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MAKING SENSE OF PUBLIC SCIENTIFIC CONTROVERSY: A CASE STUDY EXAMINING SCIENCE COMMUNICATION AND PUBLIC ENGAGEMENT SURROUNDING GENETICALLY MODIFIED MOSQUITOES IN THE FLORIDA KEYS

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MAKING SENSE OF PUBLIC SCIENTIFIC CONTROVERSY: A CASE STUDY EXAMINING SCIENCE COMMUNICATION AND PUBLIC ENGAGEMENT SURROUNDING GENETICALLY MODIFIED MOSQUITOES IN THE FLORIDA KEYS

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ABSTRACT

This dissertation presents a discursive case study of a recent public scientific controversy surrounding proposed field trials of Oxitec's genetically modified (GM) mosquitoes in the Florida Keys. Despite endorsements by the Florida Keys Mosquito Control District, starting in 2011, and the US Food and Drug Administration's approval in 2016, field trial releases in the region have been stalled by intense public opposition. The research presented here attempts to better understand the nature of this controversy through a close examination of science communication and public engagement efforts. Avoiding the assumption that resistance to scientific and technological interventions is reducible to a lack of information and/or scientific literacy on the part of critical publics, this dissertation adds to a growing body of literature that challenges deficit-based interpretations of public scientific controversies.

The individual chapters of this dissertation are organized according to the types of data used to inform this research. Organizing the chapters in this way is intended to showcase how resistance to the field trials took shape in different arenas, and highlight the different positions and discursive strategies employed by a multiplicity of actors. Chapters 1 and 2 examine transcripts from two town hall meetings (held in the Florida Keys in 2012 and 2014), to map the discursive repertoires of promoters and opponents of the field trials, and achieve a deeper understanding of the imaginaries, concerns, and boundary tensions embedded in institutional, regulatory, and public discourses. Chapter 3 utilizes data on social media trends (during the height of GM mosquito discussions in the Florida Keys between 2015 and 2016) to better understand how

interested publics both engaged with information on GM mosquitoes, and managed to reframe discussions on their risks and benefits, through sharing. Chapter 4 presents narrative data from in-depth interviews (conducted between 2018 and 2019) with four activists who were instrumental in leading the resistance to the field trials, to explicate how lived experiences and identities are invoked in sensemaking around the risks of GM mosquitoes, and how resistance to the field trials is retrospectively rationalized. My analyses of these data sets are grounded firmly in a social constructionist paradigm, and integrate a variety of social constructionist theories and frameworks. As insights into the nature of the controversy are gleaned primarily through the lens of language and interaction, the majority of my methods are qualitative in nature. Occasionally, however, I do integrate quantitative techniques (Chapter 3).

The chapters in this dissertation are meant to serve as stand-alone, publishable manuscripts, and so each one approaches the controversy from a different angle. Each chapter employs a different methodology and analytical framework, and offers its own unique findings. At the same time, each individual manuscript is informed by, and is intended to build upon, findings from other manuscripts. When viewed as a collection of manuscripts, the major analytical contributions of this dissertation can be summarized as follows. First, institutionalized standards of biotechnology evaluation and communication, and their embedded imaginations of risk, progress, and 'the public,' largely constrained opportunities for meaningful democratic deliberations and contributed to the intractability of the controversy. Second, divergent assessments of the risks and benefits of GM mosquitoes (between proponents and opponents of the field trials) were illustrative of deeper ontological disagreements and rhetorical efforts

to redraw or obfuscate various symbolic boundaries (between science and other institutions, between organisms, between laboratory and society). Third, issues related to risk could not be extricated from issues related to trust in public reactions to the field trial plans. Along the same lines, opponents' willingness to trust in technical evaluations of risk was undermined by the hype surrounding the necessity and benefits of GM mosquitoes, a perceived lack of transparency, objectivity, and consistency in science and risk communication efforts, past failures on the part of regulatory bodies to appropriately predict and manage the risk of innovation, and institutionalized representations of critical publics as unscientific and anti-technology. Finally, critical publics often took on the role of alternative science communicators in GM mosquito discussions through the production, translation, reframing and/or dissemination of selective science-related information on GM mosquitoes. In the process, these alternative science communicators also, at times, circulated rumors and conspiracy theories. While acknowledging that the spread of misinformation is frequently interest-driven and harmful to the credibility of science and evidence-based policy, the perspective put forth by this dissertation also encourages it to be viewed not as an indicator of public ignorance, but as an expression of anxieties surrounding contemporary scientific and regulatory practices.

Given the high-level of media attention devoted to, and scholarly interest in, the controversy in the Florida Keys, the research that follows is not the first (and likely not the last) to explore the issues presented here. To the best of my ability, I have attempted to integrate, reference, and build on the literature that was available at the time that the manuscripts, and final dissertation, were submitted for publication. It is

important to keep in mind that this work explores the controversy only during a specific snapshot in time. Because GM mosquito discussions in the Florida Keys are ongoing, and some regulatory decisions are still pending, some of the information in this dissertation may be rendered obsolete or subject to change in the future, as new details and events emerge. Moreover, most of the discourse examined in this dissertation is representative only of the views and perspectives of the most vocal and involved participants in field trial discussions. I caution against making sweeping generalizations about larger publics based on this data. Further implications of this research to the science communication and public understanding of science literature, as well as additional limitations, are discussed in the individual chapters.

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Prior and concurrent research on the controversy examined in this dissertation (and on GM mosquito communication and regulation in general) was extraordinarily influential in directing me to new literature, exposing me to different interpretations, and shaping the overall trajectory of my research. I am grateful for the unofficial (and in most cases, faceless) collaborations that came with sharing similar research interests with Alex Nading, Zahra Meghani, Luísa Reis Castro, Carl Herndl, Tanya Zarlengo, Priscilla Bennett, Weirui Wang, Lei Guo, Elizabeth Loyer, Stephanie Phillips, Uli Biesel, and Christophe Boëte.

