



Citizen science: Case studies of public involvement in archaeology at the Smithsonian Environmental Research Center

James G. Gibb

To cite this article: James G. Gibb (2018): Citizen science: Case studies of public involvement in archaeology at the Smithsonian Environmental Research Center, Journal of Community Archaeology & Heritage, DOI: [10.1080/20518196.2018.1549815](https://doi.org/10.1080/20518196.2018.1549815)

To link to this article: <https://doi.org/10.1080/20518196.2018.1549815>



Published online: 29 Nov 2018.



Submit your article to this journal [↗](#)




Article views: 5



View Crossmark data [↗](#)



Citizen science: Case studies of public involvement in archaeology at the Smithsonian Environmental Research Center

James G. Gibb 

Smithsonian Environmental Research Center, Edgewater, Maryland, USA

ABSTRACT

While the citizen science concept has been around for decades, its definition remains fluid in a voluminous literature on the subject. In archaeology, where the concept has had little traction, are we talking about citizens working in science as technicians, or citizens doing science as scientists? Is citizen science in archaeology a marketing rebrand of volunteerism? The Smithsonian Environmental Research Center's (SERC) archaeology programme offers what may be a unique solution: a consortium of avocational and professional archaeologists in which individuals and small groups, under the guidance of the laboratory's lead investigator, develop research questions and methods, collect data, analyze, and report results, supported by team members who aid in those tasks that volunteers typically undertake in archaeology; i.e. digging, screening, and washing artefacts. These citizen scientists produce, as well as contribute to, the production of scientific knowledge. Key issues include control, authority, and variable status of participants.

KEYWORDS

Community archaeology; citizen science; Smithsonian Institution; control; authority

Introduction

Citizen scientists have been around for a long time. Within their ranks in the Anglophone world we might note Benjamin Banneker, Charles Darwin, Benjamin Franklin, Thomas Jefferson, and Ada Lovelace. There are many lesser known individuals who have practiced science avocationally, but whose names are obscure or known only within narrowly defined interests. The term itself entered the *Oxford English Dictionary* (OED) in 2014. In common usage, citizen science often equates with 'crowd-sourced science' and 'crowd science' (Smith 2014, 758–759). The Royal Society of London, originally an 'invisible college of natural philosophers' (Kronick 2001), was at the forefront of crowd-sourcing beginning in the late seventeenth century, with Christopher Wren, Robert Boyle, Robert Hooke and many others relying on correspondence from fellow natural philosophers – 'The Republic of Letters' (Kronick 2001) – who were merchants, planters, and persons of independent means from around the world.

The 'crowd' serves, implicitly or explicitly, as a cost-effective means of collecting data for scholarly institutions which typically define the research agenda (unless imposed by the state or funders), analyze data, and report findings. The OED employs *collaboration* as the key noun, and implied verb, in its definition of citizen science (see also Wiggins and Crowston 2015); but it does not address the asymmetrical power relationship between professional scientist and volunteer, perhaps because the relationship is inherently voluntary for both parties, hence the power to coerce appears not to exist. Nevertheless, power and authority—expressed in terms of control

CONTACT James G. Gibb  JamesGGibb@verizon.net  Smithsonian Environmental Research Center, 647 Contees Wharf Road, Edgewater, Maryland USA 21403

© 2018 Informa UK Limited, trading as Taylor & Francis Group

over a project and resources—structure the relationship between cooperating vocational and avocational scientists.

Professionalization of most scientific fields, that the aforementioned lady and gentleman natural philosophers instigated (Snyder 2011), occurred throughout the nineteenth century, ironically creating that gulf between amateur and professional that has characterized science and audiences for science ever since. Archaeology certainly finds itself in the same situation today. And such is the context for the founding of the archaeology programme at the Smithsonian Environmental Research Center (SERC) near Annapolis, Maryland (USA).

From the first days of the Citizen Science in Archaeology programme at SERC, we reflected on the meaning and intent of citizen science. When the programme began in summer 2012, I greeted a group of three volunteers: not silver-haired retirees, but 20-somethings. Whatever misconceptions SERC's administration and I might have had for the expected demographic of empty-nesters and retirees, it didn't take brilliant insight to realize that these particular volunteers likely were here for something different. And as we were joined by retirees, persons trying to reenter the job market, others with disabilities looking to land their first job, and home-schooled students, it became clear that they all had needs and interests that included, but went beyond feeling useful or finding a social outlet. We needed to think about what we mean by citizen science and how that concept might embrace a broad range of individual interests, and how professional scientists could promote, or disappoint, those interests. And we needed to decide whether calling archaeological technicians 'scientists' violates demands for accuracy, precision, and integrity. Measuring phenomena is integral to science, but science defines what we measure and why, and—ideally—the ethical framework in which we undertake a study. That dichotomy distinguishes technicians (measurers and recorders) from scientists (determiners of what gets measured, how, and why). Finally, we needed to recognize that no static definition of citizen science suffices: it must be flexible and adaptable to a wide range of settings and circumstances (European Citizen Science Association 2015).

With the concurrence of SERC's citizen scientist/volunteer coordinators and members of the Smithsonian Environmental Archaeology Laboratory (SEAL) team (comprised wholly of citizen scientists), we developed a programme together in which participants could be scientists, or technicians aiding scientists, or ... as it has turned out in practice ... could shift back and forth between technician and scientist, sometimes hourly, depending on individuals' specific roles on particular projects during the course of a day (Sharova's [2017] 'continuum of engagement' and Haklay's [2013] levels of volunteer participation applied to the programme and to individual participants). This isn't the conclusion of this paper however; it is the point of departure: how has SERC conceptualized a form of citizen science in archaeology through practice?

It is my contention that creating the opportunity for avocational archaeologists to do science and to do so creatively, collaboratively, and independently—not just collect and process ancient trash, but to develop and address scientific questions through hypothesis formulation, quantitative analysis, and reporting—can produce sustainable and highly productive community archaeology programmes. Furthermore, providing participants with the opportunity to publish and present the results of their work at professional conferences lends structure to resource use and rewards those willing to engage at that level. Integral to the SEAL model is the willingness and ability of the supervising archaeologist to cede a high degree of control to the people who join the programme. We go beyond, or at least stretch the meaning of, co-creation, one part of the engagement spectrum (Bonney et al. 2009; Bollwerk, Connolly, and McDavid 2015a, 2015b), by down-playing if not eliminating the 'co-' in 'co-creation' and the distance it implies between professional scientists and non-professional-scientist colleagues. Much of what follows in this piece is my exploration of what six years at the head of the SEAL team suggests are the primary issues. I finish with three examples of the nearly 20 citizen science projects that we have undertaken, a discussion of principal accomplishments, and reflection on the programme's weaknesses.

