

Citizen Science as Resistance: Crossing the Boundary Between Reference and Representation

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Abstract

This article analyses citizen science as a resistance practice with regards to the contradictions that emerge when scientific methods are used for political struggles. Departing from how science and politics are constructed as a contrast, as recently put forth by philosopher Bruno Latour, the scientific method for creating reference and the political method for gaining representation are analysed as they are articulated in citizen science. This evokes further contradictions between local acts of resistance and the global aspirations of scientific methods, challenging both the particularity of micropolitics and the universality of science. Building on previous case studies of citizen science practices, a number of conclusions are drawn regarding the potentials and dangers emerging from a science that takes place in the peripheries of established institutions. The article concludes that citizen science can be a very successful resistance practice, as long as it is able to produce novel facts that still adhere to scientific methods and standards and remains connected to the established institutions of science.

Introduction – From Toxic Rain to Scientific Papers

In 1994, a gooey rain poured down on the residents of Crockett and Rodeo, California. After drying up, the rain left a sticky layer of an unidentified substance everywhere. Soon, hundreds – what later became thousands – of local residents fell sick with respiratory problems, skin irritation and nausea after a sixteen day release of what was subsequently identified as “catacarb”, a toxic catalyst used in oil refinery processes. The nearby refinery from where the chemical had originated

was run by Unocal (merged into Chevron Corporation in 2005), but the company acted as if nothing had happened (Hallissy, 1997; Nijhuis, 2003). However, the local residents – some suffering from chronic conditions because of the toxic release – had no definitive proof that Unocal was responsible and, thus, could be held liable.

A year later, attorney Edward Masry and his research assistant Erin Brockovich¹ began funding the development of a ‘bucket’ that could be used to collect air samples around the Unocal refinery. These buckets were based on a much more expensive instrument called the Summa canister, a standardised device used by scientists for grabbing air samples. The Summa canister cost around \$2000,² but the buckets made by Masry’s team could be built for merely \$125, significantly lowering the costs for independent air grabs (O’Rourke and Macey 2003: 388–90). In total, 30 buckets were distributed to citizens of Rodeo, who began monitoring the air quality on a regular basis. Partly due to the merit of the buckets, the 1997 lawsuit against Unocal resulted in a settlement where 6,000 residents received \$80 million in compensation for their injuries (Nijhuis, 2003).

The buckets were later improved by Denny Larson, the program director for *Communities for a Better Environment*, who reduced the cost of the units – and more importantly – Larson organised the residents in teams called ‘bucket brigades’ (O’Rourke and Macey, 2003). The concept quickly spread to other local communities, and in 2003 there were about 25 bucket brigades (Nijhuis, 2003). The buckets were approved by the US *Environmental Protection Agency*, which was an important step towards standardising the instrument and, consequently, the method of bucket brigades, hence, increasing the legitimacy of the procedure (Ottinger, 2010). In 2014, the results of samples collected with the help of buckets near oil and gas production plants across five states were published in a peer-reviewed journal, which concluded that

¹ Brockovich was made famous with the 2000 biographical film bearing her name, which documented her first lawsuit against the Pacific Gas and Electric Company.

² According to the Louisiana Bucket Brigade, the price for a “bucket” today is \$75 and a Summa canister \$2000, see <http://labucketbrigade.org/content/bucket>, retrieved 20150123.

there were potentially dangerous concentrations near the compounds, and that '[c]ommunity-based research can provide an important supplement to state air quality monitoring programs' (Macey et al. 2014: 1). Following a series of trials and validations, the buckets had become scientific. What started as a community reaction to a toxic release had progressively evolved into a *citizen science*, which was producing measurements that were accurate and systematic enough to be published as 'proper science'.

Nevertheless, this type of monitoring – sometimes referred to as community environmental policing or 'civic technoscience' (Wylie et al. 2014) – entails an inherent contradiction. In a local act of resistance, the bucket brigade activists turned to methods and instruments borrowed from a *scientific* method that creates *chains of reference* (Latour, 2013). However, grabbing air samples in the field, bringing them to a laboratory for tests and publishing the results involves more than the creation of instruments that can be freely improved and modified without patent restrictions.³ By turning to science, the *local* act of resistance necessarily takes a detour to *global* epistemic standards that are of a different mode and are measured according to very different criteria.

Before analysing the phenomenon of citizen science as resistance, however, a brief discussion on the multiple meanings of the term citizen science is needed. Thereafter, I will proceed to analyse the phenomenon of citizen science through the conceptual lens of what Bruno Latour calls 'modes of existence'. Then, departing from a recent article by Dan McQuillan (2014) on the counter-cultural potential of citizen science, which re-opens the conceptual duality between 'Royal science' and 'nomad science' as expressed by Gilles Deleuze and Félix Guattari in the early 1980s, I will discuss where citizen science as resistance is situated in relation to established institutions of science. Finally, I will look more closely at the way citizen science as a resistance practice defines, envelops and renders visible different territories to uproot the distinction between local and global. This way, it will be possible to map out a bit more accurately the limits and possibilities of citizen science as a form of resistance.