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Finally, none of this would have been possible without the vision, the sacrifices, and the teachings of my mother, Elaine Taylor. Thanks, Mom. Your memory continues to guide and inspire. This one is for you.

PREFACE

This dissertation is presented in manuscript format. Chapter 1, titled "Barriers to inclusive deliberation and democratic governance of genetic technologies at the science-policy interface," was published in the *Journal of Science Communication* on June 14, 2019. Chapter 2, "Mosquitoes out of place: Claims-making, representation and boundary politics in the debate over field trial releases of genetically modified mosquitoes in the Florida Keys," was accepted for publication on February 15, 2019 and will be featured in an upcoming edition of *Studies in Symbolic Interaction*. Chapter 3, "Shaping GM mosquito discourse through sharing: The framing and gatekeeping of information on social media," and Chapter 4, "Understanding organized opposition to field trials of genetically modified mosquitoes through narrative: Activists' sensemaking work and rationales for resistance," are currently in preparation for submission to *Science Communication* and *Public Understanding of Science*, respectively. Co-authorship on these manuscripts is indicated on the title page for each chapter. Supplemental materials for each chapter provide additional information on data and methodology that was not included in the body of the manuscript.

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CHAPTER 1

BARRIERS TO INCLUSIVE DELIBERATION AND DEMOCRATIC GOVERNANCE OF GENETIC TECHNOLOGIES AT THE SCIENCE-POLICY INTERFACE

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ABSTRACT

Advances in 21st century genetic technologies offer new directions for addressing public health and environmental challenges, yet raise important social and ethical questions. Though the need for inclusive deliberation is widely recognized, institutionalized risk definitions, regulation standards, and imaginations of publics pose obstacles to democratic participation and engagement. This paper traces how the problematic precedents set by the 1975 Asilomar Conference emerge in contemporary discussions on CRISPR, and draws from a recent controversy surrounding field trial releases of genetically modified mosquitoes to explicate the ways in which these precedents undermine efforts to engage publics in decisions at the science-policy interface.

Introduction

Rapid advances in genetic technologies are revolutionizing the life sciences and are increasingly being promoted as viable solutions to an array of public health challenges and environmental issues (Bennett & Jennings, 2013; Champer, Buchman, & Akbari, 2016; Champer et al., 2016; Doudna & Charpentier, 2014; Gao, 2018; Hsu, Lander, & Zhang, 2014; National Academies of Sciences, 2018; Sinkins & Gould, 2006; Tester & Langridge, 2010). From eradicating infectious diseases and treating genetic disorders, to sustainably improving agricultural productivity and restoring lost biodiversity, the applications of genetic modification and genome editing are seemingly endless. Yet, lurking behind every promise heralded by the 'new genetics' are dystopic imaginations of the future. Myriad uncertainties surrounding the unanticipated impacts of genetic technologies, as well as concerns over the potential for their misuse, "touch on ethical and societal questions that cannot be answered by scientists alone" (Gregorowius, Biller-Andorno, & Deplazes-Zemp, 2017, p. 355), and necessitate a rethinking of current regulatory standards and modes of public engagement.

The wide-ranging implications of new genetic technologies call for inclusive, public deliberation that incorporates a diversity of stakeholder voices, concerns, and forms of expertise in debates over research and innovation (Benjamin, 2016; Gregorowius et al., 2017; Hurlbut, 2015a; Jasanoff, Hurlbut, & Saha, 2015). In addition to helping to anticipate unforeseen impacts of new technologies, secure public trust and confidence in science, and uphold democratic ideals, such deliberation also works to expand society's collective "ethical imagination" (Benjamin, 2016, p.

54). However, opportunities for inclusive deliberation and democratic governance of emerging technologies, are bounded by culturally-specific, institutionalized imaginations of the risks and benefits of innovation, the proper roles of experts and non-experts in state-science-society relations, and the meaning of 'public good' (Burri, 2015). The ways in which publics are constructed, through institutional, regulatory, and expert discourses, influence communication, engagement, and stakeholder involvement in policy decisions (Barnett, Burningham, Walker, & Cass, 2012). Moreover, regulatory norms for identifying, assessing, and managing potential risks establish the parameters of permissible discourse, and shape the extent to which diverse voices are heard in matters of policy and technology implementation.

This paper explores institutionalized standards of governance and engagement surrounding genetic technologies in the United States, and how they relate to practices of inclusion and exclusion in public deliberations. This exploration begins with a discussion of the Asilomar Conference on recombinant DNA in 1975, and the problematic precedents it set in terms of governance and engagement. We then turn our attention to how the legacy of Asilomar informs current discussions on CRISPR-Cas9 genome editing[1], and the ways in which Asilomar-based standards for regulation and engagement are simultaneously challenged and upheld. Finally, lessons for responsible governance and inclusive deliberation are gleaned from a case study of a

[1] Unlike traditional recombinant DNA technologies that rely on restriction endonucleases (bacterial proteins) to cut and reassemble genetic material from different organisms, the CRISPR (Clustered Regularly Interspaced Palindromic Repeat segments of prokaryotic DNA) technique utilizes RNA sequences to target specific regions of a host's genome through complementary base-paring. When combined with Cas9 (a CRISPR derived enzyme), these RNA sequences can be used to add, remove, or alter genomes, once inserted into host cells. When compared to recombinant DNA technology, CRISPR-based techniques for gene editing have been heralded as a cheaper, simpler, and more precise method of genome editing. Moreover, CRISPR allows for multi-gene editing, rather than just single gene modifications.

recent controversy surrounding proposed field trial releases of genetically modified mosquitoes in the Florida Keys to control vector-borne disease. We use this case to further elucidate current challenges to public engagement, inclusive deliberation, and democratic governance.

Asilomar, Risk Governance, and Imagined Publics

In the early 1970s, the development of recombinant DNA (rDNA), the backbone of pre-CRISPR biotechnology, was met with swift concerns from both inside and outside laboratories in the U.S. In light of the uncertainties and potential dangers of this new technology, scientists called for, and agreed upon, a voluntary moratorium on rDNA research in 1974. The following year, a group of preeminent molecular biologists, lawyers, and other specialists, convened at the Asilomar Conference Center in Pacific Grove, California to assess the risks of rDNA and establish guidelines for how to proceed safely and responsibly with research. After three and a half days of discussion, the conference culminated in a set of agreed upon risk containment guidelines that allowed for the moratorium to be lifted.