Before doing so, a few caveats:

1. SEAL team projects focus on archaeology, particularly of the historic era (c. 1600–1950 CE) along the east coast of the USA, with forays into related subfields of anthropology, ecology, geography, geology, social history, labour and economic history, and mining and manufacturing engineering. It is not my contention that this model can be applied in other fields, such as biomedical research. I'm not saying it can't; I simply lack the experience and training in other fields to advocate for the adoption of the SEAL model elsewhere.
2. The SEAL model is one of a number of justifiable, productive models that serve the public interest. Most promote enhancement of scientific research while sating the public's appetite to engage in scientific discovery (Smith 2014). The Audubon Society has sponsored its annual Christmas Day bird count for well over a century, involving many thousands of volunteers and yielding high quality data. I don't advocate replacing one model with another; however, I suggest that there may be room for a SEAL-like model within larger, longer-established citizen science programmes.
3. This paper is explicitly about a specific model of citizen science: it is not a comprehensive survey of citizen science in general, which has become a field unto itself, with an expansive, learned literature to which archaeology has contributed little until recently (Smith 2014 and Bollwerk, Connolly, and McDavid 2015a). Shirk et al. (2012) offer an entrée into this literature and the European Citizen Science Association (2015) has developed ten principles of citizen science presented in 26 languages. Principles 1 (involving the public in scientific research) and 4 (participation in all levels of research and dissemination) are especially pertinent to the SEAL model.
4. Readers should not misconstrue this piece as a call for professional archaeologists to abrogate their ethical responsibilities. I advocate ceding some control; for example, giving team members the right to veto a particular project, or component of a project. Or, as is commonly the case, to undertake a new project that one or more members find interesting and that lies within the team's abilities, existing or prospective. Without some degree of control and responsibility to an institution, a citizen science programme is unsustainable and probably implausible; but even with centralized institutional power and authority, a high degree of independence is possible. Characterizing the model as green-lighting untrained, undisciplined enthusiasts to do whatever they want to do with institutional blessing would both wilfully misconstrue the model and suggest the ridiculous situation that the Smithsonian Institution would ever permit such a practice, much less support it.

I dislike having to make disclaimers, especially at the outset of a discussion; but I want to be clear about what this model does, and what it is not designed to do. Those interested in applying it can, and should, adapt it to the specific situations in which they find themselves. Concept flexibility and adaptability are fundamental to citizen science (European Citizen Science Association 2015). That said, let's briefly explore the concept of citizen science and then examine several representative SEAL projects.

Citizen science?

Seemingly elegant, the two-word term (often abbreviated *Cit-Sci* in conversation) doesn't clearly convey its intended meaning. Most if not all scientists, and people in general, are citizens of one place or another; so, what meaning does *citizen* bring to the concept? Well, it is meant as a positive, non-controversial simulacrum for non-professional (or amateur, avocational, or hobbyist) in the context suggested by the second part of the term. That meaning is not inherent in *citizen*, which has to do with political status in a given polity, particularly vis-à-vis rights and responsibilities. Intended or not, *citizen*, when connected to *science*, could imply generally held rights and responsibilities in science; viz., non-professional scientists may have the right, and even the responsibility, to participate in the production of scientific knowledge. I don't think there is any literature to support that sense of the word, but the SEAL model embodies it nevertheless. *Science* is more equivocal in that it is a noun modified by the adjective *citizen*; viz., science produced by citizens. Haklay (2013,

117–118), discussing the level of citizen science participation that I advocate, challenges professional scientists to reflect on their identities as citizens and the relationship of their work to community concerns. While scientists, particularly ornithologists and astronomers who have benefited greatly from public assistance in collecting and processing data, acknowledge the important role of volunteers in the production of science, few would regard citizen scientists as the producers of science. After all, that's our job, right?

Listing in the *Oxford English Dictionary* indicates that its editors regard citizen science as something more than an adjectival phrase, a whole greater than its parts: '*citizen science* n. scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions' (Oxford English Dictionary 2014).

The definition situates citizen science in an institutional setting, and only the inclusion of 'often' implies alternative arrangements. Certainly the citizen scientists of the seventeenth through mid-nineteenth century practiced outside of institutions, operating out of their own libraries, mostly using their own funds, and subject only to the constraints of their own domestic arrangements. Developing institutions such as the Royal Society of London and the French Royal Academy connected scholars and offered venues for presenting papers outside of a university setting, but initially they lacked the funding, equipment, and space that might have provided leverage in controlling members' work. Leverage resided in their ability to confer or rescind membership and the prestige associated with fellowship.

Broadly, citizen science means participation in a particular branch of science by individuals previously untrained in the ethics and methods of that field; i.e. citizen scientists. But participation is an ambiguous word in this context, and the nature of possible public participation varies with the field of study and specific projects. Wiggins and Crowston (2015), for example, surveyed citizen science project leaders representing 77 distinct projects, combining the analysis of those data with two case studies, revealing shared features, but also considerable variability in funding, goals (education, resource management, knowledge), nature of participation, quality control, and rewards. It isn't clear whether any of the projects in the study were archaeological. Sharova (2017), using survey data from all of the citizen science work conducted at SERC, has described a continuum of engagement that includes the entirety of the scientific process, but where participants in the aggregate prefer the role of data collector. Further analysis of that dataset may identify statistically significant differences among the nearly 20 SERC laboratories employing citizen scientists, most of which do not offer an alternative. I concentrate on the application of citizen science in archaeology and illustrate with examples from the SEAL team.

Citizen science has acquired other names that grew out of practice with ecology, conservation, and environmental monitoring projects, creating such a welter of terms that Shirk et al. (2012, 30) have offered Public Participation in Scientific Research (PPSR) to embrace the many variants and Bollwerk, Connolly, and McDavid (2015b) gravitate toward participatory research as the organizing concept, building on Simon's (2010) notion of the 'participatory museum.' Scholars have also distinguished different points along a continuum of public involvement in the production of science, from contribution to co-creation (Bonney et al. 2009), and archaeologists Bollwerk, Connolly, and McDavid (2015a) have brought together ten papers on the latter. Haklay (2013, 115) offers another four-stage system of increasing participation: crowd-sourcing, distributed intelligence, participatory science, and extreme citizen science. I am concerned less with what we should call this participation and more with understanding the fluidity of roles and the part of professional archaeologists in promoting, or dissuading, participation through design. Does a family watching an excavation from behind a rope line, like Rip Van Winkle gazing upon the Hudson River, participate simply through appreciation? How about the casual volunteer on a Saturday Dig Day who shovels plough zone or screens soil, or washes and labels artefacts? The retiree or aspiring student participating weekly? And what about the individual compiling and analyzing census data from a home computer, researching a particular artefact, or developing and implementing a middle-range theory experiment with fellow team members? Clearly, there are different levels of participation (Sharova 2017); but all are constrained by a person in

authority who exercises greater or lesser control over the degree to which any one person or group can actively engage in an archaeological investigation, either through personal intervention ('You can't do that and remain a part of my team') or allocation of institutional resources ('If you do this I can let you have some of that'). Clearly, we need to conceptualize citizen science in a way that accounts for levels of participation, control as an expression of power and authority, and the rights and responsibilities of non-professional scientists in the production of science (Bollwerk, Connolly, and McDavid 2015b). There is considerable literature on levels of participation (Shirk et al. 2012; Haklay 2013; Sharova 2017), but the other two issues warrant consideration.

Conceptualizing citizen science

There is an extensive literature on citizen science, particularly in the fields of biology and conservation (Shirk et al. 2012; Agrawal and Inamine 2018), and in informal science education (Bonney et al. 2009; Wiggins and Crowston 2015), the latter focusing on the effectiveness of citizen science in meeting project objectives, generally phrased in terms of production of scientific knowledge, sharing the content of that knowledge with participants, and increasing the public's understanding of the scientific method (Dickinson et al. 2012). Research methods rely heavily on rigorous surveys of participants and anthropological participant observation. Surveys have proven challenging due to the often ad hoc organization of citizen science projects that lack reliable sources of funding, the highly varied nature of projects, and evaluators imposing heuristic tools that lack the flexibility to accommodate the dynamic character of at least some citizen science projects. The latter is especially pertinent to the operation of SERC's citizen science in archaeology programme where the variability seen among citizen science projects across various fields manifests within SEAL.

Bonney et al. (2009) surveyed ten citizen science projects, categorizing them as follows:

- **Contributory projects:** designed by scientists and to which the public contributes data;
- **Collaborative projects:** designed by scientists, but the public may help refine project design, analyze data, or disseminate findings, as well as contribute data; and
- **Co-created projects:** designed by scientists, but in which at least some of the public engages in most or all steps of the scientific process, including question selection, research design development and implementation, analysis, and dissemination.

