Redefining Citizen Science in the USGS?: A Community Development and Participation Perspective

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Abstract

Citizen science, or participation in the scientific process by members of the general public, is an important tool for science education and community empowerment. However, many agencies and institutions engaged in citizen science programming do not fully embrace their own definitions of citizen science, relegating community participation to data collection alone. In this paper, I explore the case of a United States Geological Survey (USGS) citizen science project on the Colorado River in Grand Canyon. I draw from my personal experience as a citizen scientist on this project, interviews with citizen science program managers and experts as well as community development, community participation, and youth focused citizen science literatures to argue to that the USGS:

1. Adjust its definition of citizen science to reflect actual activities and practices
2. Adjust activities and practices around citizen science to adhere more fully to its current definition.

Background

Community for Data Integration (CDI) is a working group of scientists and researchers with a shared interest in the generation, use, and communication of scientific data including data derived from USGS citizen science programs. CDI is funded and led by the USGS (Govoni, L. D., & Liu, S., 8 February 2018). CDI defines citizen science as "scientific observation, measurement, research, and related activities conducted, in whole or in part, by amateur or nonprofessional scientists and other citizen volunteers"[1]. The USGS itself currently defines citizen science as "scientific work undertaken by members of the general public, usually in collaboration with scientific institutions" (USGS, 30 September 2015)[2]. Both of these definitions suggest broad citizen or community participation in all parts of the research process. Because the USGS identifies as "leading federal agency in fostering citizen science," it is an interesting and appropriate institution for scrutiny here. Do USGS citizen science practices align with the institutions' own definitions of citizen science?

Citizen Science "History"

The history of citizen science as a scientific research and education strategy is not easily summarized. As Dickenson and Bonney highlight out in "Why Citizen Science?," the introduction to Citizen Science: Public Participation in Environmental Research, the "earliest published information about ecology and natural history [in North America] came primarily from 'amateur' naturalists such as Henry David Thorough and John Muir" (Dickinson, J. L., Bonney, R., & Fitzpatrick, J. W., 2015). I add Rachel Carson, to this list and note that prior to European colonization, people native to the Americas were scientists and stewards of these lands.

While the specific origin narrative of amateur science is contested, it is clear that the past decade has seen significant increase in discourse around citizen participation in professional science projects (Dickinson, J. L., Bonney, R., & Fitzpatrick, J. W., 2015; Metes, J. M., 2017). Citizen science data collection has led to publication of a variety of scientific journal publications. Long established projects including the Audubon Christmas Bird Count, COASST, and various programs supported by the University of MN's

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[1] According to the CDG website, this definition was modified from Wikipedia in 2013. The webpage was further edited in February 2018, but there is no mention of whether this edit impacted the definition of citizen science.
[2] This definition was adopted in September of 2015.

Monarch Labs have resulted in numerous scientific publications on topics as wide ranging as effects of West Nile Virus on sensitive species and survey design (Christmas Bird Count Bibliography, 2016 November 28); Mueller, M. P. , Tippins, D. , Bryan, L. A., 2012)[34].

Current scholars in the field of citizen science tend to define the term broadly as "public participation in organized research efforts" (Dickinson, J. L., Bonney, R., & Fitzpatrick, J. W., 2015). This expansive definition captures the diversity of kinds of engagement that such projects can engender, without overstating citizen power in these processes. There appears, however, to be a disconnect between scholars in the field and agencies involved in citizen science programming, such as the USGS. The two definitions shared in the introduction to this paper define citizen science in ways that suggest public involvement with each stage in the research process. Analysis of citizen science programming demonstrates that while scientific process includes problem definition, hypothesis generation, research design, data collection, data analysis, conclusion derivation, and a variety of other sub-processes, community participation even in projects claiming the citizen science label is often limited to data collection (J. Metes, personal communication, Jan. 2018; Mueller, M. P. , Tippins, D. , Bryan, L. A. 2012.; Ries, L., & Oberhauser, K., 2015; Aceves-Bueno, E., et.al, 29 September 2017).