The Asilomar Conference has been hailed as a great success story of scientific solidarity, which curbed public anxieties and charted the course towards a "commercially successful biotechnological future" (Hurlbut, 2015a, p. 12). Beneath the surface, however, Asilomar is also a story of scientists redrawing the boundaries between science, policy, and society in ways that helped position science as the most qualified institution to define and regulate biotechnology's risks (Gottweis 1998). Throughout the meetings, conference discussions worked to narrow risk definitions to technical matters only. By failing to engage with the social, economic, and ethical

issues surrounding rDNA research and applications, the conference set a precedent for treating such issues as "outside the scope of regulation" (Parthasarathy, 2015, p. 308).

In official statements summarizing the meetings, organizers concluded that, while the risks of recombinant DNA couldn't be denied, they *could* be contained through both physical and biological barriers (Berg, Baltimore, Brenner, Roblin, & Singer, 1975). As such, risks could be controlled by the very technologies that created them in the first place (Gottweis, 1998). The conference further established that the magnitude of risk surrounding biotechnologies could be adequately estimated by expert discernments of novelty (Hurlbut, 2015b). This same logic informs the regulation of genetically modified organisms in the U.S., as evidenced by the centrality of substantial equivalence-based risk assessments that determine the safety of genetically modified products by comparing them to their non-genetically modified counterparts (Burchell, 2007).

In post-Asilomar deliberations on new genetic technologies, retellings of the conference's success in establishing public trust function to reproduce institutionalized imaginations of publics and the 'proper' role of citizens in science and technology governance. J. Benjamin Hurlbut (2015b) observes:

> *"…the public role that the Asilomar story celebrates is one of dependence, with the public passively learning—and deferring to—science's authoritative judgment about what is at stake and when a democratic reaction is warranted. The legacy of Asilomar lies less in its scientific achievements than in its implications for democratic governance of science and technology"* (p. 12).

Asilomar's establishment of an 'expert enclosure' (Gottweis, 1998, p. 104) around risk governance, risk definitions, and risk evaluations was facilitated by the fact that non-expert voices were deliberately excluded from participating in conference discussions. Expert imaginations of a public that was reactive and unqualified to weigh in on debates, combined with a narrowing of risk discourses to strictly technical matters, legitimized and justified this exclusion for conference organizers. Paradoxically, in failing to provide opportunities for proactive public engagement, Asilomar reified these imaginations of a reactive public in that, for citizens, reactive roles were the only ones available to them (Hurlbut, 2015a).

Asilomar's Legacy in Times of CRISPR

Unsurprisingly, the recent CRISPR revolution has inspired a revisiting of Asilomar's legacy in the scholarly literature (Greely, 2015; Gregorowius et al., 2017; Hurlbut, 2015b, 2015a; Jasanoff et al., 2015; Parthasarathy, 2015). The precision, affordability, and accessibility of CRISPR-based applications, are making possible not just alterations to the genomes of single organisms, but the genetic transformation of entire species (Braverman, 2017). CRISPR's potential to eradicate disease, restore lost biodiversity, and sustainably improve agricultural productivity, are paralleled by concerns over new eugenics movements, off-target mutations in genomes, and irreversible harm to the environment. The unprecedented pace and scale at which CRISPR can transform life forms, and ecosystems, combined with possibilities for its misuse, require careful reevaluations of current regulatory standards, as well as "the relationship between science and democracy" (Jasanoff, Hurlbut, and Saha 2015 para.7).

The need for new modes of inclusive deliberation on CRISPR and its applications is widely recognized by scientists, ethicists, policy-makers and activists. In addition to identifying potential biological and ecological impacts, careful consideration must be paid to the ways in which the applications of CRISPR intersect with issues of social justice and equality. As Ruha Benjamin (2016) reminds us, "innovation and inequity too often go hand-in-hand" (p.52). She writes:

> *"Gene editing techniques are seeded with values and interests—economic as well as social—and without careful examination, they will easily reproduce existing hierarchies, including assumptions about which lives are worth living and which are worth 'editing' out of existence"* (Benjamin, 2016, p. 52).

Additionally, CRISPR-based applications such as gene drives[2] problematize issues of jurisdictional control, accountability, and governance. Designed to bypass the rules of Mendelian inheritance, gene drives can rapidly alter the genetic makeup of species and can be used to alter animal vectors (so that they are no longer able to transmit disease), suppress or eliminate invasive organisms, and enhance the resilience of endangered populations to ecological changes. But, as Kevin Esvelt (one of the developers of genes drives) warns, "a release [of gene drives] anywhere, is likely a release everywhere" (cited in Le Page 2016 para.1). The ease at which gene drives can transgress both local and national boundaries makes it impossible to obtain consent from all of the stakeholders that might be affected by (and opposed to) this

[2] Gene-drives are technologies that harness the editing capabilities of CRISPR to introduce desired genes into populations. Because these introduced genes contain CRISPR components, they increase the odds of inheritance during reproduction and can be quickly propagated, leading to the widespread genetic transformation of an entire population over a short period of time.

technology, raising questions related to power, sovereignty, and political relations at both local and global scales.

Despite seemingly widespread agreement amongst social scientists and molecular biologists that the Asilomar Conference is a poor model on which to base CRISPR governance and deliberation, concerns over CRISPR have also culminated in Asilomar-style reenactments of scientific solidarity and self-regulation that are bringing both new and old issues into sharper relief. For example, in 2015, CRISPR developer Jennifer Doudna and other leading experts called for a global moratorium on human gene-editing. Later that year, 500 people, including biologists, physicians, bioethicists, social scientists, journalists, and public advocacy groups, gathered at an international summit organized by the National Academy of Sciences in Washington, D.C. Though modeled on the Asilomar conference, the summit diverged both in terms of the heterogeneity of participants and scope of discussions (many of which extended to ethics and the need for inclusive deliberation). Of particular emphasis was the need for diverse stakeholder participation, which included the individuals and groups who were likely to be the most directly impacted by CRISPR technologies and/or the most frequently excluded from policy decisions (Baker, 2016).