³ <http://publiclab.org>, accessed 20150125

Three Meanings of the Concept of ‘Citizen Science’

The concept of ‘citizen science’ is ambiguous, and there are at least three ways of understanding what it is all about. For the sake of clarity, and to provide substance to the arguments at hand, I will briefly describe all three of them, even if my analysis of specific cases of citizen science as resistance is limited to the third and last type.

The first meaning of citizen science encompasses a trend that has gained momentum in recent years and can be seen as a new wave of citizen science, arising in the form of large-scale research enterprises, predominantly in the natural sciences (Silvertown, 2009; Cooper et al. 2007; Cohn, 2008). Two projects that are often used as exemplars of Internet-based ‘mass-participation’ of volunteers in science are *Galaxy Zoo* and *Ebird*, where amateur astronomers and ornithologists, respectively, are invited to help scientists classify images of galaxies generated by various telescopes and to collect observations of migrating birds in various habitats. In this way, the abundance of data generated from research projects can be classified by volunteers as accurately as by professional scientists (Lintott et al. 2008) in a cost-effective manner (Bonney, 2009; Franzoni and Sauermann, 2015). Even if this type of citizen science has become highly visible only in the past few years, as Internet technologies have made possible an ubiquitous infrastructure for recording observations, this ‘genuine amateurism’ traces its form back to hundred-year old practices of mass observations, often exemplified with the National Audubon Society’s yearly ‘Christmas Bird Count’, starting in 1900 (Bonney et al. 2009: 978), but also in the conception of the ‘gentleman scientist’, who is often seen as integral to the scientific revolution, where figures such as Charles Darwin were devoting their lives to a true pursuit of knowledge rather than personal profit (Silvertown, 2009: 467).

Partly overshadowed by the contemporary ‘hype’ generated by the first type of citizen science presented above, there is a second meaning of the concept, which concerns ‘scientific citizenship’ as a deliberative and democratic phenomenon. A key reference here is Alan Irwin and his 1995 book *Citizen Science: A Study of People, Expertise and Sustainable Development*, which departs from the sociological framework

of risk and reflexivity, inspired by such theorists as Beck, Giddens and Bauman. However, Irwin breaks with this tradition when it comes to scientific knowledge, and instead adopts an ‘anti-essentialist’ perspective, inspired by the sociology of scientific knowledge, which allows for the inclusion of more heterogeneous forms of knowledge (Irwin, 1995: 169). Thus, the notion of citizen science designates, in Irwin’s terminology, ‘a science which assists the needs and concerns of citizens /.../ [and] implies a form of science developed and enacted by citizens themselves’ (Irwin, 1995: xi). Through an active scientific citizenship, public participation in ‘extended peer review’ and by setting up ‘Science Shops’ where citizens and scientist could meet to research common problems, the gap between ‘lay’ and scientific knowledges could begin to diminish. For Irwin, the notion of citizen science rather denotes a relationship, or an interface *between* the citizen and science, and ‘how [...] the scientific citizen [is] being constructed within current policy and decision processes’ (Irwin, 2001: 4).

In a similar fashion, Brian Wynne approaches the incommensurability between expert and lay knowledges, where ‘non-institutional forms of experience and knowledge’ (1996: 49) are contrasted with the standardised measurements of established science. Wynne argues that ‘lay people have legitimate claim to debate those assumptions [of expert knowledge]’ (1996: 59) to attend to their local needs, rather than being run over by experts who conceal the inherent uncertainty in scientific knowledge by presenting it as objective and unproblematic. Following this line of thought, citizen science is a matter of scientific citizenship, where different kinds of knowledges contest each other.

The first and second meaning of ‘citizen science’ are sometimes combined in order to justify the democratic potential of citizen science, even when citizens do not have any influence on the objective of the research process (Riesch and Potter, 2014: 109). From a policy perspective, it would be killing two birds with one stone if science could simultaneously invite the masses to participate in research via the Internet and bring about increased participation and democracy. This is, however, not where we find citizen science as resistance.

As already introduced in the beginning of this article, there exists a third form of citizen science, which can be understood as a novel form of resistance. It is recognised by three primary properties. First, in

this form, citizens are the *primum movens* (Callon, 1986) of the research process, in the sense that they are the ones taking the initiative to formulate the problem under investigation. In other words, the research questions are created by citizens outside the institution of science, whereas the two previous forms, as described above, have their starting points in problems already defined by established scientists. Second, citizen science as resistance responds to a local problem that usually (but not necessarily) affects people's everyday lives in a more or less direct way. Common cases include environmental matters or corporate misconduct that have negative impact on a particular state of affairs in a localised context. I will return to the issue of particularism below, but for now it suffices to note that there is a tension between a 'local' problem and the 'global' strategy of using scientific methods.

Third, citizen science as resistance has an emancipatory goal rather than one that can be measured in terms of scientific output. The goals may include winning legal battles, influencing policy making, putting an issue on the political agenda or promoting human rights. Even though scientific methods are utilised, the results are usually not meant to be evaluated primarily by scientists. Instead, the 'detour', via scientific institutions (such as laboratories, journals, scientific experts, etc.), is usually taken for instrumental reasons only. A scientific publication adds to the credibility of the data collected; laboratories contain the most exact instrumentation and in some cases certain expertise only resides inside academia.

