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Buckets of Resistance: Standards and the Effectiveness of Citizen Science

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Abstract

In light of arguments that citizen science has the potential to make environmental knowledge and policy more robust and democratic, this article inquires into the factors that shape the ability of citizen science to actually influence scientists and decision makers. Using the case of community-based air toxics monitoring with "buckets," it argues that citizen science's effectiveness is significantly influenced by standards and standardized practices. It demonstrates that, on one hand, standards serve a boundary-bridging function that affords bucket monitoring data a crucial measure of legitimacy among experts. On the other hand, standards simultaneously serve a boundary-policing function, allowing experts to dismiss bucket data as irrelevant to the central project of air quality assessment. The article thus calls attention to standard setting as an important site of intervention for citizen science-based efforts to democratize science and policy.

Keywords

standards, citizen science, environmental justice, air quality monitoring, democratizing science

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Through the late 1990s until 2002, African American residents of the Diamond subdivision in Norco, Louisiana, waged a heated campaign against the Shell Chemical plant adjacent to their community. They alleged that the manufacturing facility—located merely fifty feet from some of their homes—was unsafe, and that its emissions of toxic air pollutants caused serious illnesses among residents. In conjunction with their demands that Shell buy their homes to allow them to relocate, resident activists in Diamond tried to demonstrate that the air that they were breathing was hazardous to their health. They conducted their own air monitoring, measuring levels of toxic chemicals in the ambient air with inexpensive, easy-to-operate sampling devices known as "buckets."[1] Their bucket monitoring focused on gathering data at times when air quality in the community was apparently at its worst, especially during and immediately after releases from the chemical plant, and community activists compared bucket results to state regulatory standards to argue that their air was unhealthy to breathe.

Bucket monitoring by Diamond activists did more than "prove" (or attempt to prove) that local air quality was poor. More fundamentally, it challenged the standard practices used by regulators for assessing air quality. Regulators' routine monitoring strategies focused on producing data about the average concentrations of toxic chemicals over long periods to compare to ambient air standards. Activists, however, measured short-term spikes in air pollution levels and compared their data to arguably incommensurate regulatory standards to demonstrate that the air was unsafe. In doing so, they asserted that peak toxics concentrations mattered to determining whether industrial emissions threatened community health.

Bucket monitoring is typical of "citizen science"—knowledge production by, and for, nonscientists—in that it both contributed information about local air quality and suggested alternative modes of air quality assessment. Accordingly, this article might, like many other studies of citizen science, focus on the potential of resident-initiated air monitoring to improve environmental science and policy making. Scholars studying nonscientists' critical engagement with science—including community-based knowledge production efforts like bucket monitoring—have argued that such engagement can help make environmental decision making more robust and democratic (Irwin 1995; Fischer 2000) and influence the research directions of science to be more responsive to broad social concerns rather than the specific interests of elites (Martin 2006; Hess 2007). Indeed, bucket monitoring, taken seriously, might provoke research into the effects of repeated spikes in air pollution on human health. It could also—again, if it were taken seriously—move policy makers to incorporate into regulatory decisions residents' concerns about unusually high emissions during industrial accidents.

However, instead of focusing on bucket monitoring's potential effects, this article addresses a question seldom asked of nonscientists' knowledge production efforts: what makes bucket monitoring, or any form of citizen science, likely to be taken seriously—seriously enough, that is, to influence policy processes or research directions? Existing studies document cases where nonscientists' engagement with science has helped secure activist victories or changed standard scientific research practices (Brown 1993; Epstein 1996) as well as cases where similar engagement has not been successful in swaying scientists or policy makers (Allen 2003; Corburn 2005). Yet, little has been written about the underlying factors that determine the degree to which citizen science can be influential or effective, especially in shifting research agendas, changing standards of proof, or affecting policy processes.

This article concentrates on one set of factors that shapes the ultimate effectiveness of bucket activists' air monitoring efforts. In particular, I describe how standardized practices for measuring and evaluating air quality—the very standards that bucket monitoring challenges—determine to what extent and in what ways bucket data is used (or not) by regulators and chemical industry officials. Standards play a dual role in shaping the success of bucket monitoring, as evidenced by the mixed results seen by activists. On one hand, activists' use of buckets in Diamond provoked a multiyear, industry-sponsored, agency-supervised study of Norco's air quality and may have contributed to regulators' decision to take enforcement action against Shell Chemical (O'Rourke and Macey 2003).[2] These victories are attributable, in part, to a boundary-bridging role played by standards: to the extent that buckets incorporated standard air monitoring practices, activists' data enjoyed a crucial, if limited, measure of legitimacy among regulators and industry officials. On the other hand, activists were unable to change how overall air quality was ultimately assessed. Bucket monitoring's limited effectiveness in this regard, I argue, stemmed from a boundary-policing role played by standards: regulatory standards for air quality, combined with standardized practices for monitoring, provided regulators with a ready-made way to dismiss activists' data as irrelevant to air quality assessment.

Beyond simply accounting for buckets' success (or lack thereof), this article aims to suggest that standards shape the effectiveness of many forms of citizen science. Operating at the boundaries of knowledge-producing communities, standards, through their boundary-bridging and policing functions, structure judgments about the value of data produced by nonexpert groups and, in turn, influence the ability of those citizens to be accepted as legitimate participants in knowledge- and policy-making processes.