Though it was undoubtedly guided by important ethical considerations, the move towards a global moratorium was also an expression of scientific authority and its capabilities to decide what, when, and how technoscientific futures should be pursued. This was exemplified by the fact that scientists made a unilateral decision to halt gene-editing in the interest of democratic governance and public good. However, those stakeholders that were most likely to be directly impacted by CRISPR

technologies *and* left out of discussions (such as individuals with life threatening genetic diseases), were also those who were most likely to be affected by a moratorium on research that might prove to be life-saving. Even so, these voices were included in discussions only after the moratorium had been decided, again, casting them into necessarily reactive roles.

In response to the pressing need for responsible governance of CRISPR-based research and applications, the National Academies of Science, Engineering and Medicine (NASEM) drafted a series recommendations to guide responsible gene-drive practices (National Academies of Sciences, 2016). These recommendations, outlined in NASEM's 218 page report, touch on multiple issues related to biosafety, governance, accountability, education and engagement. Sponsors and supporters of gene drive research further developed these recommendations and aligned them with a set of guiding principles (Emerson, James, Littler, & Randazzo, 2017) which are summarized in Table 1.

With regard to CRISPR-based applications in non-human organisms, gene-drive developer Kevin Esvelt has advocated for a more radical approach, aimed specifically at dealing with CRISPR's potential for misuse as well as enhancing public trust and securing adequate measures of biosafety. His proposed framework for governance intends to mobilize a well-organized assemblage of stakeholders and legal instruments (Hilgartner, 2017) to "[re]engineer the scientific ecosystem" (Esvelt, 2017, p. 29). On this 'scientific ecosystem,' Esvelt (2017) writes:

> *"It is the catalyst with which we can demand change from those who control the incentives: scientific journals, funders, policy makers, and holders of intellectual properties"* (p. 29).

Esvelt's plan is to convince funders and science journals to set strict guidelines mandating full transparency and public disclosure of proposed gene drive research before agreeing to fund and publish this research. Additionally, Esvelt intends to collaborate with policy makers to leverage gene drive patents (to which he holds the property rights), to force future researchers into compliance. Accordingly, under this plan, permission to Esvelt's licenses will be granted only to those researchers who demonstrate full compliance with standards of transparency and public openness surrounding their plans for use (Esvelt, 2017). On closer inspection, one sees shadows of Asilomar in this regime. Guided by the idea that science must maintain the power of governing itself (since it is the only institution qualified to do so), Esvelt's framework continues to expand the boundaries of science deeper into the territories of law and public policy.

In thinking about challenges to inclusive deliberation in matters related to the future of CRISPR, it is instructive to explore recent controversies involving non-CRISPR based genetic technologies to explicate the ways in which stakeholder involvement in decision-making unfolds. In what follows, a controversy surrounding the use of genetically modified (GM) mosquitoes in the Florida Keys is presented as a lens through which we magnify some barriers to democratic participation that are relevant to discussions of CRISPR. Of particular interest are the ways in which scientific standards of self-regulation, narrow risk definitions, and imaginations of

publics, embed modes of governance in ways that undermine public trust and opportunities for inclusive deliberation of new technologies.

Table 1. Guiding Principles for Responsible Research and Governance

Advance quality science to promote the public good The pursuit of gene drive research must be motivated by, and aim to promote, the public good and social value. Funded research shall embody the highest quality science and ethical integrity, consistent with the current best practice guidance set by the research community and relevant decision-making bodies. *(In alignment with NASEM recommendations 5-1, p. 106)*
Promote stewardship, safety, and good governance Researchers and sponsors are stewards of science and the public trust. It is imperative that good governance is demonstrably shown in all phases of the research, and especially in relation to risk assessment and management. This requires compliance with applicable national and international biosafety and regulatory policies and standards. Research conducted with respect and humility for the broader ecosystem in which humans live, taking into account the potential immediate and longer-term effects through appropriate ecological risk assessment, is a hallmark of both good stewardship and good governance. *(In alignment with NASEM recommendations 6-1, p. 128; 8-3, 8-4, and 8-10, pp. 170–172)*
Demonstrate transparency and accountability Knowledge sharing is not only essential for the advancement of science, but for transparency to foster public trust in emergent technologies. The timely reporting of results and broad sharing of data shall be the norm in gene drive research, consistent with the tradition of openness established in its parent communities of genetic and genomic science. Measures of transparency and accountability that contribute to building public trust and a cohesive community of practice will be supported [(2), pp. 171, 177–178)]. *(In alignment with NASEM recommendations 8-5 and 8-7 p. 171, 9-2 p. 177, and 9-5 p. 178)*
Engage thoughtfully with affected communities, stakeholders, and publics Meaningful engagement with communities, stakeholders, and publics is critical for ensuring the best quality science and building and sustaining public confidence in the research. Funded research shall include the resources needed to permit robust, inclusive, and culturally appropriate engagement to ensure that the perspectives of those most affected are taken into account. *(In alignment with NASEM recommendations 7-1 through 7-8, pp. 142–143)*
Foster opportunities to strengthen capacity and education Strengthening capacities in science, ethics, biosafety, and regulation is essential for enabling agile and steady progress in gene drive research globally. Opportunities to partner, educate, and train shall be supported throughout all phases of the research, from the early stages to deployment. Strengthening capabilities within countries for testing and deploying the technology is essential for informed decision-making. *(In alignment with NASEM recommendations 6-1, p. 128; 8-1, 8-2, 8-5, 8-7, 8-8, and 8-10, pp. 170–172)*

