org/10.1109/MPRV.2014.37

Tengö, M, Austin, BJ, Danielsen, F and **Fernández-Llamazares, A.** 2021. Creating Synergies between Citizen Science and Indigenous and Local Knowledge. *BioScience*, 71(5): 503–518. DOI: https://doi.org/10.1093/biosci/biab023

Tengö, M, Brondizio, ES, Elmqvist, T, Malmer, P and **Spierenburg, M.** 2014. Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance: The Multiple Evidence Based Approach. *AMBIO,* 43(5): 579–591. DOI: https://doi.org/10.1007/s13280-014-0501-3

Tironi, M, Vega, D and **Antileo, JR.** 2021. Bude uncommon: extractivist endings and the unthinkable politics of conservation in Lafkenche territory. *Tapuya: Latin American Science, Technology and Society,* 4: 1. DOI: https://doi.org/10.1080/25729861.2021.1984639

Trisos, CH, Auerbach, J and **Katti, M.** 2021. Decoloniality and anti-oppressive practices for a more ethical ecology. *Nature Ecology & Evolution*, 5: 1205–1212. DOI: https://doi.org/10.1038/s41559-021-01460-w

Venticinque, E, Forsberg, B, Barthem, R, Petry, P, Hess, L, Mercado, A, Cañas, C, Montoya, M, Durigan, C and **Goulding, M.** 2016. An explicit GIS-based river basin framework for aquatic ecosystem conservation in the Amazon. *Earth System Science Data*, 8(2): 651–661. DOI: https://doi.org/10.5194/essd-8-651-2016

Vitos, M, Conquest, G, Altenbuchner, J, Lewis, J, Stevens, M and **Haklay, M.** 2017. Supporting Collaboration with Non-Literate Forest Communities in the Congo-Basin. In: *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17)*. New York, USA: Association for Computing Machinery, 1576–1590. DOI: https://doi.org/10.1145/2998181.2998242

Wood, C, Sullivan, B, Iliff, M, Fink, D and **Kelling, S.** 2011. eBird: Engaging Birders in Science and Conservation. *PLoS Biology,* 9(12): e1001220. DOI: https://doi.org/10.1371/journal.pbio.1001220

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