My discussion of bucket monitoring shows how standards act at the boundaries of three communities, each involved in air toxics monitoring: environmental regulators, chemical industry officials, and environmental justice activists. The first two, arguably expert, communities comprised scientists and engineers with similar training and overlapping professional networks, working in distinct institutional settings. In the course of my research (conducted primarily in 2002 and 2003), I interviewed and/or spoke informally with approximately five regulators, all technically trained, whose positions with either the Louisiana Department of Environmental Quality (LDEQ) or the U.S. Environmental Protection Agency (EPA) involved them in some aspect of air monitoring or air quality assessment. I also interviewed about ten high-ranking scientists and engineers at Shell Chemical Norco and nearby petrochemical plants in St. Charles Parish, Louisiana, about myriad topics pertaining to community-industry relations in the parish, including air monitoring, and interacted with these and other industry officials in the context of community meetings.

The third community involved in air monitoring, environmental justice activists working with buckets, was more heterogeneous but nevertheless characterized by its position outside expert networks. The community of bucket monitoring activists considered here consisted of residents of Norco and other petrochemical facility-adjacent communities who took bucket samples in conjunction with campaigns against industrial neighbors, as well as staff members and volunteers of the environmental justice nonprofit groups that supported community campaigns—including California-based Communities for a Better Environment (CBE) and, in Norco, the Louisiana Bucket Brigade (LABB).[3] Beginning in 2001, I was a participant observer at CBE (August 2001—June 2002) and LABB (July 2002—June 2003) and interacted with EJ professionals and resident activists both as an STS researcher and as a technically trained volunteer[4] responsible for researching monitoring strategies and developing tools for interpreting bucket results. As a volunteer for LABB, I also organized an event which brought together members of all three communities for a roundtable discussion of environmental monitoring.

After drawing on the STS literature to argue for the importance of standards in structuring the power relations that accompany confrontations between "citizen science" and expert knowledge, this article contrasts regulators and EJ activists' respective approaches to air monitoring—and the claims about chemical health effects that underlie them. I then describe how the bridging and policing functions of air quality standards and standard practices for air monitoring helped shape the effectiveness of bucket monitoring strategies, in part by positioning environmental justice activists and their knowledge claims with respect to expert communities. The conclusion considers the significance of standards to nonscientists' knowledge production efforts more generally, arguing for standard setting as an important site of intervention in democratizing science and environmental policy.

Toward a Political Sociology of Citizen Science

Studies of citizen science—and nonscientists' critical engagement with science more generally—have shown the potential of citizens' "local knowledge," normally inaccessible to scientists, to improve quantitative models and risk assessments (Wynne 1996; Corburn 2005); they have also shown how citizens' encounters with experts expose value judgments naturalized as "good science" and suggest alternative moral orders to be represented in scientific research (Epstein 1996; Wynne 1996). By capturing local knowledge and questioning expert values, STS scholars have further suggested, citizen science stands to transform science—providing models for more participatory forms of knowledge production and policy making (Irwin 1995; Fischer 2000; Yearley et al. 2003), and adding to scientific research agendas lines of inquiry important to the public interest but previously neglected (Martin 2006; Hess 2007).

Yet citizen science, while credited with significant results in particular cases (Brown 1993; Epstein 1996), has arguably not fulfilled its theoretical potential. Nor should we be surprised by its intermittent success: a significant and obvious obstacle to citizen scientists' efforts to shape scientific policies and practices are the often extreme disparities of wealth, education, and power (among others) between them and those they seek to influence. As a result, understanding whether and under what circumstances citizen science can fulfill its transformative potential requires a deeper analysis, focused on these disparities, their institutional bases, and their consequences for competing knowledge claims—a sort of analysis described by Frickel and Moore (2006) as a "political sociology of science." Among the issues meriting examination are, for example, the importance of collective action to advancing citizens' scientific critiques (Epstein 1996; Brown and Michael 2002; Lerner 2005), the consequences of activists' relative socioeconomic status for their dealings with experts (Epstein 1996; Cole and Foster 2001), the manner in which the structure of deliberative policy processes shapes the substance of citizens' contributions (Irwin 2001)—and, as this article suggests, the role of standards in determining how influential citizens' knowledge claims can be.

The Power of Standards

Standards do important, if at times hidden, work in shaping the uneven terrain on which citizen scientists meet experts. As part of technical practice, standards coordinate the work of scientists and provide the means for distinguishing relevant from irrelevant and reliable from unreliable information; simultaneously, they express ethical positions and expert judgments not only on technical issues but on the political, social, and economic considerations intrinsically linked to them (Majone 1984; Irwin et al. 1997; Calow 1998; Abraham and Reed 2002). Moreover, standards give these judgments political and material force far beyond particular scientific communities by establishing them as accepted, even formalized, parts of juridical practices, state regulation, and professional society codes (Majone 1984; Salter 1985; Irwin et al. 1997; Shapiro 1997; Calow 1998; Daemmrich 1998; Bowker and Star 1999; Abraham and Reed 2002). Standards then become forceful contributors to the structure of power relations; for example, they act to distribute agency among human and nonhuman actors and help determine who can and cannot participate in scientific and policy debates (Bowker and Star 1999; Frickel and Moore 2006). Standards are, if anything, more powerful because they act at an infrastructural level: once standards are established, the sociotechnical judgments they represent recede into the background, becoming visible again only in moments of controversy or as a product of active resistance (Levidow et al. 1997; Bowker and Star 1999).