Adapted from Emerson et al., 2017

GM Mosquitoes: Governance, regulation and public engagement

In 2010, the Florida Keys Mosquito Control District (FKMCD) began collaborating with the British biotechnology company Oxitec to lay the groundwork for field trial releases of Oxitec's genetically modified mosquito (OX513A *Aedes aegypti*) in the Florida Keys. Developed in the pre-CRISPR era of biotechnology, Oxitec's approach relies on traditional recombinant DNA technology to suppress mosquito populations and control the spread of mosquito borne diseases. Though Oxitec had implemented its technologies in other countries, the proposed field trial was slated to be the first time a genetically modified animal was released into an open environment in the United States. Release plans were submitted by Oxitec to the US Food and Drug Administration (FDA) in 2011 for regulatory approval. News of the release plans were met with intense opposition from local and national environmental groups, and concerned residents mobilized resistance in town hall meetings and through social media campaigns. Public criticisms of the plans were centered on questions regarding possible unintended consequences of OX513A releases on local ecosystems, Oxitec's for-profit motives, institutional rigor in risk assessment, and the degree to which different stakeholders could influence policy decisions.

Nevertheless, after 5-years of tense scientist-resident relations, the FDA released its preliminary findings in 2016, stating that the proposed Oxitec field trials posed no significant risk to human health or the environment, and solicited public input on its assessment (US Food and Drug Administration, 2016). Upon reviewing 2,641 online public comments (mostly in opposition), the FDA released its final assessment that August supporting the release plans. Amidst growing public

dissidence, elected officials decided to put the field trial plans to a non-binding vote in the November 2016 elections. Though the releases were backed by 58% of voters in the Florida Keys, 65% of voters who resided in proposed release area voted in opposition (Atkins, 2016). In light of these divided polls, officials from the Florida Keys Mosquito Control District made the decision not to move forward with the field trials. Updates to biotechnology regulatory frameworks in the U.S. in 2017 transferred oversight of Oxitec's mosquitoes to the Environmental Protection Agency (US Food and Drug Administration, 2017). On November 28, 2018, Oxitec, Ltd. issued a press release stating that the company would be phasing out the use of OX513A mosquitoes and replacing them with their newly developed, 2nd generation OX5304 mosquitoes[3] (Oxitec, Ltd., 2018). That same day, a Florida Keys Mosquito Control District press release was circulated on the Florida Keys Environmental Coalition group's Facebook page announcing that Oxitec was withdrawing its permit for experimental use of OX513A and resubmitting a new application to the EPA for an OX5034 field trial permit in the coming months (The Florida Keys Environmental Coalition, 2018).

From the start, the on-going controversy in the Florida Keys was largely fueled by the governance/risk philosophies and imagined publics that Asilomar helped to institutionally inscribe. These philosophies and imaginations undermined efforts to involve residents in discussions in meaningful ways, and manifested across multiple sites of stakeholder engagement. Matters were further complicated by the underlying market frameworks that shape the production, regulation, and communication of new

[3] Unlike OX513A, the use of OX5034 technology permits multigenerational suppression, in that matings between OX5304 males and wild type females result in the survival of male progeny only, who continue to propagate self-limiting genes within the population. According to Oxitec, this will result in greater scalability and cost-effectiveness of releases.

biotechnologies, like genetically modified organisms (Meghani & Kuzma, 2018). These issues are explored below, using stakeholder statements from two Florida Keys town hall meetings (2012 and 2014). Over four hours of audio video recordings were obtained the through the FKMCD website and YouTube and transcribed by the authors with the help of an undergraduate research assistant in the Science Education and Society Program at the University of Rhode Island.

Participants present during the meetings were identified as members of at least one of following stakeholder groups,[4] with varying levels of authority and expertise: 1) Oxitec Ltd., 2) the Florida Keys Mosquito Control District, 3) Unaffiliated Scientists, 4) Local Policy Makers/ Advisors/Public Figures, 5) Federal Regulators, 6) Residents, and 7) Activists. Oxitec, the FKMCD, and residents emerged as the most vocal and organized stakeholder groups during the meetings. It is important to note that most comments in support of the Oxitec field trials were contributed by scientists (both affiliated and unaffiliated with Oxitec and/or the FKMCD) and other public officials. The combined number of resident commenters for both meetings totaled 45 (14 for the 2012 meeting, and 31 for the 2014 meeting). Only one resident, a scientist, offered explicit support for the field trial plans. The majority of resident statements were either neutral or in explicit opposition to the field trial plans. We caution, however, that the views presented in the meetings may not necessarily be representative of Florida Keys residents at large, as some residents appeared to also be members of environmental activist groups.

[4] These groups are not mutually exclusive, in that some participants belonged to more than one group of stakeholders. For example, several scientists in attendance (unaffiliated with Oxitec and the FKMCD) were also residents. Likewise, cross-checking research online revealed that several residents in attendance were also members of activist groups.

2012 and 2014 Town Hall Meetings

As previously mentioned, at the time the town hall meetings were held, regulatory decisions surrounding the use of Oxitec's mosquitoes in the Keys were playing out under the FDA's guidance and oversight. Meghani and Kuzma (2018) conducted an in-depth analysis of the FDA's regulatory procedures as they pertained to Oxitec's GM mosquitoes, and are critical of the fact that the FDA made the decision *not* to assess field trial plans at the most stringent level of a 3-category environmental review system. This would have mandated increased requirements of detail and rigor in assessment. Instead, the FDA allowed Oxitec to submit an Environmental Assessment in which "Oxitec chose to use a qualitative risk assessment method that combines phrases of 'likelihood' with phrases of 'consequence' to estimate risk qualitatively' based on summaries of research the company itself had conducted" (Meghani & Kuzma, 2018, p. 214). Residents in attendance at the 2014 town hall meetings were equally critical of the FDA's risk assessment:

> *"Any drug that has been taken off the market by the FDA was at one time approved by the FDA. I think the concern that people have, or that, well , certainly that I have, is to understand any kind of independent evaluation that the FDA might be making, to be reassured that somehow whatever might come, is planned for, that we don't find ourselves in a few years in a situation with consequences that could not be anticipated."* –Public comment (Catherine, 2014)