However, what differs from other forms of resistance is the 'science' in citizen science. In this article, I will further explore how citizen science, as it emerges locally from the bottom-up, seems to *transcend its local context by using scientific methods*. This quality does not make this third type of citizen science inherently scientific, or inherently democratic. Neither can it be reduced to the two forms already presented. Rather, the tension between local and global, between particular and universal, creates a trajectory that may lead both to new and unexpected scientific and democratic experiments, which need to be explored in greater detail. However, it is insufficient to analyse this third form of citizen science merely as political activism, using scientific methods. It is insufficient because modern societies – or *modernity* – prevent science and politics from intermingling freely, even though they are constantly mixed up and confused. Citizen science as

resistance breaks these unspoken rules, but to understand how that happens, the demarcation between science and politics needs to be analysed in greater detail.

1. Reference and Representation

The buckets that were introduced in the beginning of this article are important for highlighting a special kind of movement, which is exploited by citizen scientists in their resistance practice, namely, the ‘short-circuiting’ of political representation by scientific reference. With this, I do not mean the symbolic dimension of the buckets, even though they appear both in the name and the logo of the ‘Bucket Brigades’. Instead, it is the use of scientific instrumentation for creating what Latour calls ‘chains of reference’ (77) which, once they have been made to work in the hands of citizen scientists, make possible a powerful political trajectory. It is worth examining some of these instruments a little closer, because without them a ‘political message’ has little more to offer than the words that compose it. With instruments, even cheap ones, a few illuminating cases show that citizen scientists can make remote states of affairs speak in a much clearer voice by turning to scientific facts.

The primary problem of scientific instrumentation is, however, that it is inaccessible to most community groups for several reasons. Not only does laboratory equipment belong to the most expensive types of technologies, it is also the most controlled form of instrumentation, requiring a constant calibration and maintenance in order to follow the standards of science (Latour, 1987; Ottinger, 2010). But when they work – or rather, when they are made to work – they can act as powerful vehicles of political action. This phenomenon was explicated in Latour’s seminal work *We have never been modern*, in which he analyses the invention of the air pump by Robert Boyle in the 1600s, and consequently, the emergence of the scientific method as we recognise it in modern societies:

In their common debate, Hobbes’s and Boyle’s descendants offer us the resources we have used up to now: on the one hand, social force and power; on the other, natural force and mechanism. On the one hand, the subject of law; on the other the object of science. The political spokespersons

come to represent the quarrelsome and calculating multitude of citizens; the scientific spokespersons come to represent the mute and material multitude of objects. The former translate their principals, who cannot all speak at once; the latter translate their constituents, who are mute from birth. The former can betray; so can the latter. In the seventeenth century, the symmetry is still visible; the two camps are still arguing through spokespersons, each accusing the other of multiplying the sources of conflict. Only a little effort is now required for their common origin to become invisible, for there to be no more spokesperson except on the side of human beings, and for the scientists' mediation to become invisible. Soon the word 'representation' will take on two different meanings, according to whether elected agents or things are at stake. Epistemology and political science will go their opposite ways. (Latour, 1993: 29)

From the scientific revolution and onwards, the modes of veridiction⁴ – the acts of speaking truthfully – that were applied in political representation and scientific reference, respectively, have been kept strictly apart. Scientific reference, in the modern world, would only be measured against its capabilities to tell the truth about the natural world, whereas political representation would be limited to the possibility of speaking for the human multitudes. Science and politics were attached to different 'felicity and infelicity conditions /.../ [that] make it possible to contrast very different types of veridiction without

⁴ The concept of veridiction was used by Foucault to clarify the difference between statements (as such) and the practice of *making* statements, to '/.../' distinguish what is announced from the act of enunciation. In the same way, when someone asserts a truth, one must distinguish the assertion (which is true or false) from the act of truth-telling, from the veridiction' (Foucault, 2014: 19-20). The usage is similar in Latour insofar as 'mode of veridiction' begins to designate a performative speech act, as Austin (1962: 14) defined in his 1955 lecture series "How to do things with words", which inspired both

reducing them to a single model' (Latour, 2013: 18). This separation – or purification – of two different modes of existence that have to be judged against different criteria has progressively intensified in modern societies, to the extent that scientific knowledge is usually found wrapped in a narrative of objectivity where facts are kept at a safe distance from politics. Conversely, political representation is kept at an arm's length from scientific facts as 'scientific rationality' is usually regarded as fundamentally undemocratic. This contradiction is, however, what gives citizen science as resistance a particular opportunity.