Standards have accordingly been a site of struggle between citizens and experts—or, more precisely, among social movement groups, academic scientists, regulators, and industries. The activism of health-based social movement organizations, for example, has often involved challenges to standardized procedures; the environmental justice movement in particular contests standards for statistical significance in epidemiological studies that systematically thwart fenceline communities' efforts to prove that disease rates are elevated in residential areas near hazardous facilities (Head 1995; Allen, B. L. 2000). Environmental justice activists also question the adequacy of regulatory standards that set allowable levels for chemical exposures, although the nonscientists involved in community campaigns have tended not to organize for the primary goal of changing such standards. Scientists and industry groups, however, have often organized to influence regulatory standard setting (Kaprow 1985; Ziem and Castleman 1989; Allen, D. 2000; Davis 2002), and cases like the establishment of threshold limit values for workplace exposures demonstrate how corporate power gets expressed in standards (Ziem and Castleman 1989; Allen, D. 2000b).

Standards and Boundaries

Although nonscientist citizens' involvement in struggles over standards has been widely noted, less attention has been paid to the ways that standards themselves shape the outcomes of these and other struggles. The work done by standards and the consequences of standardization have, in contrast, been theorized in STS research on laboratory practice and regulatory science. Insights from that research help conceptualize how standards, as infrastructural manifestations of expert judgment, shape the terrain on which citizen scientists confront expert knowledge. In particular, the literature shows that standards serve two interrelated functions of potential consequence for citizen science: on one hand, standards help coordinate scientific work, or bridge boundaries; on the other hand, standards contribute to the establishment of expert authority, and thus police boundaries.

Standards and standardized procedures have been shown to serve a boundary-bridging function, in that they allow for the production and circulation of scientific knowledge across multiple sites by guaranteeing that results generated in one site will be reliable and meaningful in others (O'Connell 1993; Fujimura 1996; Oudshoorn 1997; Mallard 1998; Bowker and Star 1999; Zimmerman 2008). In doing so, they do not eliminate the heterogeneity of individual research sites and communities (Timmerman and Berg 1997). Rather, they coordinate scientific work across diverse communities while allowing for the maintenance of distinct purposes and identities within collaborating communities (Star and Griesemer 1989; Fujimura 1996; Shostak 2007). Standards thus bridge boundaries between research communities. They also have the ability to bridge boundaries between scientific communities and groups of nonscientists: Star and Griesemer (1989), for example, demonstrate the importance of standardized methods and objects to a project requiring the cooperation of zoologists and amateur naturalists.

Although standards help bridge boundaries among heterogeneous communities, they have also been shown to police them. Specifically, standards play a role in establishing the authority of scientists and other technical experts—including professional engineers (Shapiro 1997) and expert witnesses in legal proceedings (Daemmrich 1998)—in domains outside of scientific networks. This function of standards is, of course, closely linked its boundary-bridging function: standards contribute to scientific and professional authority by (apparently) guaranteeing the universality of truths offered by experts. However, in the process of establishing some knowledge as authoritative and some communities as its credible representatives, standards marginalize alternative knowledge production processes. Thus, standards and standardized practices might be imagined to help police boundaries between science and nonscience (c.f., Gieryn 1999), with inevitable consequences for nonscientists' efforts to produce knowledge.

The dual nature of standards suggests that, with respect to citizen science, they cut both ways. Standards' boundary-policing aspect makes them a resource for experts who wish to resist nonscientists' challenges. However, the boundary-bridging aspect of standards makes them simultaneously a resource for citizens critical of expert knowledge: combined with collective action and other strategies for overcoming power disparities, standards offer opportunities for citizens to render their challenges recognizable to experts and to claim the right to participate in expert-dominated discussions of technical issues. The case of buckets as an approach to air monitoring—and, more importantly, air quality assessment—shows how standards' dual aspects play off against one another in shaping buckets' ultimate impact and suggest how standards might be more effectively exploited and challenged by environmental justice activists.

Monitoring Standards and the Challenge of Buckets

Just as activists conduct bucket monitoring out of concern for the effects of air pollution on their health, experts' standards for air monitoring also incorporate a set of claims about pollution and health—indeed, they black-box these claims. Specifically, ambient air quality standards set out thresholds for "safe" levels of chemical exposure, and monitoring protocols focus largely on generating reliable data that can be compared to the air quality standards. Through these interrelated standards, then, monitoring becomes a technical means of evaluating whether the air is safe to breathe. As an alternative strategy for monitoring, buckets offer activists the possibility of participating in the evaluation of air quality and, in turn, making claims about the health effects of air pollution. However, grounded in activists' understanding of health effects—which differs significantly from that of regulators—bucket monitoring not only departs from regulators' standardized practices but also represents a critique of them and the scientific claims that lie at their core.

Air Quality Standards

In Louisiana, ambient air levels of hazardous air pollutants such as benzene, butadiene, and vinyl chloride—the kinds of pollutants emitted by chemical and petrochemical facilities—are regulated by the Toxic Air Pollutant Ambient Air Standards (LA Title 33, Part III).[5] For each of approximately 100 chemicals, the standards specify the maximum concentration allowable in the air in terms of either an eight-hour or an annual average.