The phrase 'designed by scientists' and the implied, but undefined, distinction between 'scientists' and 'the public' structure the three categories. Shirk et al. (2012) add contractual projects, in which communities commission studies to meet their specific needs, and collegial projects undertaken by committed amateurs, but with little or no collaboration with professionals. Only with collegial projects is the distinction between scientist and the public unrecognized and the issue of designer irrelevant.

Opportunities for public participation through online reporting or processing (for examples, Bevan et al. 2014; and Seitsonen 2017) and crowd-funding (Bonacchi et al. 2015) appear to be increasing, but in North America archaeological projects in which the public can participate through excavation and laboratory processing—and most if not all of the tasks those general activities imply—probably constitute the majority of citizen science efforts in the field. SEAL, for example, conducts a Saturday 'Dig Day' once each month from May through October. SERC's Citizen Science coordinator advertises the event, taking 12 reservations each for morning and afternoon sessions to keep the number of participants manageable and to give each the opportunity to speak with a real-life archaeologist. Experienced SEAL team members staff the event. Participants contribute their labour and are nearly unanimous in their appreciation for the opportunity. The gracious staff, in turn, thanks guests for helping.

Participants in collaborative projects, by contrast, occupy a liminal space in which they are more than technicians, but less than scientists. Their role in the development of research questions can range from unsolicited, casual comments, to offering invited input. Dissemination can range from

docent training to presentations to local organizations and staffing booths or tables at local events. Experience suggests that these are individuals who contribute to a programme regularly over a protracted period, and who are inculcated with the mission and narratives of the organization in which they volunteer. They have an interest in the project, but are not fully vested.

Co-created projects, necessarily, are more complex than those characterized as contributory or collaborative. Projects pairing scientists with descendent groups often aspire to co-creation, the latter taking a leading role by stipulating what they want to know about their past, the kinds of information they find acceptable, and the degree to which they are willing to share what they have learned with broader audiences. Community participation is proportional to how much members know about archaeology, what archaeology can do, and what it cannot do. Where some members have prior experience or education in archaeology, the community can be an active, informed co-creator. Otherwise it must rely on the integrity and transparency of the scientists with whom it will work to insure that the project addresses their needs and concerns and not primarily those of their scientist partners.

Archaeology has a long tradition of collegial projects through which non-traditional researchers, largely self-trained, have produced scientific knowledge valued by institutional scholars. Heinrich Schliemann's independent work in the Eastern Mediterranean and that of Sir Arthur Evans, an Oxford University-trained scholar employed by the Ashmolean Museum, exemplify the collegial relationship, the older and more colourful Schliemann influencing his academic colleague and contributing concepts that would develop in sophistication and detail. American archaeology offers numerous examples of independent, amateur archaeologists contributing to archaeological science, if not always receiving the respect of their academic colleagues. Examples include: Ephraim George Squier, journalist, investigated the Midwestern Moundbuilders; Charles C. Abbott, physician, promoted the antiquity of humans in North America; and Roland W. Robbins, window-washer and house-painter, investigated Henry David Thoreau's Walden Pond cabin.

Contractual and collegial categories added by Shirk et al. (2012) are peripheral to the current consideration of avocational and vocational archaeologists working together toward established goals. The heuristics that Bonney et al. (2009) and Haklay (2013) developed are hierarchical, each level surmounted by one in which citizen scientists are more engaged in the work; more responsible for its successes and failures, exercising greater control over the steps in the scientific process. While one might deduce the issue of control from the stacked categories, there is nothing in either model to suggest the nature of control and how it is shared, or not shared. Most citizen science projects in archaeology—and likely in most fields—are contributory with successively fewer collaborative and co-created projects. Viewed from a different perspective, citizen science projects in archaeology exhibit different degrees to which scientists and non-scientists share control. Each have leverage which they exert to a greater or lesser extent: the non-scientists can withhold participation or access to sites or collections, thereby limiting, or possibly precluding, project advancement. Scientists bring equipment, knowledge, institutional support and legitimacy, and, perhaps, the means for securing required excavation and other permits. If we use the heuristics that Bonney et al. (2009) and Haklay (2013) provided, negotiation of control rather than exercise of control might best characterize the different levels, with the scientists arguably having the greater power and authority and public participation dependent largely on the degree to which the scientists cede control and the extent to which prospective participants feel their needs are addressed; viz., is the offer good enough.

Although I was not familiar with the term citizen science when SERC first approached me about this programme, I had been considering the relationship between volunteerism and control for a number of years. Experience with two previous public archaeology projects suggested that the level of public involvement and persistence of individual volunteers were related, at least in part, to the degree to which project professionals treated avocational archaeologists as peers. I also found myself increasingly uncomfortable with the asymmetric division between 'scientist' and 'the public,' which suggests that scientists, at least in some contexts, exist apart from the communities in which they live and work. These experiences and sentiments informed the creation of SEAL and constant reflection continues to inform how the programme's design develops.

Citizen science in archaeology at SERC

The Smithsonian Environmental Research Center is a unit of the Smithsonian Institution. The campus consists of 2,650 acres of mostly contiguous lands in the Rhode River/West River watershed that forms a subestuary within the Chesapeake Bay, the largest estuary in the USA (Figure 1). It has grown from a research station of few hundred acres of woodland and abandoned pasture in the 1960s to a collection of nearly 20 distinct laboratories focusing on estuarine studies, including biogeochemistry, ecological modelling, ecosystem conservation, fish and invertebrate ecology, forest ecology, molecular ecology, and plant ecology. Moreover, SERC operates principally or collaboratively at other facilities around the world. SEAL is among the newest and, at first blush, most anomalous of the laboratories.

If perceived as a humanity, concerned with the human experience in a well-defined time and place, and from which researchers might extrapolate to the larger human experience unbounded by time or space, archaeology seems a poor fit with the biological laboratories. The name Smithsonian Environmental Archaeology Laboratory, however, clearly situates archaeology in the larger study of humans in an ecosystem. From the outset in 2012, SEAL projects have sought to measure and analyze human stresses on the Rhode River ecosystem, not just as manifested in the aggregate by a succession of communities over the past 3,000 years, but in terms of variability within each of those communities. We offer, then, both great time depth to ecological studies in a particular ecosystem, and the opportunity to measure and understand the varied contributions of multiple residential groups on the development of that ecosystem and of the larger estuary.

SEAL is unlike any of the other laboratories at SERC. Technically, it is a project of the larger citizen science programme at SERC, not rising to the level of a programme, much less an official lab. On the other hand, it has many of the physical trappings of a scientific laboratory: a designated space, equipment, staff, and a purpose outlined in what amounts to a mission statement. But there is no paid staff and no budget for equipment or expendables. All equipment has been loaned or donated. SERC provides several networked computers and some furniture, as well as access to its fleet of vehicles and watercraft, and laboratory space. Volunteers often donate or purchase pieces of equipment or materials. I volunteer my time along with the rest of the team of regular participants which has grown from four of us in 2012, to nine in 2014, to 24 in 2018. While team members often conduct research online or at regional archives other days of the week, the entire team meets at the lab