The degree to which institutional confidence was placed in Oxitec's ability to define, assess, self-regulate, and accurately report on the risks of its product speaks to the centrality of scientific authority in policy matters, and was a common concern raised by residents throughout the controversy. The FDA's deference to scientific authority was matched by its commitment to neoliberal agendas articulated in the long-standing 1986 Coordinated Framework on the Regulation of Biotechnology (Meghani & Kuzma, 2018). This framework institutionalized the market-based logic of substantial equivalence in biotechnology regulation, stating that it would allow the U.S. to be a global leader in biotech development and commercialization by facilitating the pipeline from industry to market. This put public health interests in direct tension with those of industry and market. Yet, White House revisions to the framework in 2015 and 2017 further reinforced its commitment to neoliberalism, citing that the goal of these revisions was to 'ensure public confidence' and 'prevent unnecessary barriers to innovation' (White House 2015 cited in Meghani and Kuzma 2018: 5).

Under the neoliberalist ideology of U.S. regulation, the market itself becomes the primary mode of governing risk and innovation and the public is constructed as consumers (Burri, 2015; Jasanoff, 2005). As we have seen with Asilomar, how publics are imagined largely shapes how engagement strategies and communication unfolds. When publics are imagined by scientists and regulators to be uninformed *consumers* (and reactive ones at that), communication between stakeholders tends to be asymmetrical (mainly consisting of experts attempting to inform citizens so that they may be more likely to *buy in* to technologies). The deep and murky relationship between biotechnology governance, market frameworks, and communication was not

lost on opponents to the Oxitec field trials, making it difficult for some residents to discern where risk communication ended and public relations began. In their attempts to assess and, at times, undermine the companies risk claims, many residents and national advocacy groups took it upon themselves to conduct scientific 'audits' (Curry, n.d.) on the company and their financial dealings. During a 2012 town hall meeting one resident commented:

> *"I would like to know what peer reviews you have that are not funded by your company. Also, are you funded by the Bill and Melinda Gates foundation? I read somewhere that your company is losing 2.7 million a year since it's been founded. You obviously have many investors. One of them being a Boston banker that you're set to pay back a debt to at the beginning of 2013. I just wanna know, is that true?"* –Public comment (Florida Keys Mosquito Control District, 2012)

Others were equally skeptical about how claims to intellectual property rights and proprietary patents were affecting scientist's ability to self-regulate through peer review:

> *"I haven't seen enough third party objective research to really substantiate the claims of success that you've had in other countries. This [genetically modified mosquito] is a proprietary patented product. Who else has had access to research your product without doing wild experimentation? I understand that there's been research by collaborators, but collaborator, by definition, is not an objective term. I'm really talking about independent third party, objective research."* –Public comment (Florida Keys Mosquito Control District, 2012)

These comments align well with Wynne's (2001) observations that in many cases of controversy "public reactions are not reactions to (supposedly misperceived) risks as such, or to media representations of these, but rather are public judgements of dominant scientific and policy institutions, and their behaviors—including their representations of the public" (p. 445).

This is not to say that perceptions of risk do not matter nor that public misperceptions do not play a role in scientific controversies. Indeed, at several points in the town hall meetings (and throughout the controversy in general) public misperceptions of science and scientific topics presented obstacles for productive deliberation and engagement. More relevant to this paper, however, are the ways in which scientists' commitment to treating risk as strictly a technical matter undermined democratic deliberation. Though the decision to release Oxitec's mosquitoes was eventually brought to referendum, in early discussions the Florida Keys Mosquito Control District advocated for technocratic governance. As the director of the FKMCD explained:

> *"The people that make these decisions, I want to be the people who have the scientific background to evaluate risk. And that's really what this is all about. Is the risk of any future mosquito borne disease worse than the risk of a new technology?"* –FKMCD Director comment (Florida Keys Mosquito Control District, 2012)

Yet, the releases of genetically modified mosquitoes were about much more than the measuring of disease risk against the risk of technology for residents at the meetings. They were about the dangers of transforming society into a laboratory, residents'

place-based identities and emotional connections to the Florida Keys environment and its inhabitants (both human and non-human), matters or power and responsibility in who gets to decide the future, and issues of autonomy and consent when it comes to experimenting with genetically modified organisms in people's backyards (Herndl & Zarlengo, 2018).

The parameters of discourse, set by exclusively technical definitions of risk, prevented Oxitec scientists and the Florida Keys Mosquito Control district from engaging meaningfully with these complex issues, resulting in residents feeling that their voices were not being heard (Herndl & Zarlengo, 2018; Phillips, 2017). Further complicating the situation, were scientists narrow definition of engagement. In scientific publications and promotional materials, Oxitec frequently calls attention to the many ways in which the company conducts outreach and engagement in areas where releases of GM mosquitoes are carried out. However, during the 2012 town hall meeting, one resident, with Oxitec promotional materials in hand, pointed out:

> *"You say that you have a community engagement plan in place. This is a question of integrity, so please bear with me. You say that you that have conducted, so far, have consisted of public information events. Where have those taken place? And has anyone in this room been to one?"* –Public comment (Florida Keys Mosquito Control District, 2012)

Her question was addressed by an FKMCD staff member:

> *"I do all the public outreach through mosquito control, and I've talked to the county commission, the Key West City Commission, there's been articles in the*

newspaper. We're on the radio every week." –FKMCD staff member comment (Florida Keys Mosquito Control District, 2012)

The resident followed up on these remarks, stating:

"So for integrity's purposes Oxitec states, that to date, 'community engagement activities, so far, consisted of public information events'. I just wish to say gentlemen, I want to trust in your highest intent as scientific people, not dollar driven. But please understand that when statements like this are in your own document, it gives us pause."