The standards apparently reflect a concern with the health effects of airborne pollutants. Each standard represents an assessment of the risks that a chemical poses to human health: the eight-hour standards are based on a fraction of occupational exposure limits, and the annual standards draw on risk factors to establish levels that corresponds to increased cancer risks of one in 10,000 (LA Title 33, Part III, 274). Moreover, the form that the standard takes for each chemical is likely based on the way the chemical is believed to act on human health. That is, because cancer tends to be thought of as an effect of chronic exposure, cancer-causing chemicals are governed by annual (rather than eight-hour) average standards. Shorter term averages are typically reserved for chemicals for which short-term exposures are thought to cause health effects. Although this logic is not made explicit in the Louisiana law that establishes air quality standards, it is apparent in standards and health-based screening levels set by other agencies. The state of North Carolina, for example, divides the chemicals it regulates into "carcinogens," "chronic toxicants," "acute systemic toxicants," and "acute irritants," specifying for the different classes of chemical, respectively, annual, twenty-four-hour, one-hour, and one-hour standards.

Monitoring Standards

Since Louisiana's air quality standards suggest that health effects are a result of relatively long exposures to hazardous chemicals, the Louisiana Department of Environmental Quality's standard practices for air

Figure 1. Summa Canister
Source: URS 2003.

monitoring focus on measuring the average concentrations of air toxics over commensurately long periods. The LDEQ's toxics monitoring program collects air samples in glass-lined, stainless steel spheres, called Summa canisters (shown in Figure 1). The canisters are attached to flow controllers and pumps, which fill them at a constant rate over a sampling period of twenty-four hours. One twenty-four-hour sample is taken every sixth day to capture air quality data from all days of the week. To determine the concentrations of toxic chemicals in samples, they are analyzed using a technique designated in the federal register as Federal Reference Method (FRM) TO-15.

Data from Summa canister sampling are used to assess whether air quality in an area poses any health threats—or, more precisely, whether it meets air quality standards. Each Summa canister sample yields, for each toxic chemical measured, a value that represents the average concentration of the chemical over the twenty-four-hour sampling period. For chemicals whose annual average concentration is regulated, twenty-four-hour data are aggregated for comparison to the standards. Where eight-hour average concentrations are regulated, individual twenty-four-hour samples are compared directly to the standards—with the caveat that the concentrations in the twenty-four-hour sample must be less than one-third of the regulatory standards to guarantee that they were not violated (e.g., URS 2003). On the basis of these comparisons, regulators decide whether air quality is acceptable.

Several of the LDEQ's monitoring stations are also equipped to take short-duration air samples. These stations employ a monitor that measures the aggregate concentration of toxic air pollutants in real time and, whenever that concentration exceeds a predetermined threshold, triggers a Summa canister sample to be collected over a period of seconds. Data from these "event samples," however, are not compared to Louisiana's ambient air standards.

Air Quality and Health in Fenceline Communities

Bucket users, like regulators, are engaged in air quality monitoring out of concern for the health effects potentially caused by chemical exposures. Their understanding of how air pollution affects health, however, differs considerably from that of regulators. Residents of fenceline communities and allied environmental justice activists believe that residents are made ill by the continual presence of numerous toxic chemicals in the local environment. However, these on-going, low-level exposures, to which regulatory standards are geared, are regarded by activists as just one of the threats to community health. Community members are also exposed periodically to higher levels of chemicals as a result of flaring, start-ups, accidents, and other unplanned releases from nearby industrial facilities. These spikes in air pollution levels are seen by activists as another significant source of chemical exposure and understood as having consequences for residents' long-term health.

In talking about their experiences of living near industrial facilities, residents of fenceline communities often describe accidents and other events that emit large quantities of chemicals. Residents of New Sarpy, Louisiana, for example, frequently referred to the fourteen-hour long fire in a storage tank at the nearby Orion refinery, expressing (among other sentiments) their incredulity at Orion officials' assurances that the combustion of millions of gallons of gasoline had no impact on air quality in their community. In many cases, community members connected these events to health symptoms that they experienced, describing shortness of breath and eye irritation,

Figure 2. Bucket, as Typically Deployed (Left), and Open to Show Tedlar Sampling Bag (Right)Source: Photos by author

among others. One elderly New Sarpy woman, who asserted that Orion's frequent flaring made her heart condition worse, claimed that she had to be taken to the hospital after a period during which the smell from the refinery was so strong that she had to put her head in the refrigerator just to get a breath of clean air.

Other statements by residents and activists emphasize their belief that periodic spikes in pollution have lasting effects. When an incident at the Motiva refinery in Norco in October 2002 spewed oily gook over the town, angry residents described the black spots that coated line-drying laundry and said that they imagined their lungs must have suffered similarly. Denny Larson, bucket disseminator and community organizer, describes the illnesses he observes in fenceline communities as an outcome of residents' being repeatedly "gassed," referring to the high levels of chemicals released intermittently by facilities.

Because the pollution spikes experienced by residents of fenceline communities are thought to have important, long-term health consequences, bucket users attuned to regulatory agencies' standard monitoring practices criticize them for averaging out the most serious pollution. That is, twenty-four-hour Summa canister samples mix air collected during pollution peaks with the relatively clean air present during the rest of the sampling period, rendering pollution spikes invisible in the process of comparing air quality measurements to air quality standards. Buckets, in contrast, give activists the means to gather data about chemical concentrations during the most heavily polluted periods—and to use the data to make claims about the effects of industrial pollution on community health.