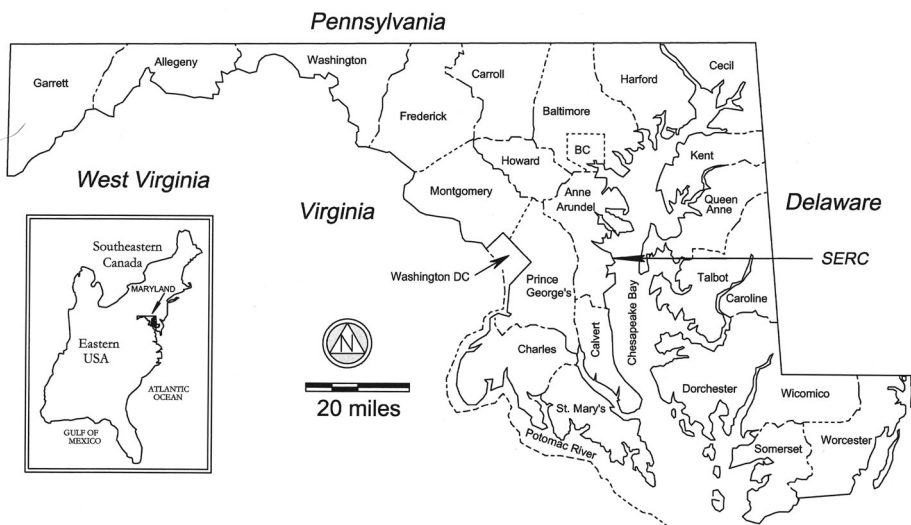


Figure 1. Map of the State of Maryland, USA, noting location of SERC. Drawing by the author.

only on Wednesdays. From there we disperse singly or in groups within the Charles M. Mathias lab and at one or more field sites, some on campus, others elsewhere in Maryland or Delaware. Six or more distinct projects typically are underway on any given Wednesday.

Projects that may be completed in a few weeks or months by a more conventional archaeology laboratory working five or six days each week necessarily take longer. And, as I indicate in the case studies below, most projects are multigenerational. In other words, a lead citizen scientist individually or as part of a team takes a project to a meaningful stopping point, generally capped by a presentation at a regional, national, or international conference and/or publication in journals, both peer-reviewed and not. The project may then lie dormant for weeks or months until a new team member or an existing one elects to take it further. One team member telecommutes from central Pennsylvania, compiling land records and recreating surveyors' plats of nineteenth-century farms, and another recently relocated to the other side of the Chesapeake Bay identifies sites and prospective informants for our shell button making project. Promiscuity is rampant, with team members working on several projects at different levels of responsibility or volunteering for other labs, local food banks, and other non-profit organizations; however, the extramural activities rarely interfere with Wednesdays at SEAL. Sustained participation is the rule, violated largely by those moving for work, or beginning their undergraduate or graduate education. One member just returned from a year of service in the Peace Corps. Of those others who left the programme for no apparent reason, none had fully vested themselves in a particular research project.

I attribute growth of the programme, and persistence, to ownership: we all own the various research projects. Citizen scientists at SEAL don't help me; they help one another. They are not 'users,' in the sense that Macalik, Fraser, and McKinley (2015) re-conceptualize museum visitors; they are creators. These are their projects, their research, and their names are on the final products, with me only occasionally appearing as a coauthor. The payoff for me is the satisfaction of participating in far more research projects than I could otherwise do, even if the rest of my working hours were not committed to providing archaeological consulting services in the private sector. While most projects occur on the SERC campus, others take team members to other counties in Maryland (Riseling 2013; Lee 2017, 2018; Eybel and Gibb 2018) and to Delaware (Berry 2014; Biuk 2018). All are ecological in focus, although some more so (e.g. meat-provisioning in the Colonial Chesapeake [Tritsch 2017, 2018]) than others (e.g. twentieth-century shell button-making on the eastern shore of the Chesapeake Bay [Berry 2014; Biuk 2018]). Still other projects defy categorization as ecological or historical (e.g. variability in household adoption of coal as fuel in the nineteenth and twentieth centuries [Eckel 2017]). The following case studies illustrate how citizens bringing little or no scientific training to a science programme, with some direction and encouragement from one professional scientist, can produce meaningful, and potentially actionable, science.

Case study 1: Historical pressures on the Rhode River oyster population

As constituted in 2017, the 'oyster shell team' consisted of a 17-year-old home-schooled student, a retired elementary school principal, and a retired federal government programme manager (Figure 2). The SEAL team had sought and tested shell middens at several sites: two late seventeenth century plantation sites, an early nineteenth-century slave site and a comparably dated midden from the plantation house; and late nineteenth-century middens created by two neighbouring, moderately wealthy farm households. All of the sites are within 0.25 miles (~400 m) of each other. Published work by colleagues at Smithsonian's National Museum of Natural History (Rick et al. 2016) suggested that oyster valve size declined in the Chesapeake Bay from 3,000 years ago (when marine populations matured in the then newly formed basin) to the late historic era due to increasing human predation on oyster populations, excessive exploitation resulting in harvesting oysters of younger age and, by extension, smaller size.

The team of Cannon, Plourde, and Breedlove (2017) identified two related questions that could be answered with the kinds of materials that the entire SEAL team had, or would soon, recover:



Figure 2. Oyster shell project team of, left to right, Kathleen Cannon, Jim Breedlove, and Leo Plourde. Photograph by the author, and Smithsonian Environmental Archaeology Laboratory at the Smithsonian Environmental Research Center.

1. Based on material recovered from oyster shell middens within a single subestuary of the Chesapeake Bay, dateable within a decade or so for historic era occupations, was there a measureable decline in oyster valve size and, if so, can we mathematically describe that decline?
2. Are patterns consistent within each period; i.e. do midden samples from contemporary sites exhibit identical patterns?

The team used Kent's (1992) manual to standardize valve measurements on well-defined anatomical landmarks. They departed from that procedure on three points: construction and use of a simple jig to insure accurate linear measurements of the left valve; use of sand weights as a proxy for valve volume; and continuous evaluation of measurement averages to detect stabilizing variances and, hence, the minimum representative sample size for a given midden (Cannon 2017).

The oyster shell study revealed a decline of oyster shell length; samples from the nineteenth century were significantly, but not dramatically, shorter than those from the earlier deposits. The anticipated sharp decline in length was not in evidence. The team detected similar patterns in valve height and the Height:Length ratio. The seventeenth-century valves exhibited greater volume, as measured by filling each with sand and then weighing the sand, sand weight serving as a proxy for volume (Figure 3). Methodologically, the team determined that slight differences in sample sizes were necessary, with some assemblages exhibiting greater variability than others. Further analyses will examine both variation (movement through space) and change (movement through time) among the assemblages, amplified with additional samples from different periods and households.

With the team leader leaving to start her undergraduate career, the oyster shell team will reconstitute and continue the work to include additional samples from other historic era sites and from aboriginal shell middens, of which there are many along the shores of the Rhode River.

Case study 2: Meat-Provisioning in the Colonial Chesapeake

Between 2008 and 2010, *The Lost Towns of Anne Arundel Project* (a county government programme) conducted extensive excavations at the site of a late seventeenth-century plantation house site (Sparrow's Rest, 18AN339) that they discovered in front of a mid-eighteenth-century plantation house ruin that is now part of the SERC campus. Beginning in 2013, the SEAL team explored the plantation