Fig. 1 – Depicts the research process as depicted in *To Wonder, To Learn* (Mckenzie, J. A., 2005)

Theoretical Framing

Community Development is the theory and practice of strengthening community agency and capacity through addressing challenges and enhancing community assets (Rubin H. J. & Rubin J., 2008; Osterman P., 2002). Community developers argue for social programs that respond directly to community needs and desires, meaning that citizen science in the spirit of community development necessitates consideration for community members in all parts of the scientific process. Further, community developers frequently center the notion of self-interest in discussions about participation and power. The idea here is that all parties,

[3] Despite growing enthusiasm amongst government officials, educators, policymakers, and some scientists, concern for the rigor and validity of a publically collected data remains high amongst some in the scientific community. Aceves-Bueno et al.'s review of citizen science data quality literature includes studies finding that data collected by amateurs is more accurate than data collected by professionals (29 September 2017). Other studies find that youth collected data is as accurate as adult collected data (Aceves-Bueno et.al., 29 September 2017). Still other studies find that volunteer ability to detect ecosystem changes, for example, is limited (Aceves-Bueno et.al. 29 September 2017).

[4] It is important to note that not all publications resulting from these citizen science projects are focused on community collected data. Instead these publications focus on learning outcomes and education impacts.

defined as persons to communities, in a truly collaborative process should be empowered to act in their own self-interest and to pursue their own goals and objectives. A pursuit of self-interest, as opposed to a charity, on the part of all parties, ensures long-term commitment to initiatives for community change (DeFilippis, J. 2010, Tönnies, F., & Loomis, C. P., 2002). Relevant to the question of citizen science in particular, Aceves-Bueno et.al find that “if citizens scientists have an economic or health stake in the outcome percent agreement is, on average 68% higher than the general volunteer type” (286).

Sherry Arstein’s (1969) Ladder of Citizen Participation, displayed below, argues against the normative assumption that citizen participation in research is inherently positive.

Fig. 2 – Depicts the Ladder of Citizen Participation theorized by Sherry Arstein in 1969 (Arnstein, S. R. 1969).

She suggests a spectrum of community participation from non-participation to degrees of citizen control, with a variety of intermediary rungs such as a placation and delegated power. Fundamentally, this model asks “who holds the power in relationships between researchers (or policymakers) and members of the public?” Arnstein’s ladder, while useful to this conversation about institutional power, has been widely critiqued for its reductive nature and inability to capture nuance. Community organizers, researchers, planners, and policymakers agree that full citizen control may not always be desirable or possible (Collins, K., & Ison, R., 2009., Kopetzky, A. D., 2009., Tritter, J.Q. 2016). I include the model here, however, to establish that community participation experts are agree expected to be explicit about the kind of community participation they solicit, be it consultation, placation, information, partnership, or full participation (extending to problem definition).

Finally, researchers and practitioners in the field of youth-focused community and citizen science continue to explore the question of "authentic participation." In May 2016, the UC Davis Community and Citizen Science Center hosted a convening of educators, program leader, and researchers focused on bridging theory and practice around youth-focused community and citizen science. Researcher-presenters at this convening argued that citizen science creates opportunities for diverse roles and complex products, concluding that youth-focused citizen science must demand authentic participation not only in scientific processes but “within local, professional, and peer communities” (Summary Report).

The Grand Canyon Context - Light Trapping in the Grand Canyon

Since 2012, the USGS has been engaged in a citizen science project deep inside the Grand Canyon. The Grand Canyon Monitoring and Research Center (GCMRC), interested in understanding the wide-ranging impacts of Glen Canyon dam, developed a citizen science program to support the collection of adult aquatic insect samples. GCMRC has partnered with guides and outfitters for nearly 5 years, sending kits containing small bottles of ethanol and black lights with interested parties. Citizen scientists set a light trap, a plastic container filled with ethanol accompanied by a black light, at the river's edge each night of their 14-21 day trips down the Colorado River. Insects caught in the trap are bottled and transported back to GCMRC at the conclusion of the trip, where scientists count and identify the specimens. Citizen participants receive $10.00 for each sample they provide.