This exchange reveals that an understanding of 'community engagement' may mean different things to different stakeholders. It seems that both Oxitec and the FKMCD were defining engagement, at least at that time, primarily in terms of media outreach.[5] Resident statements articulate a dissatisfaction with this shallow level of engagement in such important matters and demonstrate how easily trust can be eroded when the language of engagement does not accurately represent actual engagement practices. Moreover, in the case of the Florida Keys controversy, the public was only invited to participate in field trial discussions *after* release plans had already been set in motion, leading many residents to feel that the town hall deliberations were nothing more than a 'dog and pony show' (Catherine, 2014; Florida Keys Mosquito Control District, 2012).

Conclusion: Lessons for CRISPR

The controversy surrounding the use of GM mosquitoes in the Florida Keys offers several important lessons that are relevant to discussions on CRISPR in its early

[5] In subsequent years, Oxitec began campaigning door to door and through telephone calls.

stages of application and implementation. First, the goals of inclusive deliberations on new genetic technologies are unlikely to be achieved if scientists are unwilling to yield control over exclusive definitions of risks. Limiting risks to technical matters reduces the scope of discourse in a way that is detrimental not only to science-society relations, but also to responsible modes of governance that consider not just the biological/ecological harm of new technologies but the social consequences as well. While CRISPR deliberations seem much more attuned to ethical considerations, it is important to remember that the current regulatory frameworks for biotechnology governance in the U.S. (under which CRISPR and its products are likely to be regulated), are centered on a definition of risk as exclusively technical in nature. If ethical deliberations are to be reflected in ethical regulations, we must rethink how risk is defined at the regulatory level as well.

Second, the standard for scientific self-regulation combined with the neoliberalized modes of market governance written into regulatory frameworks, may undermine the ability of regulatory agencies to prioritize safety in regulatory decisions and can contribute to the erosion of public trust. Discussions of CRISPR governance must be scrupulously attentive to these matters, as well as the ways in which modes of governance reproduce particular imaginations and representations of the public, as this affects how deliberation and engagement is carried out. Persistent, institutionalized imaginations of publics as reactive consumers present major obstacles for transparent, inclusive, and symmetrical communications between scientists and the communities they engage with. In striving for more democratic forms deliberation, publics must be

reimagined as active participants who are capable of making contributions to discussions on new technologies and their implications.

Finally, stakeholders in science-related policies may hold different understandings about what engagement means. When expectations for engagement are not met, or engagement practices are inconsistent with the language used to describe it, publics may feel that they are being left out of the decision making process and/or deceived. In thinking about CRISPR, clearer definitions and standards of engagement are needed. Inclusive deliberation on CRISPR technologies should also include discussions on what engagement means and for whom, as well as what forms of engagement are needed to ensure that diverse voices are included, heard, and served by these deliberations. Moving forward, it is imperative that the terms of CRISPR engagement are set democratically, and in ways that work to empower citizens and their communities in the governance of new technologies.

The National Academies of Science, Engineering and Medicine's (2016) recommendations for governing gene drives are a step in the right direction in thinking about responsible CRISPR practices, including modes of public engagement (see sections 7-1 to 7-8 of the NASEM report). Target Malaria (a non-profit group researching the use of gene drives for vector control) for example, has aligned their governance and engagement strategies closely with the NASEM recommendations in efforts to engage diverse stakeholder voices, cultivate public confidence, and incorporate local values into governance practices in areas where gene-drive mosquitoes are being considered for release (Target Malaria, 2016). Had similar recommendations been developed, articulated, and adhered to during early discussions

of Oxitec's field trials, it is possible that some of the controversy in the Florida Keys may have been prevented (or at least tempered). Still, there are problematic gaps in NASEM's recommendations that need to be carefully considered moving forward. For example, Neuhaus, (2018) points out that the vagueness of the definition of 'community engagement' that so haunted the Oxitec trials in the Florida Keys, is not adequately resolved in NASEM's report. Moreover, NASEM's report "fails to acknowledge the strong commercial drivers that may bring gene drives into use" (Thomas, 2016: n.p.). Future research on CRISPR and its applications need to be especially attentive to these gaps and work to narrow them, lest they undermine frameworks for precautionary governance and inclusive deliberation.

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CHAPTER 2

MOSQUITOES OUT OF PLACE: CLAIMS-MAKING, REPRESENTATION, AND BOUNDARY POLITICS IN THE DEBATE OVER FIELD TRIAL RELEASES OF GENETICALLY MODIFIED MOSQUITOES IN THE FLORIDA KEYS

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ABSTRACT

This study presents a discourse analysis of contentious hybrid forum discussions surrounding a proposed release of Oxitec's genetically modified (GM) mosquito (OX513A *Aedes aegypti*) in the Florida Keys. Grounding our work in the sociological literature on problematic animals, claims-making, and boundary work perspectives, we analyze audiovisual recordings and transcripts from two town hall meetings in Monroe County, Florida to explore how claims-makers discursively position genetically modified mosquitoes as matter in, or out, of place for rhetorical purposes related to their regulation and governance. We argue that struggles to control the symbolic representation of mosquitoes (both GM and wild) as problematic/ unproblematic are deeply embedded in understandings of other social problems, and reveal claims-makers' efforts to maintain, extend, and/or narrow various social and physical boundaries.

Introduction

It is widely accepted in the sociological literature that the meaning of animals is socially constructed— extending from the rhetorical work of claims-makers, as well as cultural understandings of, and appreciations for, the boundary between nature and culture (Arluke and Sanders 1996; Brown and Michael 2001; Franklin 1999; Hobson-West 2007; Jerolmack 2008). As Arluke and Sanders (1996:9) explain, "although animals have a physical being, once in contact with humans, they are given a cultural identity as people try to make sense of them, understand them, use them, or communicate with them." For some animals, the cultural identity imbued on them by the humans they come into contact with is problematic, as they are transformed into public health issues, ecological nuisances, and pests through discourse and human social interaction (Arluke and Sanders 1996; Fine and Christoforides 1991, 1991; Goedeke 2005; Jerolmack 2008; Larson 2008).