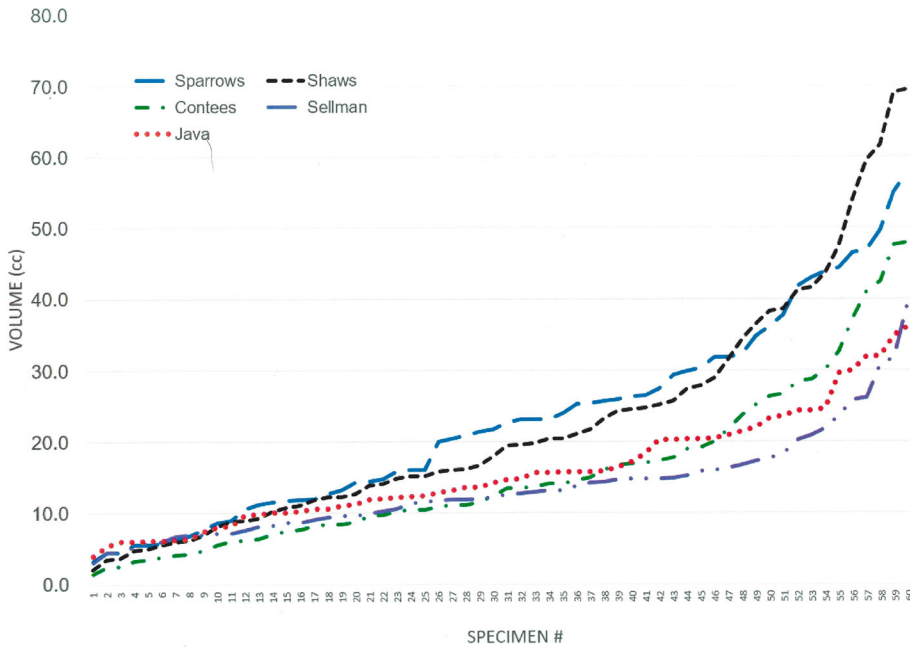


Figure 3. Distributions of oyster valve volumes from the Shaw's Folly (1650s–1680s) and Contees Wharf (1800–1850) sites (Cannon 2017). Smithsonian Environmental Archaeology Laboratory at the Smithsonian Environmental Research Center.

household of the contemporary Shaw's Folly site (18AN1436). The Sparrow and Shaw families, related by marriage, were part of the Quaker community that formed around the Rhode and West rivers in the last third of the seventeenth century. Both yielded large quantities of food-related bone, those from the Sparrow's occupation separable by stratum and artefact association from those related to the occupation of the eighteenth-century mansion. Shaw's Folly is a single component site.

In 2014/2015, citizen scientist Kiley Gilbert learned how to identify element and species from the fragmentary remains, a process aided by her undergraduate work in biology and 'the road kill' collection at SEAL that provides type specimens (Gilbert 2015). Miller (1984), in his doctoral dissertation on meat-provisioning in the Colonial Chesapeake, determined that domestic livestock dominated the meat component of the colonists' diet on the late seventeenth-century frontier, despite the well-documented abundance of indigenous birds, fish, and mammals. We discussed Miller's findings and the SEAL team's overall research effort and settled on two questions:

1. Did the pattern revealed by Miller (1984) for Maryland and Virginia hold for a single watershed, the Rhode River?
2. Do the middens of the contemporary deposits of the Sparrow's Rest and Shaw's Folly sites have identical patterns and how might we make that determination?

Gilbert (2015) confirmed Miller's (1984) observation: while she identified some wild birds, fish, and mammals (white-tailed deer were virtually absent), as well as some domesticated yard fowl and some sheep, cow and pig bones dominated the assemblages. By applying variants of the Shannon-Weaver diversity index and Shannon equitability index, Gilbert established that the two assemblages exhibited similar heterogeneity and richness (numbers of species present and representation within each species), but the proportions of cow and pig bones differed. Sparrow's Rest deposits yielded significantly more cow bone than pig relative to those of the Shaw's Folly site where pig bones outnumbered those of cattle, suggesting different animal husbandry strategies (Figure 4). Following

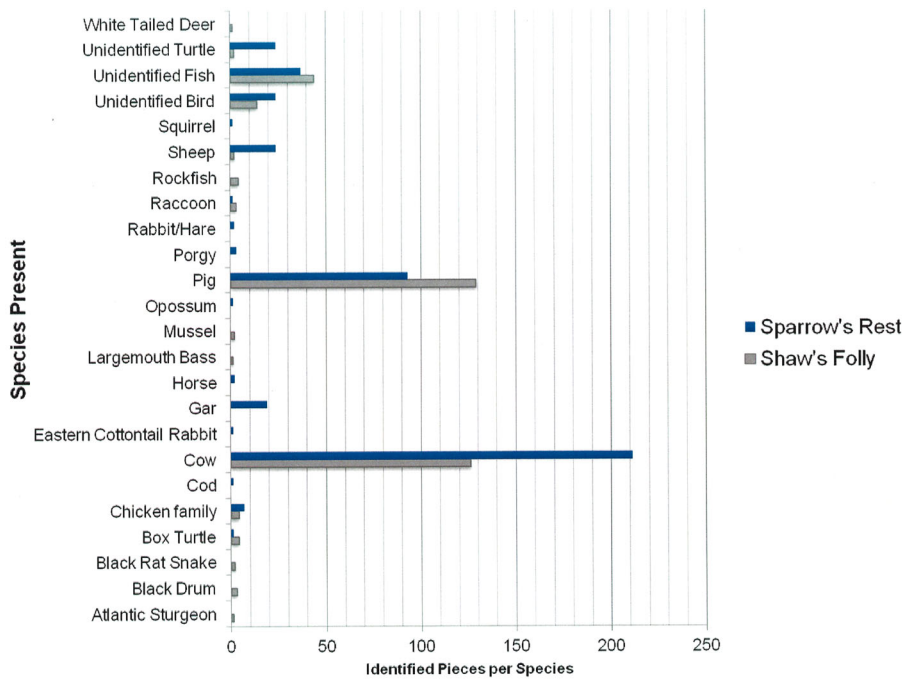


Figure 4. Numbers of identified bones, by species for the contemporaneous Shaw's Folly and Sparrow's Rest (1650s–1680s) plantations sites (Gilbert 2015). Smithsonian Environmental Archaeology Laboratory at the Smithsonian Environmental Research Center.

Gilbert's departure, citizen scientist Valerie Hall (2018), now a doctoral candidate at the University of Maryland, continued the analysis as we try to determine the potential varied effects that different husbandry practices may have had on the local ecosystem.

Case study 3: Erosion and sedimentation

While surveying archaeological deposits around an extant house on the SERC campus with eighteenth- through twentieth-century components, our team encountered a fieldstone and brick footer just below the sod and about 100 ft (33 m) in front of the house. Deposits yielded domestic and architectural debris from the first half of the nineteenth century suggesting a summer kitchen for the main house. The brick portion of the footer was only three courses thick. Clearly much had been lost through cannibalization of the structure and erosion. Excavation of a unit near the edge of a ravine 300 ft (~100 m) downslope from the footer revealed more than 3 ft (1 m) of redeposited sediments, each lens yielding charcoal flecks and a few small artifacts consistent with those recovered from around the footer upslope (Figures 5 and 6). Those sediments blanketed a plowed soil that yielded only aboriginal pottery (Grady 2016).

There are two models that could explain this process of sedimentation, each looking to a different mechanism. Episodic sheet erosion around the footer moved soil and some artifacts downhill, probably beginning in the mid-nineteenth century. Alternatively, an expedient path used by motorists in the second decade of the twentieth century created an erosional problem through the southern third of the site of which the footer is a part, and that problem persisted until paved in the middle of the twentieth century; but not before the loss of as much as 5 ft. (1.52 m) of soil along portions of the driveway.