Fig. 3 + 4 – Depict the USGS Light Trapping Citizen Science protocol in action.

Early findings from this research indicate that edge-laying insects like mayflies, whose larva are a food source for the endangered native fish, the Humpback Chub, are heavily impacted by tidal effects caused by the dam. Mayfly eggs are laid through cementation (Kennedy et.al, 2017). The eggs are attached to the underside of rocks and logs on the edges of the Colorado. When the water level is high, immediately after a dam release, these eggs are covered by river water. When the water level drops significantly as water travels downriver from the dam, the eggs are left exposed and vulnerable to drying (Kennedy et.al 2017).

GCMRC research ecologists are clear that the citizen science aspect of this project is critical to its success (J. Muehlbauer, personal communication, Jan. 2018). Citizen scientists, since the project's inception have collected thousands of samples and millions of individual insects. Professional scientists collect for the project on the Colorado a few times each year, but non-professional data yield and coverage is more abundant and more thorough than sampling by professional scientists.

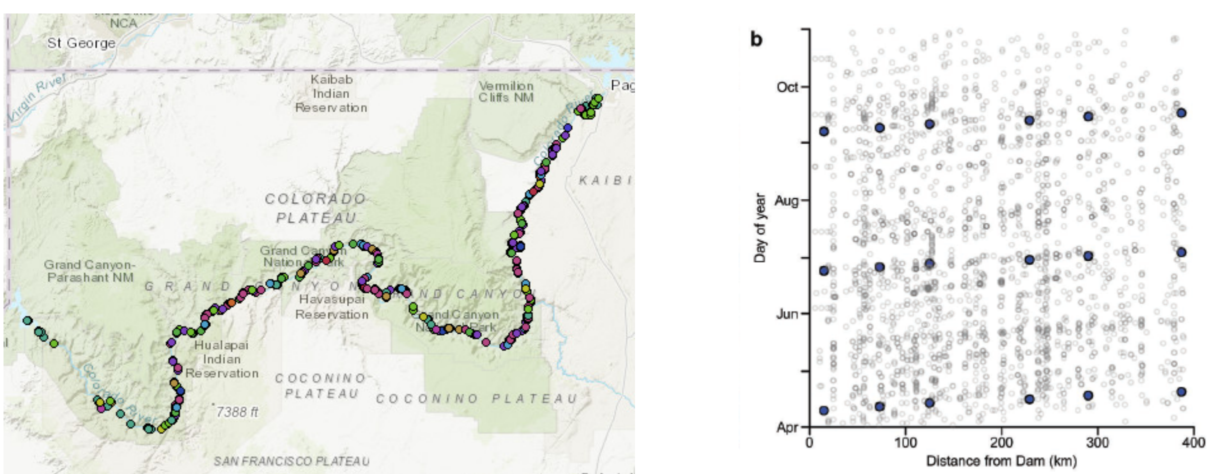

Fig. 5 – Depicts sampling locations for the USGS Light Trapping Citizen Science project. The color of the dot corresponds to the outfitter/guiding company leading the collection

Fig. 6 – Depicts sampling done by professional scientists (blue) compared with sampling done by citizen scientists (gray). The quantity and frequency of samples collected by professionals are dwarfed by the quantity and frequency of samples collected by non-professionals.

Results from this release confirm results from previous research on other dam rivers indicating that hydropeaking, or river tidal effects produced by dam releases, has strong and negative impacts on aquatic insect diversity (Kennedy et.al, 2017).