Bucket Monitoring

Buckets, like Summa canisters, are a kind of "grab sampler": they collect samples of the ambient air by sucking it into an evacuated vessel. The buckets use a hand-held, battery-operated vacuum cleaner to pump the air out of a five-gallon plastic container,[6] then draw ambient air in through a stainless steel inlet to a nonreactive plastic (Tedlar) bag inside the container (see Figure 2). To best represent peak chemical concentrations, the vacuum pump chosen for the bucket fills the Tedlar bag over a period of several minutes—a period brief enough to capture the levels of pollution caused by unplanned industrial releases, yet long enough that subtle shifts in wind direction do not significantly affect the quality of the sample. Once a sample is collected, the Tedlar bag is removed from the bucket and sent to an analytical laboratory, where chemical concentrations are determined using FRM TO-15, the same method used by regulators and industry to analyze samples collected in Summa canisters.

Bucket monitoring is typically conducted by fenceline communities, like Norco, allied in campaigns against local polluters with environmental justice nonprofits like the Louisiana Bucket Brigade. EJ groups provide training on the use of buckets and help community members incorporate bucket data into their campaigns. Groups of both sort constitute a loose network of bucket users who share a set of practices for air monitoring with the buckets, two aspects of which are of particular importance with respect to regulators' monitoring standards. First, in contrast to the predetermined sampling schedule maintained by regulators, fenceline community residents take bucket samples only when pollution in the neighborhood is apparently at its very worst. Louisiana Bucket Brigade staff, for example, instructs residents to take samples when they would rate the smell in the neighborhood to be at least a seven on a scale of 1 to 10. In this sense, bucket sampling is comparable to regulators' "event sampling." However, the way that activists routinely use bucket data to make claims about chemical health effects also contrasts with regulators' standard approach to interpreting monitoring data. Chemical concentrations measured in individual bucket samples are compared directly to the Louisiana Ambient Air Standards (whereas event samples never are), as well as health-based screening levels developed by other states. For example, in 2000, New Sarpy residents and LABB issued a press release stating that bucket results had shown benzene in the community at three-and-a-half times the Louisiana standard. Activists make the comparison without acknowledging that the standards refer to eight-hour or annual averages and that their sampling data represent a single three- to six-minute period. They also routinely include information about the health effects of the chemicals detected in bucket sampling, noting, for example, that benzene is a known carcinogen.

In its departures from regulators' standard monitoring practices, bucket monitoring represents activists' critique of the way those standards treat peaks in air pollution levels. Bucket data measure chemical concentrations during the peaks, which regulators' twenty-four-hour samples do not. Moreover, by comparing peak data directly to regulatory standards for average levels, activists assert (albeit implicitly) that the peak concentrations experienced in fenceline communities are consequential for long-term community health. These challenges to experts' practices make buckets typical of citizen science. Like other community-based data collection activities, such as popular epidemiology, bucket monitoring questions not only experts' claims about local environmental quality (i.e., that air quality poses no threat to human health) but their methods of arriving at them as well. Bucket monitoring also suggests that community members, who, unlike regulators, are present for unplanned industrial releases, have an important role to play in assessing air quality; buckets, in this sense, capture one kind of "local knowledge."

Because of the challenges it poses, bucket monitoring arguably shares with other kinds of citizen science the potential to reshape expert methods, to alter scientific research directions, and to foster inclusion of nonscientists in policy making. Yet, its effectiveness in doing so has been limited. Regulators may more regularly conduct event sampling, and regulators and industry have in a few places, most notably Norco, conducted additional ambient air monitoring in response to pressure from bucket users. However, experts' fundamental approach to monitoring and, more importantly, to using monitoring results to assess air quality has not changed considerably. An important part of the explanation for buckets' partial success lies in the way that standardized practices for monitoring structure experts' responses to bucket data and claims based on it.

"EPA Approved": Standards' Boundary-Bridging Effects

The boundary-bridging function of standards, I have suggested, lies in standards' ability to extend scientists' confidence in the reliability and commensurability of data generated in diverse research sites (O'Connell 1993; Mallard 1998). Because bucket monitoring in Louisiana fenceline communities largely eschews the LDEQ's standardized practices for measuring air toxics concentrations, the validity of bucket data is frequently questioned by regulators. However, bucket monitoring's use of the TO-15 method for sample analysis lends a measure of credibility to bucket data, demonstrating the potential of standards to bridge boundaries not only among expert communities but between communities of experts and nonexpert activists. Buckets' use of FRM TO-15 not only allows one aspect of the monitoring method to go unquestioned by regulators skeptical of the validity of activists' data, it also makes it easier for activists to draw on regulators—and their authority as members of an important expert community—in efforts to claim legitimacy for buckets as a monitoring technique.

When I spoke to environmental regulators about buckets, they expressed doubts about the validity of bucket data and, in turn, about its ability to serve as evidence of unhealthy air quality in fenceline communities. One engineer with the permitting division of the EPA, for example, told me in an informal conversation that he and his colleagues did not know how reliable the data from buckets were and thus had reservations about acting on problems that bucket data appeared to show. They preferred, he said, to use familiar monitoring methods whose results they were more comfortable with. Jim Hazlett, in charge of air toxics monitoring at the LDEQ, expressed more pointed concerns about the validity of bucket data, focusing on the Tedlar bags in which samples are collected. The agency's experience with the bags, he told me, showed that the bags themselves were often "dirty"—contaminated with residual polymers and other chemicals that appeared in sample results even though they had not been in the ambient air. In addition, the activists with whom I interacted reported that regulators (and industry scientists) frequently tried to discredit bucket data by suggesting that community members were likely to inadvertently contaminate samples by storing Tedlar bags in inappropriate places or by taking samples too near secondary sources of pollution, like burning cigarettes or idling cars.