Sarah Grady tested the models by analyzing the average weight of ceramic sherds from three locations: units around the footer, units 15–30 ft (~5 m–10 m) downhill from the footer, and from

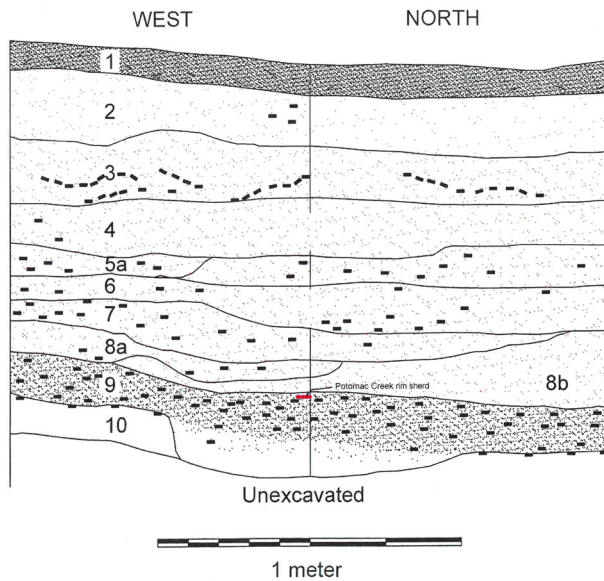


Figure 5. Sellman's Connexion Unit 11 profile depicting multiple lenses of redeposited material. (Grady 2018). Smithsonian Environmental Archaeology Laboratory at the Smithsonian Environmental Research Center.

the unit at the base of the slope. The results revealed decreasing sherd size with distance (a classic fall-off curve), supporting a gentler, more incremental loss of soil through sheet erosion rather than dramatic movement of sediments and inclusions in high velocity runoff from the driveway which would have produced a pattern of poorly sorted ceramics, a pattern not evident in an analysis of variance (Grady 2018).

Discussion

The three case studies only sample the various projects in which SEAL's citizen scientists have engaged since June 2012, and the descriptions, necessarily, are brief and convey neither the



Figure 6. Sarah Grady excavating Unit 11 at Sellman's Connexion (Grady 2018). Smithsonian Environmental Archaeology Laboratory at the Smithsonian Environmental Research Center.

considerable effort nor pride of the individuals and teams that brought them to fruition. Of greater importance in this discussion is that these projects ended, or achieved milestones, at the discretion of the citizen scientists participating in those projects. This, I think, is unusual and brings us back to the issue of control. In most citizen science projects, the principal investigator determines when a project begins and ends. When citizen scientists have fulfilled their roles, their participation is at an end and they either find another project or pursue some other interest (Smith 2014, 754). The SEAL model both leaves these decisions to the citizen science investigators and offers subsequent or concurrent projects in which team members can participate during or after completion of their primary project.

The SEAL model offers another advantage that may be lacking in most other public engagement programmes: fluid roles. The field team may bring in buckets of oyster shells from a mid-nineteenth century midden one week and a small group from a local organization addressing intellectual and developmental disabilities washes them the next under the direction of a citizen scientist. On the following Wednesday our oyster shell team may spend two hours measuring the left valves and evaluating the results, after which they will disperse to other projects, cataloguing artifacts, excavating, or organizing collections. In another situation, a team of two cataloguers discusses the gross inadequacies of the SEAL director's two-dimensional cataloguing system, attracting the attention of a couple of other team members, and in a nonce we have a working group studying the problem of using the available computer programme applications to develop a functional system accommodating all of the lab's collections. Members of our pollen extraction team readily shift to artifact conservation while awaiting the outcome of a step in the former, then shift back again as the iron or glass objects desalinate. A team member, having completed a task in the archaeology lab may drive the half mile to the main SERC lab to continue processing soils for our sediment analysis.

The number of diverse projects in which SEAL team members are involved at any given moment make fluidity and decentralized decision-making possible, and indeed necessary. If we focused on a single site, addressing a single research problem, the need for flexibility would diminish, as would the opportunities for creativity and ownership. We could work on one site and offer individuals and small teams the task of measuring, cataloguing, and analyzing one of a small number of narrowly defined classes of objects; e.g. ball-clay tobacco pipes or vessel glass. When those tasks are completed, they are out of a job. More importantly, they have engaged in an activity that, by itself—and I have had experience with a programme in which this was a regular practice—is inherently non-scientific. Specifically, the exercise does not address a non-trivial research problem: it is part of a larger analysis that may be question-driven, but into which the volunteers are not fully integrated. And, in the end, there are only so many classes of material culture that one can assign. Multiple projects involving different kinds of questions (anthropological, archaeological, historical, ecological), but contributing to a single larger question (the effects of variability in a community's stresses on an ecosystem), can accommodate a boundless suite of projects that involve various sites and deposits of different periods, social formations, technologies, and linkages to larger socioeconomic systems.

Among the accomplishments of the SEAL team to date are a lengthy list of regional, national, and international conference presentations of original research by women and men—ages 17–70-something, mostly of European heritage, but including four Asian American, two African Americans, and one Hispanic American—and a growing list of publications as projects begin to come to fruition. Participation also has helped three high-school students gain acceptance to undergraduate schools of their choice, four individuals find places in masters programmes, and two individuals with masters degrees earn berths in doctoral programmes. Three of those individuals have reflected on citizen science and themselves as one-time citizen scientists (Grady, Hall, and Janesko 2016). Retirees, with no plans to develop new careers, have found their own rewards in the programme, the specifics of which remain a mystery to me and, perhaps, are none of my business. Sharova's (2017) survey of SERC citizen scientists indicates that the opportunity to assist in creating new scientific knowledge is the primary consideration, but I suspect that a survey tailored specifically to the SEAL team would evince different, and perhaps more complex, motivations. In any case, a distinction between support of science and participation in science may prove illuminating: a monetary

donation is qualitatively different from weekly participation. For myself, I have enjoyed, sometimes vicariously, the ability to undertake projects that remained idle for years for lack of time and resources, and new research projects that I had not previously imagined. And I derive satisfaction in SEAL not *using* citizen science, but *being* citizen science.

But let's not be Pollyannaish: the SEAL model clearly has weaknesses. While the team works with a neighbouring African American community, we have not succeeded in retaining participants from locally prominent minority communities. Asian American participation has been remarkable given the lack of high profile Chinese, Japanese, or North Korean communities in the area, but SEAL has not had any South Asian participants. The team largely consists of middle class individuals of European heritage. Part of the difficulty of recruiting a more diverse team is the means by which we recruit: prospective participants come to us, we don't seek them out. Once prospects enter our midst, they become the targets of a well-practiced pitch from the principal investigator and not a few of the other team members. Few escape. Public 'dig days' promoted widely by SERC have brought diverse groups to SEAL, but we haven't been as effective in recruiting among them as we have among those who have learned about us through other means and ask to visit and volunteer. We offer some laboratory opportunities on Saturdays, for those for whom school or employment monopolize weekdays, but the lives of the people we reach are busy and many cannot, or will not, make the commitment.

A surprising number ask me how we fund the project. It can be difficult to fund. At SEAL, we have been fortunate in receiving a large donation of equipment and expendable materials from a professional archaeologist leaving the area, virtually eliminating reliance on borrowed equipment. But the model relies heavily on citizen science participation in professional archaeology meetings and finding funds for membership, registration, and travel to conferences for aspiring young professionals and older folks well-established in, or retired from, careers has become increasingly difficult. All of our team members are from middle class backgrounds with limited resources or other commitments for the resources they have. Abstract submission deadlines and conference dates inspire and motivate development of meaningful research projects. Commitments to presenting papers help younger participants develop research and presentation skills, and successful completion of those papers, and increasingly publication of results, enhances their prospects for admission and funding in academic programmes. Again, the motivations for those not pursuing careers in archaeology are personal, but no less significant. Two generous grants from the Smithsonian helped fund participation of team members in regional and international conferences from 2013 to 2016. Funding in 2017 and 2018 has relied on private resources.

The large number of ongoing projects also poses short-term and long-term problems. Multiple demands and changing conditions often require shifting resources, effectively 'moth-balling' one or more projects, adversely effecting efficiency and, potentially, quality of research. The team successfully addresses collections organization and storage issues, as well as artefact conservation, but rapidly depleting storage space at SEAL will create a problem over the next five years. A focus on sampling middens, archiving samples, and discarding some materials (mollusk valves, coal, and brick, mortar, and burned daub) after cataloguing helps reduce collections volume. If additional samples are needed to address future questions, the sites can be revisited, but the growth of collections remains inexorable, if somewhat managed. Running multiple projects necessarily means collecting data and artifacts, and there are costs in managing both.