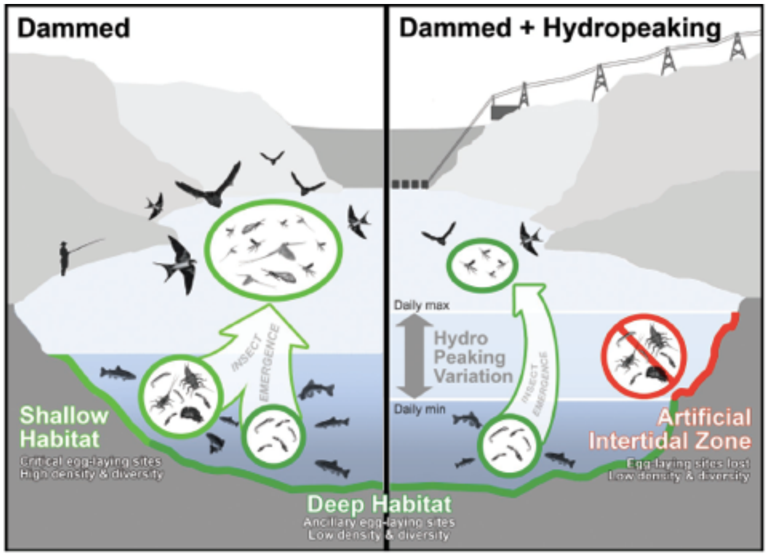

Fig. 7 – Depicts compares impacts of dammed and dammed/hydropeaking (or tidal effects) rivers. Dammed/hydropeaking rivers, like the Colorado in the Grand Canyon can experience limitations on aquatic insect and invertebrate diversity.

The Kennedy et.al confirms that edge layers are more highly impacted by hydropeaking than open water layers and that egg mortality is significantly increased when low flows occur around dusk (2017). Data from the light trapping project has produced multiple publications including a 2017 paper recommending "stable low flow releases" during the weekends when hydroelectricity demand is low (Kennedy et.al, 2017). This stable low flow releases would ensure that eggs remain submerged in water for longer periods of time, decreasing the risk of egg desiccation.

Analysis

In many ways the GCMRC's light trapping citizen science initiative is similar to other successful public participation projects. It engages members of the public, compensates participants, produces data useful to scientists, and generates policy recommendations. However, the project also illustrates shortcomings of citizen science programming within the USGS and other agencies - educational and community empowerment opportunities are missed when community participation extends only to data collection (Ries, L., & Oberhauser, K., 2015; Mueller, M. P. , Tippins, D. , Bryan, L. A., 2012; Summary Report).

As I mention in the protocol description above, the supply pack provided to participants in the light trapping project includes bottles of ethanol (one for each collection day), a small Rubbermaid container, a backlight, map books (to locate the river mile for each collection), a scientific notebook (to record location, wind speed, collection time, etc.) and writing utensils. Notably, the kit does not contain copies of the articles produced by the data or an instruction guide to help participants identify the insects they collect.

I want to be clear that the light trapping initiative was never intended as a community empowerment or educational effort. Research ecologists managing and coordinating the project are clear that the motivation for developing this citizen science project is data collection. Because the length and inaccessibility of the Colorado River banks, traditional sampling methods are not easily applied. While education does occur, particularly with youth groups like Grand Canyon Youth, most citizen scientists are in fact guides with Colorado River based outfitters. Relationships with guides and outfitters ensure that GCRMC is in conversation with citizen scientists on a regular basis. As participants become more familiar with the protocol, they collect better (more precise) data and are able to make recommendations regarding protocol improvement (J. Muehlbauer, personal communication, Jan. 2018). (These conversations have resulted in the inclusion of additional Rubbermaid containers (because containers can easily crack) and extra batteries (for the black light).

While GCMRC representatives are explicit about their intention to operate a community data collection initiative, GCMRC continues to label its work on the light trapping project citizen science. As the introduction to this paper indicates, citizen science definitions actively utilized by the USGS and its CDI working group, refer to broad engagement with scientific processes. Again USGS defines citizen science as "scientific work undertaken by members of the general public, usually in collaboration with scientific institutions." CDI defines citizen science as research conducted "in whole or in part" by amateur or non-professional scientists. These definitions, when contrasted with actual activities and practices of citizen science projects, overstate community involvement and power within all stages of the research process[5].

Conclusion

I make the argument that, in order to operate citizen science programs with integrity, the USGS (including CDI) should:

1. Adjust its definition of citizen science to reflect actual activities and practices.
2. Adjust its activities and practices around citizen science to adhere more fully to its current definition.