The questions raised by regulators about the validity of bucket data revolve around the method and equipment used in sample collection—that is, around activists' substitution of Tedlar bags housed in plastic paint buckets for the Summa canisters used by regulatory agencies and industrial facilities. Regulators' skepticism about bucket results does not, however, extend to issues related to sample analysis. That is, although activists use a commercial laboratory to determine the concentrations of air toxics in their samples while regulators rely on in-house laboratories, regulatory agency scientists and engineers appear comfortable assuming that the results of laboratory analyses are valid, and that the reliability of the data is limited by how faithfully the sample itself represented the ambient air.

Bucket monitoring's use of the TO-15 method of sample analysis appears to give regulators (just) enough faith in the validity of bucket data to investigate high concentrations of chemicals documented by buckets. For example, in Norco in 1998, one bucket sample showing high levels of methyl ethyl ketone and other chemicals prompted additional monitoring by environmental agencies, who confirmed the results and traced the chemicals back to a leak at Shell Chemical. According to activists, regulators have conducted their own monitoring in response to bucket sampling in other communities as well; however, when residents' complaints about odors were made without the quantitative confirmation provided by bucket data, regulators almost never took action.

Buckets' use of the TO-15 method for sample analysis does more than shield one part of the monitoring approach from criticism and make regulators more likely to act on activist-generated data. It can additionally ally activists—albeit peripherally and tenuously—with regulators and allow them to draw legitimacy from their associations with regulatory agencies, as powerful scientific institutions. Activists involved in bucket monitoring, both when promoting buckets and responding to critics, claim that the bucket is an "EPA-approved" method. The claim stems from the involvement of EPA Region 9 early in the development of the buckets. The agency officially approved a "quality assurance project plan" (QAPP) for bucket monitoring in Northern California's Contra Costa County. The EPA deemed that the buckets provided data of "sufficient quality" to meet their objectives (giving community members and local government officials additional information about air quality) in part because they used "established analytical methods," namely FRM TO-15 (Plate 2001). Then, in conjunction with the development of the QAPP, an EPA Region 9 laboratory analyzed a series of bucket samples and unused Tedlar bags which "partially addressed" questions about the validity of data and the storage conditions of the sampling bags (Plate 2001). The EPA laboratory was able to conduct this testing because it was already set up to perform TO-15 analyses, and laboratory scientists' assessment of bucket results was based on their extensive experience with the method. The buckets' use of FRM TO-15, then, facilitated the involvement of EPA Region 9 in testing and sanctioning the buckets, which in turn enabled activists to claim for their alternative monitoring method the approval of the powerful regulatory agency.

More recently, EPA Region 6 sponsored an investigation into the validity of bucket results that likewise offered the potential for regulatory agency involvement to bolster buckets' legitimacy. The Houston/Galveston Citizen Air Monitoring Project (HGCAMP), a 2002-2003 collaboration between the EPA, the Texas Commission on Environmental Quality, several local governments, and citizens of the heavily industrialized area, involved citizens in taking simultaneous bucket and Summa canister samples to compare results obtained through the two methods. Samples were taken at citizens' discretion, during the malodorous periods that would normally trigger bucket sampling, and were analyzed by a Region 6 laboratory. The results of the comparison were mixed, and regulators like LDEQ air monitoring expert Jim Hazlett interpreted the fact that bucket and Summa canister data compared well in only some cases as validating their doubts about the quality of bucket results.

Although HGCAMP did not in fact add to the legitimacy of buckets in the eyes of experts, expert responses to the project indicate the power of the side-by-side testing and demonstrates, again, the boundary-bridging function of standards. Hazlett and other regulators who mentioned the Texas study to me looked to it for reliable information about the quality of buckets with respect to a standard method widely used by regulatory scientists. Had the comparisons between the two methods been consistently favorable, the study could have squelched many of regulators' doubts about the validity of bucket results and given activists another EPA-generated pronouncement with which to counter the buckets' detractors. Regardless of their outcome, these crucial comparisons were possible because bucket results were based on the same sample analysis technique that standard Summa canister monitoring used, meaning that results from the two methods were directly comparable. As in the case of EPA Region 9's involvement with the buckets, here again the use of FRM TO-15 brought bucket monitoring in close proximity to the regulatory community and created the possibility—unrealized in this case—for regulatory agencies to lend their scientific authority to activists' monitoring method.

Thus, while the validity of bucket results is routinely questioned by environmental regulators, their criticisms tend to focus on the areas in which bucket monitoring techniques deviate from the monitoring approaches routinely used by regulators themselves. Where buckets incorporate aspects of regulators' standard practices, particularly in their use of the TO-15 analysis technique, they are far less likely to be questioned. Moreover, the use of the federal reference method for sample analysis gives activists the opportunity to temporarily ally themselves with communities of regulatory experts. In the process, it allows for validation of bucket results by regulatory agency laboratories and creates the potential for activists to claim some measure of the EPA's scientific authority for their own data. Although the scientific validation of bucket results is only rarely to the advantage of activists, the bridge that the sample analysis standard creates between regulatory agency scientists and bucket monitoring community activists does at times contribute to the overall legitimacy of activists' data—if only by increasing regulators' familiarity with the method and their understanding of its specific limitations. FRM TO-15's boundary-bridging function, at least with respect to the buckets, stands in contrast to the role played by the Louisiana Ambient Air Standards, which tend to reinforce boundaries between activists and expert communities by distinguishing data relevant to determining whether chemicals in the air might pose a threat to human health from that which cannot be used for the assessment of air quality.