Finally, we have not yet contributed to the larger scientific efforts at SERC in any significant way. This inadequacy does not appear to be due to the kinds or quality of SEAL's research, or the larger conception of community variability and its effects on ecosystem change. It does appear to be due to the pace of the research. Varying amounts of research by team members occurs throughout the week, but the major effort is confined to Wednesdays. That is the only day that I can guarantee my presence and the rest of the team members all have commitments outside of SERC that limit what they can contribute. Technical reports have been written and conference papers read, but peer-reviewed papers only now, six years into the programme, are beginning to be published.

And we are only beginning to integrate research results, for example, bringing together the oyster shell analyses with those of the non-molluscan fauna. Flotation has failed to yield significant quantities of identifiable macrobotanical specimens and the developing palynology lab is just beginning to finalize and apply protocols for pollen extraction and identification.

Conclusions

Citizen science isn't necessarily fast science, but it can be more than enhancement of professionally directed science. Without adequate, dependable resources (read *funds*), the future of any given citizen science project, however organized, will remain uncertain (Dickinson et al. 2012). Grounding any project in an institution helps insure sustainability and elevates it from temporary, if open ended, to a programme that can place some demands on the institution for support. There are significant problems concerning the sustainability of the SEAL programme: The SEAL model, however, is not tied to the programme. The concept of organizing volunteers around a dynamic suite of related projects in which participants can exercise creativity and judgment in consultation with a professional archaeologist can be applied in many settings. Participation in professional conferences and publishing provides both motivation and acknowledgement of the scientific contributions made by citizen scientists.

Different citizen science projects can have different goals for participants. Among those is promotion of scientific literacy through experiential, informal science learning: participants learn specific scientific content and the application of scientific method (Trumbull et al. 2000; Bonney et al. 2009; Dickinson et al. 2012). In the process, a project both generates knowledge and better equips at least a portion of a community to understand and express *informed* opinions on, for example, the use of science in the development of public policy. (Whether or not citizen science achieves all or any of these goals is a subject of continuing evaluation in the literature.) If, however, increasing scientific literacy is a stated or implied goal of a project that employs citizen scientists, the project must afford volunteers the opportunity to fully engage in the science. Counting and weighing large numbers of left oyster valves recovered from a series of shell middens very effectively teaches participants how to count and weigh left oyster valves from a series of shell middens. The skill is not particularly transferable to other aspects of life, nor does it provide any insight into the scientific method. Case study 1, described above, involves intensive measuring and weighing of oyster valves, but it does so in an effort to measure and statistically evaluate both method and results as the team explores long-term impacts of varying household strategies on the exploitation of the Rhode River subestuary of the Chesapeake Bay. The team's ownership of the questions has taken them beyond the tedium of sorting and measuring, instilling a clear sense of the scientific method and the value of sampling and quantitative analysis, and producing scientific knowledge that will contribute to larger questions about the experiences of human communities and the effects of those experiences on the ecosystems of which they were parts.

I see myself as part of the larger community and of the intimate community we have created together at SEAL. Through training and experience, I influence the framing of research questions, but to say that I alone framed the questions or was uninfluenced by fellow team members would be inaccurate. I exercise a leadership role, no doubt; but perhaps thinking of myself as both a leader and a scientist helps repel that self-perception of being apart from, rather than a part of, the citizenry.

Acknowledgements

SERC Director Anson 'Tuck' Hines suggested and enabled the creation of the Citizen Science in Archaeology programme. I am pretty sure that what we created was not entirely what he had in mind, but he seems pleased and I am indebted to him for the opportunity to participate in what has become the most rewarding part of my career. Julia Elkins helped me

develop the initial concept of SEAL, and Alison Cawood and her citizen science staff (Maria Sharova, Cosette Larash and Jillie Drutz) have aided its implementation and, along with SERC's public facilities and security staffs, continues to do so. Our citizen science corps, past and present, numbers nearly one hundred, too many to cite here; but Sarah A. Grady, who has been with us from the beginning, and George F. Riseling, Jr., require special acknowledgment. I also thank some of our most active team members: Jim Breedlove, Siara Biuk, Tim Bowders, Kathleen Cannon, Kathleen Clifford, Elizabeth Eckel, Mike Eybel, Kiley Gilbert, Richard Gorski, Bruce Green, Valerie Hall, Barbara Israel, Sarah Janesko, Derek Johnson, Chi hai Kalita, Ron Kolson, Allison LeBlanc, Jocelyn Lee, Cindy May, Janet Medina, Dan Meyer, Jill Meyer, Chloe Moyer, Pete Neal, Bob O'Connor, Katsura Pennington, Linda Perkins, Leo Plourde, Pat Ratkowski, Ray Sarnacki, Carol Shomette, Maeve Stevens, Megumi Takahashi, and Mike Tritsch.

Disclosure statement

No potential conflict of interest was reported by the author.

Notes on contributor

James G. Gibb (Binghamton University, PhD 1994) directs the Smithsonian Environmental Research Center's Environmental Archaeology Laboratory (SEAL). He has researched and published on numerous topics in archaeology, from a Paleoindian site in Maryland, to patterns of wealth among seventeenth-century Chesapeake Bay planters, to production strategies among late nineteenth-century cheese manufacturers in the Northeastern USA. With a team of citizen scientists engaged at all levels of archaeological investigation, from archival research to data collection to analysis and reporting, Jim investigates the ecosystem stresses created by socially differentiated households in the Rhode River watershed of the Chesapeake, analysing biological materials and artefacts from tightly dated archaeological deposits from the mid-seventeenth through twentieth centuries.

ORCID

James G. Gibb  <http://orcid.org/0000-0002-7319-1042>

References

- Agrawal, Anurag A., and Hidetoshi Inamine. 2018. "Mechanisms Behind the Monarch's Decline: Migratory Failure may Contribute to the Dwindling of This Iconic Butterfly's Population." *Science* 360 (6395): 1294–1296.
- Berry, Bailey E. 2014. "Parizek Button Station: Analysis of a Button Cutting Factory in Milford, Delaware." *Maryland Archeology* 50 (1): 4–7.
- Bevan, Andrew, Daniel Pett, Chiara Bonacchi, Adi Keinan-Schoonbaert, Daniel Lombraña González, Rachel Sparks, Jennifer Wexler, and Neil Wilkin. 2014. "Citizen Archaeologists. Online Collaborative Research About the Human Past." *Human Computation* 1 (2): 183–197.
- Biuk, Siara. 2018. "Shell Button-Making on the Delmarva Peninsula, ca. 1930s–1990s." In *Landscape and Legacy: Environmental Archaeology at the Smithsonian Environmental Research Center*, edited by Valerie M. J. Hall. Thematic issue, *Northeast Historical Archaeology*, in press.
- Bollwerk, Elizabeth, Robert Connolly, and Carol McDavid. 2015a. "Co-Creation and Public Archaeology." *Thematic Issue of Advances in Archaeological Practice* 3 (3).
- Bollwerk, Elizabeth, Robert Connolly, and Carol McDavid. 2015b. "Introduction to Special Issue on Co-Creation and Public Archaeology." In *Co-Creation and Public Archaeology. Thematic Issue of Advances in Archaeological Practice* 3 (3): 178–187.
- Bonacchi, Chiara, Daniel Pett, Andrew Bevan, and Adi Keinan-Schoonbaert. 2015. "Experiments in Crowd-Funding Community Archaeology." *Journal of Community Archaeology & Heritage* 2 (3): 184–198.
- Bonney, Rick, Heidi Ballard, Rebecca Jordan, Ellen McCallie, Tina Phillips, Jennifer Shirk, and Candie C. Wilderman. 2009. *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.
- Cannon, Kathleen C. 2017. "Analysis and Comparison of Seventeenth and Nineteenth Century Oyster Shells on the Rhode River, Maryland." Presented at the annual meeting of the Council for Northeast Historical Archaeology, Portsmouth, New Hampshire, November 9–12.
- Cannon, Kathleen C., Leo Plourde, and James Breedlove. 2017. "Harvest of the Bay: Observations and analysis: Oyster shell Samples obtained from two Historic Middens at the Shaw's Folly and Contees Wharf Sites." Presented at the annual meeting of the Middle Atlantic Archaeology Conference, Virginia Beach, Virginia, March 16–19.

