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Youth-focused citizen science: Examining the role of environmental science learning and agency for conservation

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ABSTRACT

Citizen science by youth is rapidly expanding, but very little research has addressed the ways programs meet the dual goals of rigorous conservation science and environmental science education. We examined case studies of youth-focused community and citizen science (CCS) and analyzed the learning processes and outcomes, and stewardship activities for youth, as well as contributions to site and species management, each as conservation outcomes. Examining two programs (one coastal and one water quality monitoring) across multiple sites in the San Francisco Bay Area, CA, in- and out-of-school settings, we qualitatively analyzed in-depth observations and pre- and post-program interviews with youth and educators. First, we examined evidence from the programs' impacts on conservation in the form of contribution to site and species management. We found that youth work informed regional resource management and local habitat improvement. Second, we examined the youth participants' environmental science agency (ESA). ESA combines not only understanding of environmental science and inquiry practices, but also the youths' identification with those practices and their developing belief that the ecosystem is something on which they act. We found that youth developed different aspects of environmental science agency in each context. We identify three key CCS processes through which many of the youth developed ESA: ensuring rigorous data collection, disseminating scientific findings to authentic external audiences, and investigating complex social-ecological systems. Our findings suggest that when CCS programs for youth support these processes, they can foster youth participation in current conservation actions, and build their capacity for future conservation actions.

1. Introduction

As conservation science and practice increasingly address key challenges in the context of social-ecological systems, we need to better understand how people learn and take actions within those systems. In particular, understanding how environmental and science learning are related to conservation behaviors, now and in the future, is a crucial component of addressing conservation issues from global climate change, degrading water and air quality, biodiversity loss, habitat fragmentation, and fisheries collapse (Monroe, 2003; Schultz, 2011). Positioned as a means to accomplish education and conservation science, citizen science projects have increased in the last decade, (Bonney et al., 2014; Theobald et al., 2015). We refer here to community and citizen science (CCS) as activities or programs in which members of the public collaborate with professional scientists on scientific research and monitoring in either scientist-led or community-led endeavors. CCS, inclusive of citizen science, often includes participants collecting data, but may also include designing the research question and methods, data analysis and interpretation, and/or disseminating conclusions to research and decision-maker audiences (Bonney et al., 2014; Shirk et al., 2012). We specifically include community science, as well as citizen science, in order to include projects that are specifically community-led, often targeting environmental justice issues, that may not identify with the term citizen science (Pandya, 2012). Increasingly, these CCS efforts include youth (up to 18 years old) as well as adult participants.

Educators and conservation organizations have enormous expectations for youth participation in CCS ranging from science learning outcomes, environmental stewardship outcomes and connection to place, and positive youth development through civic engagement (Barton, 2012; Bonney et al., 2015; Krasny et al., 2014). Understanding how youth participation in CCS might contribute to conservation requires a close look at how youth-focused CCS actually happens, and the nature and role of learning and participation. That is, how do youth involved in CCS participate in environmental science and decision-making, what outcomes for conservation occur in the near-term, and in what ways might this participation involve science and environmental learning that will help youth contribute to environmental problem-solving into the future? In this paper we address these questions by examining

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case studies of youth-focused CCS programs, in both in-school and community-based contexts, with the goal of better understanding the role of CCS in enabling members of the public to understand and contribute to environmental problem-solving.

1.1. Conservation impacts of youth CCS

Despite its potential, there is increasing but limited evidence of conservation impact from adult-focused CCS, which we review below, and few have studied whether and how youth-focused community and citizen science contributes to conservation. Conservation impacts are difficult to measure, but Kapos et al. (2008) developed a useful evaluation framework, suggesting six areas of conservation activities that contribute to conservation directly (through site and species management) and indirectly (through education, research, livelihoods related to conservation, and policy). For CCS, which typically targets research, management and education, we consider two main ways youth-focused CCS may contribute to conservation via the data they collect and via impacts on the youth as individuals: 1) *Conservation research and management* - the scientific information generated can inform conservation research and site, species, and land management, and 2) *Conservation learning and action* - the individual participants in the project can learn and be otherwise personally impacted by participating, such that they behave in environmentally responsible ways individually or collectively, immediately, and/or in the future. We cluster both learning and action because these are impacts on the individual, rather than about the impacts of the data collected to inform conservation.

Recent evidence demonstrates that citizen science-generated data derived from CCS have been used effectively in both conservation research (Theobald et al., 2015), and natural resource management and decision-making (Aceves-Bueno et al., 2015, McKinley et al., this issue). In response to concerns about the quality of CCS data, many argue that it is subject to the same Quality Assurance/Quality Control procedures, study review and scrutiny as any scientific work published in peer-reviewed journals or used for decision-making (Cox et al., 2012; Kremen et al., 2011). In the case of youth, van der Velde et al. (2017-this issue) have shown that youth-collected data can even exceed the quality of that collected by adults, as demonstrated in their study of youth mapping local trash.