"Representative" Data: Standards' Boundary-Policing Effects

In addition to establishing the validity of air monitoring data, standards guide judgments about what data are relevant to the assessment of air quality. Specifically, the Louisiana Ambient Air Standards are framed in such a way as to demand that arguments about whether the air is healthy to breathe rest on data about annual and eight-hour average chemical concentrations. In doing so, they effectively reinforce boundaries between activists and communities of regulatory and industry experts: although activists see the data produced by buckets as indicating that the air in their communities is unhealthy, ambient air standards offer regulators a way to deem activists' data irrelevant to the assessment of air quality. Furthermore, because of the high costs associated with producing relevant data, the standards help ensure that air quality assessment remains an expert domain; activists' data are reinterpreted as a contribution to the much narrower domain of air emissions-related problem solving.

Activists routinely use bucket monitoring as a way to participate in making claims about the air quality in fenceline communities, drawing on quantitative data from the buckets to back up their assertions that the air is unhealthy. Although activists will point to any measured levels of chemicals known to present health hazards as indicators of a problem, they use comparisons to regulatory standards (and other government-issued screening levels) to argue that the levels of pollution created by industry exceed the levels that the state has determined to be safe. Activists are not ignorant of the incommensurability of their data, based on samples taken over a period of several minutes, and standards expressed as eight-hour and annual average standards. However, by persistently making the comparison, they assert that the peaks of air pollution that buckets measure do matter to the health effects experienced by residents and that regulators' monitoring practices should take them into account.

Regulators, however, reject activists' claims that bucket monitoring can substantiate residents' concerns about the long-term health effects of pollution, using state ambient air standards to establish bucket results as irrelevant to assessing air quality. Jim Hazlett of the LDEQ told me in an interview that he had a major problem with activists' use of bucket data:

> You can't really take that data and apply it to an ambient air standard. And that's what a lot of citizens have a tendency to do. And, of course, the media is more than happy to go along with that. So we see a headline, the citizen group over here found a, took a sample and found benzene that was 12 times the state standards. Well, it's not true. I'm sorry, but that's not what it was.

Hazlett went on to explain that the ambient air standards reflected that, although levels of toxics in the air fluctuate, one needed to look at longer-term average levels to get a representative picture of air quality and evaluate its potential effects. Because bucket monitoring could not provide average, or representative, data, he argued that citizens could not use it as a basis for making claims about the quality of their air or neighboring facilities' performance relative to the state's standards. By applying the standards to bucket data, Hazlett was able to ignore the important challenge that buckets made to the standards themselves—namely that experts' monitoring practices could not yield data that would adequately represent the health risks faced by fenceline communities.

In granting a measure of legitimacy to buckets, regulators also turned a blind eye to the buckets' fundamental critique of how air quality was assessed. To the extent that they acknowledged the validity of bucket data, regulators saw it as potentially useful to the limited task of identifying and fixing problems at industrial facilities. Both Hazlett and EPA scientists to whom I spoke informally said that, when they saw short-term data indicating very high levels of chemicals, whether from buckets or from regulators' own event sampling, they would take it as an indicator of a potential problem at a facility. If no release that might account for the chemicals had been reported, they would use that monitoring data to try to work with the facility to find and remedy the problem. Jim Hazlett gave one example in which the LDEQ saw a high reading from a monitor in Lake Charles and took it to a nearby facility, which scrutinized some of their processes and found a significant leak. Bucket activists, similarly, report an incident in Mossville, Louisiana, where bucket results helped convince EPA officials to use their own sophisticated, mobile monitoring equipment to investigate high ambient levels of benzene, which they ultimately traced to a large, uncontained pile of contaminated rags. Bucket results were thus seen as potentially having a role in regulators' (and industry engineers') efforts to manage facility emissions—but ambient air quality standards helped distinguish this task from that of making judgments about the acceptability of air quality in communities.

Standards not only policed the boundary between regulators, as experts who could legitimately make pronouncements about air quality, and bucket monitoring citizens without the scientific authority to participate in air quality assessments. They also reinforced a boundary between citizens and industrial facility scientists and engineers, who were able and willing to take advantage of the standards' boundary-bridging aspects to establish themselves as a second group of legitimate participants in air quality assessment. In particular, in Norco, bucket monitoring during Diamond residents' protracted campaign (Lerner 2005) arguably led Shell Chemical Norco and the neighboring Motiva refinery to sponsor an extensive ambient air monitoring program in the small town. In consultation with regulators, academic scientists, community members, and the consulting firm which carried out the monitoring, Shell and Motiva designed a program which adopted wholesale the standardized monitoring practices used by the LDEQ. It collected twenty-four-hour samples in Summa canisters every sixth day and set up event samplers triggered by total VOC levels; sampling data were averaged and compared to the Louisiana Ambient Air Standards (URS 2003). On the basis of their monitoring, company officials declared that air in Norco met state standards and implied that air quality posed no health risk to Norco residents. Because they were based on well-known, approved methods, these claims were readily accepted by regulators overseeing the program. Although no bucket samples have been taken since the monitoring program was initiated several months after the end of residents' campaign against Shell, it is unlikely that they would be recognized even to the extent that they were previously; Shell's data, produced in accordance with standards, would almost certainly supersede any data offered by citizens.