This is where the instruments used in citizen science take on an interesting role as mediators between these two incommensurable modes of veridiction. Instruments enable local groups to take a shortcut (or a detour, it depends on the level of effort needed) towards political representation by using scientific facts – or reference – as a leverage point, even though it contradicts the ideal of purity of keeping science and politics apart. For example, in London there is currently a campaign to stop the construction of a new tunnel under the river Thames. The No Silvertown Tunnel group has thus begun to measure levels of nitrogen dioxide to halt the political decision. In a recent call for participation, the campaign organisers wrote:

Foucault and Latour. But the Latourian notion is radically extended in comparison to both Foucault and Austin in one important regard. Latour's modes of veridiction are not limited to the relation between subjects and language. Instead, it forms an 'existential' concept that extends beyond strictly human forms of enunciation and goes further than asking only 'how subjects are effectively tied within and by the forms of veridiction in which they engage' (Foucault, 2014: 20). For example, knowing about far-away galaxies involves telescopes, computers, scientists and means of processing digital images. The mode of veridiction we apply to the truth or falsity of such knowledge is not restricted to speaking, but rather involves everything from lenses and microchips to the hypotheses formulated by the scientists. In other words, Latour extends modes of veridiction to include not only the conditions under which subjects are able to speak truthfully, but also to the assembling of objects that make such statements possible.

Results from the study will be used in the campaign against the Silvertown Tunnel, which is being proposed by TfL [Transport for London] with the support of Newham Council and Poplar & Canning Town MP Jim Fitzpatrick. / .../ Earlier this month, London's deputy mayor for transport, Isabel Dedring, admitted to MPs that City Hall's planned river crossings would lead to a "doubling of traffic" on local roads. We're looking for volunteers who can spare a couple of hours next week to help us install tubes that can measure levels of nitrogen dioxide in the air – and who can spare a couple of hours in early March to take them down again.⁵

By mounting diffusion tubes on lamp posts in the streets of London and leaving them to collect air over a month's time, the No Silvertown Tunnel campaign has been able to measure levels of nitrogen dioxide for three years, showing that they exceed the EU standards of emissions considerably, sometimes even twice the limit for what is considered habitable.⁶ But the results of the diffusion tubes are not only treated as matters of fact about which substances are present in the London air. What is 'in the air' has also, as shown in the quoted passage above, become a political *matter of concern* to the Transport for London, a member of parliament and the deputy mayor for transport and everyone who follows the No Silvertown Tunnel's instructions on how to write a letter to 'your representatives'.⁷ What is 'in the air' is determined by diffusion tubes that are mounted in the streets and sent off to a laboratory, then returned as data that can be projected on a map and compared to standards determined by a European Union directive; a chain of reference that has been assembled and made to

⁵ <http://www.silvertowntunnel.co.uk/>, accessed 2015-02-26.

⁶ <http://www.silvertowntunnel.co.uk/our-study/2014-silvertown-tunnel-pollution-study-results/>, accessed 2015-02-26.

⁷ <http://www.silvertowntunnel.co.uk/say-no/how-you-can-stop-the-silvertown-tunnel/>, accessed 2015-02-26.

work. This activity – reference as resistance – is what distinguishes citizen science from other campaigns. Representation is not a direct relation between the campaign organisers and a large number of people that have to be convinced to support your cause, but instead, representation takes a detour via matters of fact that *translate* molecules in the air into a local injustice that can be acted upon at a later instance.

In environmental activism, it seems like the citizen science model proves quite successful. To define a problem, to give it certain gravity, creating reference sometimes has greater weight than public outrage and fury. However, reference is also both tiresome and usually expensive to create. Consequently, Wylie et al. who have analysed the US-based community Public Lab, argue that laboratories need to be accessible to the citizen scientists, not as displays of scientific progress, but as live instruments that can be used for ‘civic technoscience’:

We challenge the academy to similarly adapt, and to open its doors to supporting civic technoscience. Imagine networks of skilled technicians in chemistry labs — also citizens of technoscience — volunteering their knowledge. The academy could also open doors to facilities such as photographic darkrooms, and could give public access to tools such as spectrometers during off-peak hours. The majority of laboratory equipment is after all often purchased with public money through government grants. (Wylie et al. 2014: 123)

Citizen scientists still depend on laboratories and standards that are outside their immediate context. The Louisiana Bucket Brigade sends their air samples to a California lab, each unit of analysis costing \$500, where ‘[t]he air from the bag is run through a Gas Chromatograph Mass Spectrometer, which compares the "fingerprints" of the sample with the fingerprints of about 100 toxic gases in the computer library.’⁸ In other words, the mobile and lightweight buckets and diffusion tubes still depend on remote laboratories. And it is because of these laboratories that the citizen scientists can compare

⁸ <http://www.labucketbrigade.org/content/bucket>, accessed 2015-02-28.

their sampling instruments with the standards already defined by ‘proper science’ and their much more expensive technologies (see Ottinger, 2010: 260-261).