- Dickinson, Janis L., Jennifer Shirk, David Bonter, Rick Bonney, Rhiannon L. Crain, Jason Martin, Tina Phillips, and Karen Purcell. 2012. "The Current State of Citizen Science as a Tool for Ecological Research and Public Engagement." *Frontiers in Ecology and the Environment* 10 (6): 291–297.
- Eckel, Elizabeth. 2017. "Patterns of Domestic Coal Use in the Post Bellum Chesapeake." Presented at the annual meeting of the Council for Northeast Historical Archaeology, Portsmouth, New Hampshire, November 9–12.
- European Citizen Science Association. 2015. "Ten Principles of Citizen Science." Accessed July 19 2018. <https://ecsa.citizen-science.net/documents>.
- Eybel, Mike, and James G. Gibb. 2018. "Copper Mining in Colonial through Early Republic Maryland." Presented at the annual meeting of the Middle Atlantic Archaeology Conference, Virginia Beach, Virginia, March 15–18.
- Gilbert, Kiley A. 2015. "Animal Species Diversity at Two Colonial Sites." Paper presented at the 45th Annual Meeting of the Middle Atlantic Archaeology Conference, Ocean City, Maryland, March 12–15.
- Grady, Sarah A. 2016. "Erosion and Sedimentation at a nineteenth-century Farmstead." Paper presented at the Annual meeting of Society for Historic Archaeology, Washington DC, January 6–10.
- Grady, Sarah A. 2018. "Human Impacts on the Land: A Look at the Historic Sellman House (18AN1431)." In *Landscape and Legacy: Environmental Archaeology at the Smithsonian Environmental Research Center*, edited by Valerie M. J. Hall. Thematic issue, *Council for Northeast Historical Archaeology*, in press.
- Grady, Sarah A., Valerie J. M. Hall, and Sarah N. Janesko. 2016. "Engagement, Agency, and Activism Through Environmental Archaeology: A Citizen Science Program at the Smithsonian Environmental Research Center." *Practicing Anthropology* 38 (3): 46–47.
- Haklay, M. 2013. "Citizen Science and Volunteered Geographic Information—Overview and Typology of Participation." In *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*, edited by D. Z. Sui, S. Elwood, and M. F. Goodchild, 105–122. Berlin: Springer.
- Hall, Valerie M. J. 2018. "Neither Fish nor Fowl: The Environmental Impacts of Dietary Preferences at Two Seventeenth-Century Maryland Households." In *Landscape and Legacy: Environmental Archaeology at the Smithsonian Environmental Research Center*, edited by Valerie M. J. Hall. Thematic issue, *Council for Northeast Historical Archaeology*, in press.
- Kent, Bretton W. 1992. *Making Dead Oysters Talk: Techniques for Analyzing Oysters From Archaeological Sites*. Crownsville, Maryland: Maryland Historical Trust.
- Kronick, David A. 2001. "The Commerce of Letters: Networks and "Invisible Colleges" in Seventeenth- and Eighteenth-Century Europe." *The Library Quarterly* 71 (1): 28–43.
- Lee, Jocelyn X. 2017. "Where Water Once Flowed: Terminal Archaic Sites on Relict Stream Channels." Presented at the annual meeting of the Council for Northeast Historical Archaeology, Portsmouth, New Hampshire, November 9–12.
- Lee, Jocelyn X. 2018. "Cultivating Historic Farms: A Study of Late-Nineteenth Century Maryland Farms." In *Landscape and Legacy: Environmental Archaeology at the Smithsonian Environmental Research Center*, edited by Valerie M. J. Hall. Thematic issue, *Council for Northeast Historical Archaeology*, in press.
- Macalik, Jana, John Fraser, and Kelly McKinley. 2015. "Introduction to the Special Issue: Discursive Space." In *Discursive Space*. Thematic issue of *Curator: The Museum Journal* 58: 1–3.
- Miller, Henry M. 1984. "Colonization and Subsistence Change on the Seventeenth Century Chesapeake Frontier." Unpublished Ph.D. Dissertation, Department of Anthropology, Michigan State University.
- Oxford English Dictionary. 2014. "Citizen Science." *The Oxford English Dictionary*. Oxford, UK.
- Rick, Torben C., Leslie A. Reeder-Myers, Courtney A. Hofmana, Denise Breitburg, Rowan Lockwood, Gregory Henkese, Lisa Kellogg, et al. 2016. "Millennial-Scale Sustainability of the Chesapeake Bay Native American Oyster Fishery." *Proceedings of the National Academy of Sciences* 113 (23): 6568–6573.
- Riseling, George F. Jr. 2013. "The St. Francis Cemetery (18ST859) Fylfot: From Anonymous Bauble to Pivotal Artifact." *Maryland Archeology* 49 (1): 23–28.
- Seitsonen, Oula. 2017. "Crowdsourcing Cultural Heritage: Public Participation and Conflict Legacy in Finland." *Journal of Community Archaeology & Heritage* 4 (2): 115–130.
- Sharova, Maria. 2017. "Exploring a Continuum of Engagement in a Citizen Science Program." Presented in the symposium *Understanding Participants*, at the annual meeting of the Citizen Science Association, St. Paul, Minnesota, May 17–20.
- Shirk, Jennifer L., Heidi L. Ballard, Candie C. Wilderman, Tina Phillips, Andrea Wiggins, Rebecca Jordan, Ellen McCallie, et al. 2012. "Public Participation in Scientific Research: A Framework for Deliberate Design." *Ecology and Society* 17 (2): 29–49.
- Simon, Nina. 2010. *The Participatory Museum*. Electronic Document, <http://www.participatorymuseum.org/read/>, accessed 30 May 2018.
- Smith, Monica L. 2014. "Citizen Science in Archaeology." *American Antiquity* 79 (4): 749–762.
- Snyder, Laura J. 2011. *The Philosophical Breakfast Club & the Invention of the Scientist*. Dibner Library Lecture, December 6, 2011. Washington, DC: Smithsonian Libraries.
- Tritsch, Michael R. 2017. "Social Distinctions in Plantation Economies: Comparative Analysis of Faunal Remains from Contees Wharf Slave Site and Java Ruin Plantation Mansion." Presented at the annual meeting of the Council for Northeast Historical Archaeology, Portsmouth, New Hampshire, November 9–12.

- Tritsch, Michael R. 2018. "Analysis of Faunal Remains From Contees Wharf Slave Site (18AN339)." *Maryland Archeology* 51 (1 & 2): 4–14.
- Trumbull, Deborah, J. Rick Bonney, Derek Bascom, and Anna Cabral. 2000. "Thinking Scientifically During a Citizen-Science Project." *Science Education* 84 (2): 265–275.
- Wiggins, Andrea, and Keven Crowston. 2015. "Surveying the Citizen Science Landscape." *First Monday* 20 (1), 5 January 2015. Accessed June 4, 2018. <http://firstmonday.org/ojs/index.php/fm/rt/captureCite/5520/4194>.