Bucket activists might hypothetically become legitimate participants in air quality assessments by, like Shell, adopting more completely standards for air monitoring, but two things stand in the way. The first is logistical: the cost of conducting monitoring using regulators' protocols would be prohibitive for even a relatively well funded EJ nonprofit, and it would be difficult (though not impossible) for such a group to adequately staff such an effort. But as significant as the logistical obstacles are, the second hurdle is far more important. Activists cannot adopt standardized monitoring practices without at the same time acting as though the health effects of chemicals depend on their average concentrations—and undermining a central premise of bucket monitoring, that occasional bursts of airborne toxins do matter to health effects. Because activists seek to contest not only expert claims about air quality, but the very standards for producing those claims, they cannot unproblematically adopt those standards as part of their effort to be acknowledged as legitimate participants in air quality assessment.

The consequences of standards' boundary-policing aspect are significant. Standards and standardized practices help silence arguments by bucket users that different kinds of data are necessary to address their health concerns. By policing the boundaries between activists and expert communities—allied through the boundary-bridging aspect of standards—they also exacerbate the uneven distribution of power between industrial facilities and fenceline communities: facilities, endowed with considerably greater financial and technical resources than activist groups, are able to implement standardized monitoring methods and to become participants in regulatory processes (i.e., judging whether air is safe to breathe) to which community members find it difficult to gain access. Through their boundary-policing function, then, standards decisively limit the extent to which bucket monitoring can contribute to activists' goals of getting regulators and industrial facilities to act on issues of air quality and health in fenceline communities.

Harnessing Standards in the Service of Citizen Science?

Bucket monitoring, and citizen science more generally, is appealing from the standpoint of projects to democratize science and science-based policy. Citizens' scientific efforts demonstrate that so-called "laypeople" can be meaningfully involved in knowledge making and policy making; by revealing the values inherent in expert knowledge, citizen science bolsters arguments that they must be. Yet, even modest forms of democratization, including the incorporation of a citizens group's knowledge claims into, for example, a local siting decision, are hard fought. Examining the partial success of buckets suggests one set of obstacles. Specifically, it shows how regulatory standards and standardized practices help to crystallize resistance to citizens' broader participation in science. Standards make experts' judgments and practices robust, in part by linking them to other powerful political and legal infrastructures; in the process, standards can provide grounds for excluding nonscientists from decision making—not because they are not experts but because they have no relevant information to offer.

Viewing standards, at least in their boundary-policing aspect, as a potential obstacle to citizen science and, more broadly, citizen participation in science-laden issues, suggests the need for standards themselves to be an object of democratization projects. That is, because standards partially structure debates over who can participate, and in what discussions, ensuring broader public participation demands that standards do not categorically rule out the involvement of citizens in knowledge making or policy making. Organizing to influence the setting of standards, which tend to recede into the background, is likely to be more difficult than organizing to limit the harms of a looming, malodorous petrochemical plant. But by enacting alternatives to standardized practices, citizen science at least pushes standards into the foreground. Sympathetic scholars have a complementary role to play in making the consequences of standards visible and, recognizing that standards are always a work in progress, helping identify moments of fluidity during which standards may be more easily acted on.

If standards are often an obstacle to citizen science, they are also potentially a resource. Indeed, perhaps the most surprising insight offered here is that the possibility exists for citizen scientists to use standards to their advantage, to exploit standards' boundary-bridging aspect to gain access to expert-dominated arenas. The challenge for citizen science, then, lies in making strategic use of standards—deciding, in particular, which parts of the boundary to bridge and which detachments of border police to leave unchallenged. By combining an alternative sampling device with a standardized method for producing sampling data (and effective organizing), bucket users were accepted, if grudgingly, as participants in generating data about unplanned releases from chemical facilities. Being accepted as participants in discussions of whether air quality is healthy, though, would seem to require a different strategy, one that speaks more directly to annual and eight-hour average air standards. By using real-time air monitors instead of sampling devices, for example, activists could document both average chemical concentrations and peak exposures; the contrast between the two could form the basis for pointed attacks on the ambient air standards' implicit claim that only averages matter to health. Developing strategies for simultaneously exploiting and challenging standards in particular cases of citizen science is no small task—but it is one that may be aided by recognizing the double-edged power of standards.

Notes

1. Since their invention in 1995, buckets have become well known and widely used in the environmental justice movement. O'Rourke and Macey (2003) and Overdevest and Mayer (2008) offer accounts of the development and dissemination of buckets.
2. Overdevest and Mayer (2008) theorize other ways, largely unrelated to regulators' assessments of data quality, that buckets further community activism.
3. Community members and affiliates of EJ nonprofits are, for many purposes, distinct communities. They are treated as a single community here because, despite their other differences, they share a common approach to conducting monitoring and using monitoring results, largely as a result of community groups' dependence on nonprofit organizations for funding and technical assistance. Indeed, the bucket itself acts as a boundary object in organizing this relationship between the communities and is surrounded by its own set of standardized practices; I regret that it is beyond the scope of this article to discuss these aspects of the bucket in detail.
4. I hold an undergraduate degree in engineering.
5. Aggregate levels of this group of chemicals are also regulated by the National Ambient Air Quality Standards for total VOCs; however, the federal government does not set limits on ambient concentrations of the individual chemicals. Only a few states have ambient air standards for toxic air pollutants comparable to Louisiana's.
6. Originally, a paint bucket, from which the device takes its name, the containers being used in more recent models of the samplers are similarly sized bulk food storage canisters with snap-top lids.

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Bio

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