If the USGS prefers to move forward with its current model, limiting community participation in citizen science to the data collection phase of research, it should modify its definition to accurately reflect the scope of citizen engagement. For example, CDI's definition might shift from citizen science as "scientific observation, measurement, research, and related activities conducted, in whole or in part, by amateur or nonprofessional scientists and other citizen volunteers" to citizen science as scientific data collection conducted in part by amateur or nonprofessional scientists and other community volunteers. The USGS definition might shift from citizen science as "scientific work undertaken by members of the general public, usually in collaboration with scientific institutions" to scientific work, usually data collection, undertaken by members of the general public often in collaboration with scientific institutions. These proposed definitions reflect the reality that where the USGS is concerned scientists not amateurs or non-professionals almost always frame the scientific question, design the research, analyze the data, and communicate outcomes. The power to ask the initial question does not lie with the public and therefore there is not USGS research done "in whole" or without "collaboration with scientific institutions."

If the USGS is interested in challenging its current model and scrambling hierarchies between professional and amateur scientists, it should modify its activities and practices to reflect its current aspirational definition(s) of citizen science. Again, it is important to emphasize the full community participation in all aspects of the research process is not always appropriate or desirable. Citizen scientists are unlikely to be paid for their labor, may not have the training necessary to be successful, and/or may face other challenges (related to time, transportation, need for childcare) that may limit their participation. However, community participation in states of the research process including and beyond data collection is possible and is

[5] Mueller et.al. reach the same conclusion after their analysis of the Audubon Christmas Bird Count, coining the term top-down citizen science" (2012).

happening. I present two examples below that illustrate the potential of citizen science to solve community challenges.

In 2015, Taking Neighborhood Health to Heart, a Denver-based non-profit organization, partnered with University of Colorado, Boulder air quality researchers to develop a citizen science project testing for the presence of perchloroethylene (PERC) in participant homes (Collier, A., 2015 August 24). This project was driven by a community desire to understand the levels of perchloroethylene, a chemical utilized in dry cleaning, present in a vacant dry cleaner shop located next door to a local Boys and Girls Club (Collier, A., 2015 August 24).Scientists, including project lead Ashley Collier, engaged in the collaboration were interested in evaluating new, less expensive PERC and radon testing kits (2015 August 24).

On the coast of California between San Francisco and Santa Cruz, a unique collaboration is underway between the Amah Mutsun Land Trust and the University of California, Santa Cruz (UCSC A&PG, 2017). The Amah Mutsun Relearning Program (AMRP) represents collaboration effort between the Amah Mutsun Tribal Band (AMTB) the UC Santa Cruz Arboretum & Botanic Garden (UCSC A&PG, 2017). AMRP has multiple objectives including the relearning of traditional ecological knowledge and resource management and the testing of these practices, by western researchers, to understand best practices for fire management in the region (UCSC A&PG, 2017).

These examples demonstrate that community members and scientists *can* enter into relationship as partners and equals. While scientists in these examples still possess greater access to technical resources and funding, community members possess real, authentic power in that they clearly defined the issues that became the subject of the collaborative research project. Again, the notion of self-interest is salient here. In these cases, unlike perhaps the case of the light trapping project, all parties have a stake in the question at hand, as it pertains directly to the health of their communities (in the case of community members) and/or to urban/prairie ecology and environmental justice (in the case of researchers)[6].

I conclude, as the examples above illustrate, that citizen science toward community empowerment is possible if and when scientists share power to define the central issue or problem with members of highly impacted communities. and appropriate in some cases. I conclude the current definitions of citizen science make claims about community empowerment without operationalized activities and practices that produce community agency and capacity. In order to do the work of citizen science with integrity, the USGS must adjust its citizen definitions and/or its protocols, so that the definitions describe accurately the work done collaboratively between scientists and community members. These recommendations ultimately are an invitation to the USGS to engage in reflexivity around and make an honest accounting of its citizen science programming.

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[6] As I discuss above, it is not always practical or appropriate to involve all community members in all stages of the research process. My argument is that such collaborations are possible in some instances and therefore deserve consideration.

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