Citizen science and the creation of chains of reference may, however, take on a slightly new meaning when applied in different political contexts. The Thai Baan citizen scientists of the Mekong River, who are struggling to resist dam constructions and blasting of the rapids to enable heavier boat traffic, have found the approach of research to be efficient means of resistance as a complement to protests and occupations. By approaching the imminent ecological crisis (see Ziva et al. 2012) with scientific means, ‘[m]any view Thai Baan research as a safer and potentially less politically sensitive way to empower communities’ because ‘[s]cience is often assumed to represent the neutral voice of reason. In the Mekong region, governments are more comfortable speaking about science than they are about political topics such as human rights’.⁹ The protests that originated in the ‘Assembly of the Poor’-movement of the mid-1990s (Palmgren, 2008) could thus expand their toolbox with the Thai Baan research, which appears to be less controversial, safer and more comfortable. In a sense, citizen science even appears to be less political – it renders neither protests nor arrests as it reports on facts. Instead, it works as a ‘short-circuit’, which – drawing on the original meaning of this concept as found in electrical engineering – creates a path where there is almost *no resistance*. Scientific facts, once made immutable (which, of course, is a tedious practice), can travel without encountering the usual forms of opposition, thus creating a displacement of what can be contested.¹⁰ As

⁹ <http://www.internationalrivers.org/resources/citizen-science-supports-a-healthy-mekong-7759>, accessed 2015-02-28.

¹⁰ This argument is indirectly supported by the negative results that have come out of citizen struggles that have been limited to ‘lay’ knowledges and ‘lay epidemiology’. For example, Lora-Wainwright (2013) shows how Chinese villagers living under severe pollution conditions fell back on individualised strategies of coping, as they were not able to reduce the uncertainty in establishing a correlation between pollution and health risks. However, as Liu shows, reporting on the conditions in the Chinese ‘Cancer Villages’ is sometimes also met with harsh repression and censorship, and both local and

reference detaches from its immediate local context and is circulated as scientific inscriptions, it is possible to speak of a *strategic universalism* (paraphrasing Spivak's (1984) concept of strategic essentialism), where the immutable mobiles (Latour, 1999, 2013) – buckets, tubes or fish statistics – have to be judged according to a scientific mode of veridiction. Tear gas may disperse a crowd of protesters occupying the streets, but to counter facts that arrive fresh from the laboratory, you have to build a *better* laboratory. Scientific reference and political representation, as different modes of existence, take on this contradictory role in some instances of citizen science, as a form of resistance by other means appearing to be perfectly apolitical because it comes in the shape of scientific universalism.

2. Nomadic vs Royal Sciences?

Understanding the construction of scientific facts from a Latourian perspective means making no a priori judgements on essential properties of the 'scientific method'. Rules of method are always immanent to the network of scientists, instruments and institutions that make the construction of reference possible. This way, there can be nothing essentially different with citizen science in comparison with established science, no disagreement in the 'scientific world view'. In other words, if there is a difference in the way citizen science and institutional science is practised, it cannot be settled by claiming that citizen science is of a different 'kind'.

international NGOs are often blocked from taking action against local pollution disasters (Liu, 2009). As a contrast, International Rivers report on the 'Green Hunan' citizen scientists who monitor the Xian River watershed. By testing the water quality and tracking pollutants they are able to write reports that are then sent to governmental authorities and companies. In one case, they succeeded in closing down the plant of a local company, because simple litmus tests revealed that the plant had secretly discharged pollutants into the river at night. (Yan, 2012). Even though the examples here are few, there seems to be a qualitative difference between reporting on 'lay knowledges' in comparison to using standardised methods of measurement, such as the litmus paper, where the latter – an *immutable mobile* – acts on politics in a much more responsive way (even though pH-values are supposed to be 'free from politics').

However, in a recent article, Dan McQuillan suggests that citizen science, at least ideally, should adopt the counter-cultural approach of ‘nomadic science’ to reach its full potential. McQuillan writes:

Nomadic science is a form of empirical investigation that has no need to be hooked up to a grand narrative. The concept of nomadic science is a natural fit for bottom-up citizen science because it can valorise truths that are non-dual and that go beyond objectivity to include the experiential. In this sense it is like the extended peer review of post-normal science but without the need to be limited to high-risk high-stakes questions. (McQuillan 2014)

While the concept of nomadic science in Deleuze and Guattari may seem tempting as a way of understanding citizen science as resistance because it draws attention to a community science that (at least initially) lacks the institutional support of established science, I will argue that this approach can be misleading. On the contrary, as attested to in the cases discussed in this article, it seems like citizen science derives its legitimacy precisely from the aspects that define the opposite to ‘nomadic’ or ‘minor’ science operating in a ‘smooth space’; namely what Deleuze and Guattari called ‘Royal science’, which creates ‘striated’, metric spaces (Deleuze and Guattari, 2004: 398–413) that submit the world to measurable, countable and compartmentalised units. This way, Royal science has the capacity to delimit a space by counting; it can define a territory by its population, a sample of air by its chemical composition or a galaxy by its stars.