Documenting evidence for the impact of CCS participation on conservation learning and resulting behaviors, or conservation actions, is far less straightforward. Several studies have looked at adult learning outcomes of citizen science, which provide evidence of increased understanding of specific ecological or science content (Brossard et al., 2005; Evans et al., 2005), science skills (Evans et al., 2005), or a commitment to carry out future stewardship activities (Crall et al., 2013). However, the relationship between environmental learning and conservation behaviors is impacted by a suite intrinsic and extrinsic variables (Heimlich and Ardoin, 2008; Hungerford and Volk, 1990), and can involve short-term (social-marketing, providing incentives and feedback), long-term behavior change strategies, (cultivating environmental literacy) (Kollmuss and Agyeman, 2002; Monroe, 2003), and the development of environmental identity, which some theorize provides a link between learning and action (Clayton and Opotow, 2003).

Beyond behavior change, CCS can also be a part of efforts to reframe the goals of environmental education to focus on developing individual and community capacity to think critically, learn continually, and act adaptively to promote more resilient socio-ecological systems (Krasny and Tidball, 2010; Stevenson et al., 2014). Because socio-economic and political conditions can undermine the links between learning and resilience (Ballard and Belsky, 2010), we need to examine not only learning outcomes but also processes, and not just variables but the words and actions of people participating in science research that they believe contributes to something meaningful. With respect to youth, for whom we are banking not solely on current behaviors but on the capacity and agency to learn and make decisions into the future, we must understand why and under what circumstances participation in CCS might lead to environmental and science learning, conservation behaviors, and resilient systems.

1.2. Examining youth-focused CCS activities and learning impacts

Questions about what constitutes youth-focused CCS abound. For programs that center around the educational goals of CCS, how is youth-focused CCS distinguishable from doing a classroom science lab or field study in a local park? For our purposes, we define youth-focused CCS as activities by youth that produce data or results disseminated to and useable by professional scientists, agencies and/or managers. Therefore, despite their provision of high quality opportunities science learning, we do not include field-based or lab investigations by students whose data and findings are not disseminated outside the school or not used for research or decision-making.

The expectations for youth-focused CCS are well founded, but under-researched. Science education research in formal classrooms and informal learning settings provides evidence of how engaging in the practice of science affords not only a way to learn experientially (Kolb, 2014), but also provides the opportunity for youth engagement in scientific discourse and reasoning (Chin and Osborne, 2010; National Research Council, 2009). We also know that investigating environmental problems and scientific questions provides students with a meaningful context for learning science as well as a way to engage with their local place and community in transformative ways (Barton and Tan, 2010; Stevenson et al., 2014; Uzzell, 1999). Particularly, evidence from youth participatory action research, in which youth drive the research process, demonstrates how youth can gain capacity, skills and confidence for asking and answering questions collaboratively and enhance their connection to their local place (Ardoin et al., 2013; Cammarota and Fine, 2010). Yet existing literature on the education outcomes of the wider range of youth-focused CCS programs is limited to the potential activities and engagement strategies that may lead to strong science and environmental education outcomes (Kountoupes and Oberhauser, 2008; Morrisseau and Voyer, 2014). Further, while youth citizen science in schools is promoted as a promising context for addressing science education standards (Trautmann et al., 2012), the question remains as to whether school-based citizen science can truly foster the more democratic, social justice outcomes many hope for (Calabrese Barton, 2012). To move the field forward, we must develop a framework that can be used across a spectrum of experiences - in schools and out-of-schools - and can help researchers move beyond conjecture about potential or analogous impacts.

Further, we need a framework for conservation learning and action that addresses issues of power and positionality, rather than being resigned to only typical environmental behaviors such as recycling, minimizing home energy or water use, or picking up trash. Inside and outside of school, youth, especially those from marginalized communities or populations, often don't feel empowered to act, or don't have access to the means through which to take meaningful action in science and conservation, (Basu and Calabrese Barton, 2009). We argue that tightly bounded definitions of environmental learning and conservation action do not take in account young people's histories, ambitions, resources, and networks that are unique and particular to the places and communities they live, nor do they reflect the nature of learning that we see happening when young people engaged with authentic environmental CCS.

1.3. Environmental science agency (ESA)

To begin building a framework to help us understand both current and future environmental actions and behaviors of youth in CCS, we draw on Basu and Calabrese Barton's (2009, 2010) concept of critical science agency. In developing critical science agency, youth rely on science subject-matter knowledge to make change, and to leverage their