This becomes most evident in the cases where citizen scientists actively strive to adhere to the standard measurements of established laboratories. As mentioned above, both the Bucket Brigades and the No Silvertown Tunnel projects depend on laboratory practices, threshold levels and standards of measurement that are already approved and tested by either established scientists or government institutions, such as the Environmental Protection Agency (EPA). Even if the methods of collecting air samples are unorthodox (see below), their measurements are made to comply with the metric properties of Royal science in order to comply with the mode of veridiction that has already been defined by established science. Not only are their

instruments tuned into the standards set by the EU and the EPA,¹¹ the very mode of ‘occupying space’ is indeed orthodox in epistemology. Nomad science operates in a ‘smooth (vectorial, projective, or topological) space’ where ‘space is occupied without counting’, whereas Royal science is at work in a striated and metric space where ‘space is counted in order to be occupied’ (Deleuze and Guattari, 2004: 399). The spaces that citizen scientists make knowable through their investigations, the spaces that are contested and need to be redefined (in terms of pollution levels), are re-occupied through the very act of counting. The No Silvertown Tunnel campaign measures nitrogen dioxide in cubic metres,¹² so are the results of the Bucket Brigade samples (Macey et al. 2014). The modes of veridiction for citizen science need to be comparable with established science to be regarded as ‘scientific’.

Even in cases where citizens scientists go directly against the science produced by the state, they do not seem to deviate from the metric and striated spaces of Royal science. In connection with the Fukushima Daiichi nuclear disaster, the Japanese government avoided publishing their surveys of radioactive downfall. A citizen science group called Safecast then began to construct cheap Geiger-counters, which could measure the radioactivity levels in the areas surrounding the meltdown. Not only did their readings provide much appreciated information to the residents near Fukushima, it also put pressure on the government to release their measurements.¹³ However, even in this instance of head-on collision with the state agencies, the citizen scientist appeals to the fundamentally metric empiricism found in the model of Royal science, according to Deleuze and Guattari. Sean Bonner, the Safecast Global Director, responds as follows to a question concerning taking positions:

¹¹ See also <http://blog.epa.gov/ej/2014/01/it-doesnt-take-a-fireman/>, accessed 2015-03-02.

¹² <http://www.silvertowntunnel.co.uk/our-study/2014-silvertown-tunnel-pollution-study-results/>, accessed 2015-03-02.

¹³ <http://www.newsweek.com/2014/11/07/how-civic-science-changing-environmentalism-279777.html>, accessed 2015-03-01.

- Are you guys anti-nuclear, do you take a position?
- - No, not at all. We just know that there is data that exists and there is data that should exist. And creating it, the data doesn't take one side, one way or the other, so if we can just get the data and give it to the people that are immediately affected by it, then that's a good thing.¹⁴

The same can be said for citizen science project that approach community monitoring in a similar fashion, such as Mapping for Change.¹⁵ There is a 'neutral empiricism' in citizen science, which makes it very successful in occupying a space and taking it away from the body that had epistemic authority over it before. By counting the pollution and radiation levels according to Royal metrics, the above mentioned citizen science projects have all succeeded in 're-territorializing' a space in their production of a different picture of the state of affairs. This picture may of course be contested, criticised and discredited, but such a trial must take place on the level of established science. When the Louisiana Bucket Brigade contests the claims by Shell Norco about there being no chemical releases in their local community, they do so by displaying air sampling results that belong to Royal science (O'Rourke and Macey, 2003: 391). The results are territorial, metric and civil, against the secretive behaviour of Shell Norco, which prefers working with 'public relations' rather than scientific methods.

McQuillan concludes that '[t]aking a position such as nomadic science, openly critical of Royal Science, is the anti-hegemonic stance that could qualify citizen science as properly countercultural'. This, I would argue, highlights the limitation of thinking of citizen science as 'counter culture'. In the cases discussed in this article, it is not Royal science that is contested. The objects of resistance are the construction of a new tunnel in London, the oil refineries polluting the air in Louisiana, Chinese hydro-electric power plants upstream of the river

¹⁴ PBS News Hour, <https://www.youtube.com/watch?v=pLdOkKAeROg#t=590>, accessed 2015-03-01.

¹⁵ See <http://www.mappingforchange.org.uk/>, retrieved 2015-03-01.

Mekong or the Japanese government refusing to publish their findings on radioactivity levels. Royal science is the *means* of resistance for these groups, not the object. Science is not the culture that needs to be countered. Instead of ‘jamming the motor’ of the technoscientific culture (Palmås, 2008), citizen science has opened up a space of experimentation that affirms and remains very much connected to established science. These alliances even extend to the level of technology. As Wylie et al. (2014) show, the DIY aerial maps created by ‘civic technoscience’ activists, had their ‘grassroot maps’ integrated with the Google Map service in 2011, mainly because they provided higher resolution than satellites¹⁶:

Moreover, grassroots mapping creates maps of a quality such that formal data archives find the maps attractive to curate and integrate with their collections. In 2011 Google began integrating Grassroots Maps, served through Public Lab’s online archive, into both Google Maps and Google Earth (Adams, 2012). The superior resolution of Public Lab images makes them readily distinguishable from surrounding satellite images in Google Earth and Maps (Wylie et al. 2014: 118).

The aerial snapshots, created by Public Lab in order to render visible the environmental hazards and injustices, are projected onto the maps from Google, the leading Silicon Valley cartographer that has a key role in producing the way we understand and navigate in contemporary culture, the contemporary ‘imperial’ map *par excellence*. Moreover, the ‘extreme citizen scientists’ are ‘yoking local knowledge to international expertise’ as a way of expanding conventional science with the collective intelligence of local expertise (Rowland, 2012), and the

¹⁶ Since the kites and balloons that carry the digital cameras used for creating aerial maps can fly at such a low altitude, the resolution of their images can also be higher than those produced by satellites. For example, Warren (2010: 67) compares maps produced by ‘grassroots mapping’ in Lima, Peru, which have a resolution of 4.4–7 cm/pixel compared to the available Google (satellite) Maps that could only produce a 29 cm/pixel resolution.

Achuar people in the Peruvian Amazon create maps using ‘participatory GIS’ to reclaim their territory from oil drilling companies that pollute the rivers they depend on (Orta-Martínez and Finer, 2010). Through citizen science, they are able to gain the attention from the government and resist the oil industry.¹⁷

To sum up, citizen science appears to more successful when it conforms to standardised ways of making the world measurable and projectable onto a conventional map. Instead of inventing a qualitatively different science, it takes advantage of already established methods belonging to ‘Royal science’. Thus, instead of countering scientific cultures, it borrows from them, but that does not necessarily mean reproducing them. Despite citizen science using quite conventional methods, it invents novel *questions* that aim for emancipation rather than pure science.

3. Concluding Remarks

Citizen science as a form of resistance utilises a contradiction in modern sciences, in which science is regarded as neutral and free from politics while simultaneously being the driving force in the constitution of the societies we live in. By turning to scientific methods in their political struggles, citizen scientists are able to ‘short-circuit’ the conventional modes of seeking political representation and use reference as a mediator in re-presenting the state of affairs that have come under controversy. However, this general phenomenon becomes a lot messier the closer you look at each instance in which resistance and scientific methods are combined. Just like there is no instant formula for a ‘pop up’ democracy, neither does citizen science appear out of thin air, like a Swiss Army knife that retains the same functionality wherever you drop it (see Latour, 2013: 332). Citizen science seems to require at least a minimum amount of recognition of both citizenship and science. But even if such infrastructure is present, citizen scientists always run the risk of being ignored or having their voices being drowned against stronger interests.

¹⁷ <http://thetyee.ca/News/2013/04/26/Activism-Citizen-Science/>, accessed 2015-03-02.

What is novel about citizen science is not the mixing up of science and politics *per se*. Such interminglings already take place in so many forms where scientific expertise informs political decision-making and vice versa. On the contrary, what makes citizen science interesting as a form of resistance is the production of scientific facts *outside* the institution of science. This way, citizen science reshapes the predicament of ‘lay people’ being dependent on the knowledge generated by scientific ‘expertise’. In many of the cases discussed in this article, the citizen scientists have circumvented these two roles – at least temporarily – in their making of chains of reference that bring back data that can be used in political struggles. This, I will argue, requires that we update our understanding of what ‘lay’ and ‘expert’ knowledges entail when analysing citizen science. For example, in Stephen Yearley’s studies of environmental movements and their relationship to scientific expertise (Yearley, 2005), there is a discussion about the problematic relations that emerge between environmental movements and science. This is exemplified with the case of preservation of whale populations, where environmental activists found their arguments against killing whales strengthened by scientific facts that showed declining populations. But, when science later on concluded that the populations were increasing, the environmental movement risked losing their moral argument against whale hunting. In the face of scientific facts, the activists remained powerless, in Yearley’s description, because their ‘lay’ knowledge paled in comparison. I argue that citizen science in its resistance form suggests a very interesting escape out of such sedimented lay and expertise relations. In the citizen science that I have attempted to map in this article, the citizens are the prime movers of the epistemic practice, no longer limited to “contextual” knowledges, which are generated outside of scientific institutions’ (Irwin, 1995: xi). They have collapsed the distinction ‘between formalized science (which often claims to be universal) and the less-systematized (and often ‘local’ – although not necessarily in the geographical sense) knowledges possessed and developed by citizen groups’ (Ibid). Citizen science destabilises the problematic distinction between ‘lay, or “local” knowledge’ versus ‘scientific or universal knowledge’ (Wynne, 1996: 77) because reference – when instrumented and performed transparently – must be judged according to a mode of veridiction that is proper to the sciences. In the case of the whales

(which I will return to below), the moral argument against hunting them will remain contextual, in comparison to the question of how many whales that swim in the oceans. Even though related, modernity still keeps these two questions apart because they cannot be judged according to the same criteria. Citizen science can re-connect them, but only by transcending the role of having ‘contextual’ knowledges. To give weight to the moral arguments, whales must be counted.

This way, citizen science that turns to fact production as a form of ‘strategic universalism’ must be understood beyond the distinction of local and universal knowledges. There is, of course, no such thing as universal knowledge in an absolute sense – reference always has to be enveloped in a network. But, it does not suffice to describe citizen knowledge production as ‘local’ (although all knowledge is local, even when it uses telescopes in orbit to understand the universe), because as we use such terminology we risk reducing these knowledges to ‘traditional’ forms of experience, which are easily discredited by actors that have more epistemic authority. The air samples taken by the Louisiana Bucket Brigade or the radiation measurements mapped by the Safecast community in Fukushima are not more local – neither are they less universal – than institutional science. They are, of course, different because they have lower budgets, less formal education and simpler instrumentation, and they will always struggle to voice their concerns when at odds with ‘science proper’. However, more importantly, they differ in who gets to decide what is a research problem and how it should be investigated. The institution of science can measure if whale populations increase or decrease in the oceans, and this knowledge can be both used and abused as arguments about whale hunting. However, when citizen scientists enter the scene, the demarcation between hard facts and moral arguments becomes much more difficult to uphold. This form of citizen science is not immediately recognised in the accounts of Wynne, Yearley and Irwin, maybe because it is of recent date, or maybe because the distinction between lay and expert knowledge is too strong from these authors’ perspective.

The Alaska Whale Foundation¹⁸ relies on volunteer observations of marine mammals, especially humpback whales, for conducting ‘novel studies that shed light on the biological richness and uniqueness of Southeast Alaska, and engender broad support for conservation programs’.¹⁹ This ‘conservation-oriented research’ keeps close watch on the baseline health of whale populations. Moreover, the members of the foundation consist of both scientists using the observations in their research (Fournet et al. 2015; Szabo & Duffus, 2008) and volunteers as ‘efficient, low-cost methods to collect large amounts of data’,²⁰ even though these roles seem to overlap in many ways. In this hybrid position between established science and volunteer monitoring, the Alaska Whale Foundation has occupied a powerful moral and scientific position, as they are able to survey the waters and keep an eye on noise pollution, entanglement in fishing nets and acidic pollution that threaten the whales.

In this article, I have emphasised the practice of citizen scientists conducting their own empirical research and what the political implications of facts generated in such investigations may be. Nevertheless, this account does not exhaust every aspect of the ‘messy’ conditions under which such knowledge production takes place. In-depth case studies of citizen science projects are needed to give a more complete and complex description. As Yearley writes, many environmental issues that affect the public are not necessarily scientific questions, but are determined instead in other regulatory systems, where actors such as the EPA (as discussed earlier) may have a decisive role in the outcome of a controversy (Yearley, 2005: 137-9), as confirmed in Ottinger’s detailed study on how the Louisiana Bucket Brigade had their methods ‘EPA-approved’ rather than approved by scientists (Ottinger, 2010: 258-61). Thus, it is imperative to remain

¹⁸ <http://www.alaskawhalefoundation.org/research-page/#citizen-science>, accessed 2015-04-19.

¹⁹ <http://www.alaskawhalefoundation.org/conservation/#conservation-oriented-research>, accessed 2015-04-19.

²⁰ <http://www.alaskawhalefoundation.org/research-page/#citizen-science>, accessed 2015-04-19.

perceptive of the complexity of the networks involved in each case. And it is equally important to examine closely the different modes of veridiction enveloped by these networks to avoid applying an idealised treatment of how knowledge is produced.

I have argued that citizen science is most successful not as a countercultural phenomenon that attempts to bring about a new form of science, but rather, it seems as citizen science derives its impact from affirming the epistemic standards of conventional science and by connecting to their publishing practices. This, however, does not contradict the fact that citizen scientists in many ways create completely novel forms of making the world knowable. In their concern for local problems, sometimes ignored by authorities or the public sphere, their efforts and investigations can be truly game changing. As O'Rourke and Macey have shown, there is a unique aspect in the very method of the Bucket Brigades for making the local visible in a way that has gone largely unnoticed by established forms of science:

“Sniffers” are responsible for recording odors of concern and alerting samplers when they believe there is a serious pollution release. Sniffers are usually located in prime spots in a community for first smelling odors from a plant (such as along the fenceline of a refinery). Using knowledge of prevailing wind directions and chemical releases, the community selects households to receive training in identifying and recording noxious smells (such as a rotten egg smell, gasoline, oil, or various chemical smells), health symptoms (such as nausea, irritated eyes, sore throat, or headache), and unusual sounds (such as explosions or pressure releases). Sniffers are also trained to call the appropriate government authorities to report incidents and complaints (O'Rourke and Macey, 2003: 389).

Before the mobile, yet immutable, instruments of buckets are applied, the citizen scientists are using their own bodies to navigate in their toxic environment. If there is a nomadic aspect of citizen science along the lines of Deleuze and Guattari's terminology, it would consist

of these ‘sniffers’, moving in a smooth space to detect singularities of smells, sounds and haptic sensations (Deleuze and Guattari, 2004: 528-529). Such nomadic perceptions are also present in Lora-Wainwright’s study of embodied knowledges among Chinese villagers, who report on smells, irritations, aches and breathing problems as a form of ‘lay epidemiology’ (2013: 310). Nonetheless, there is one important difference between these two cases. The Chinese villagers lack the necessary mediator for creating chains of reference. This is because when the buckets are applied for grabbing air samples in Louisiana, space is immediately striated and perceptions of toxic pollutants are translated into micrograms per square meter. When the air is sampled through the use of scientific instrumentation, the substances in the air that cause nausea, irritation and headaches can be put under the close inspection of laboratories. Only then is it possible to map the territory with numbers. Only by counting, citizen scientists can make the state of affairs count as political problems.

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