Cultural understandings of animal problems are often deeply embedded in an understanding of acceptable human-animal sociospatial relations (Fine and Christoforides 1991; Jerolmack 2008; Larson 2008, 2010, 2011), and their accompanying discourses both "mirror and inform processes of how human groups are constructed as problematic" (Jerolmack 2008:73). In tracing how animals are transformed into social problems through discourse and social interaction, the concept of 'imaginative geographies' (Jerolmack 2008: 72) is instructive. When animals are perceived to transgress socially acceptable physical and/or conceptual boundaries, they are often experienced as 'out of place,' and cultural anxieties manifest around their potential to pollute human habitats and ways of life (Douglas 1966; Jerolmack

2008). Jerolmack (2008) observes that problematic animals "expose(s) culturally derived modernist conceptions of proper, morally appropriate, spatial relations between animals and society" (73). This paper expands this observation, and the concept of imaginative geographies, to better understand an ongoing controversy surrounding field trial releases of genetically modified mosquitoes in the Florida Keys.

In recent years, transgenic mosquitoes have taken center stage in discussions of public health measures to control vector borne diseases. Transgenic strategies for managing mosquitoes, and the diseases they transmit, rely first on the genetic modification of mosquitoes in the laboratory (to either limit their ability to reproduce or render them incapable of acquiring/transmitting disease) and then their release into wild populations. First created in 2002 by the British biotechnology company Oxitec, transgenic mosquitoes have been hailed by supporters as a cheaper, more effective, and more environmentally-friendly solutions to mosquito control when compared to traditional vector control strategies such as pesticide spraying. Still, uncertainties surrounding the long term impact of releases of transgenic mosquitoes on local ecosystems abound, and field trial plans in the United States have been marred by controversy and public opposition.

That the genetically modified mosquito would be constructed as a social problem may seem obvious, considering the myriad boundaries that are explicitly transgressed in the creation of transgenic organisms. As Smits (2006) notes, "central to public discomfort about new technologies is the notion that they are unnatural" (489). However, like any new technology, the problematic status, and unnaturalness, of the genetically modified mosquito is not given, but instead extends from particular

discursive "configurations of matter and meaning" (Kasemets et al. 2015: n.p.), as well as perceptions of acceptable spatial relations—both physical and conceptual--between humans, animals, and social institutions. In the controversy surrounding genetically modified mosquitoes in the Florida Keys, stakeholder struggles to control *how* science, and its products are represented, as well as debates over *what* technoscientific futures are worth pursuing (Jasanoff and Kim 2015), often bring various boundaries, and boundary transgressions (physical, metaphysical, epistemic, social), into relief. Regardless of whether or not boundary transgressions pose a threat to physical well-being, boundary transgressions are inherently 'risky' in the sense that may disrupt symbolic systems of ordering physical and social worlds (Douglas 1966), and as such, are subject to legitimization, negotiation and/or contestation through discourse. In the process, existing relations between actors (both human and nonhuman), social groups, and institutions may be reproduced and/or reconfigured.

Through a discourse analysis of contentious town hall meetings in the Florida Keys we identify and unpack the various configurations of matter, meaning, and space that emerged in stakeholder representations of genetically modified mosquitoes. We find that both scientists promoting releases, and residents opposing them, engage in boundary work to position genetically modified mosquitoes as matter in, or out of place in their efforts to problematize or deproblematize their use, and to support divergent claims regarding their safety and effectiveness. We argue that these claims are anchored not only in imaginative geographies of nature, but also the imaginative geography of science as an institution, and serve performative functions related to risk communication, regulation and governance.

Controversy in the Keys

In 2010, following an outbreak of Dengue Fever in Key West, the Florida Keys Mosquito Control District (FKMCD) began collaborating with the British biotechnology company Oxitec to explore the possibility of implementing transgenic vector control strategies in the region (Maxmen 2012). Oxitec had recently released its genetically modified (GM) *Aedes aegypti* mosquito (OX513A) during experimental field trials in the Cayman Islands and had demonstrated success in reducing local *Aedes aegypti* populations by 80% (Harris et al. 2011). The bio-logic of Oxitec's approach rests on "rigging natural selection" (Molteni 2017: n.p.) by introducing genes that affect reproduction and creating scenarios in which modified mosquitoes can outcompete their wild counterparts. OX513A *Aedes aegypti* mosquitoes are first modified in the laboratory to carry two copies of a dominant lethal allele construct (RIDL system[1]), and a fluorescent gene marker. The RIDL system genes direct the production of proteins that disrupt cellular functioning. The fluorescent gene markers allow scientists to monitor the persistence of OX513A mosquitoes in the environment post-release. During the larval stage, OX513A mosquitoes are supplied a steady diet of tetracycline which inactivates the RIDL system and prevents premature death. As they mature, the mosquitoes are mechanically separated by sex, based on size differences, and females are removed[2]. Once they reach adulthood, the males are then released en masse, to increase the likelihood that they will mate with wild type females and pass on the RIDL construct to offspring. Since genetically modified males are homozygous dominant for the RIDL system, all offspring from these matings will

[1] RIDL stands for "Release of Insects with Dominant Lethality"
[2] Female *Aedes aegypti*, alone, are responsible for disease transmission as males do not bite.

carry a copy of the lethal allele. In the absence of tetracycline in the environment, the majority of these heterozygote offspring will not survive to adulthood (Oxitec 2017).

Despite field trial successes and endorsements by global public health advocates such as the Gates Foundation, Oxitec's early field trials were not without controversy. Environmental activists criticized Oxitec's lack of transparency (Nading 2015) and the company's "colonialist attitude" (Reis-Castro and Hendrickx 2013), noting that Oxitec had failed to consult and engage local communities, and conveniently exploited regulatory loopholes in the countries where releases were carried out. Some scientists were equally critical of Oxitec's approach and cited concerns related to scientific rigor, independent assessment, and narrow considerations of risk (Reeves et al. 2012). In the United States, field trial release plans were submitted by Oxitec to the Food and Drug Administration (FDA) in 2011 for regulatory approval. News of the FKMCD-Oxitec collaboration was met with staunch opposition from both local and national groups and by 2012, a Change.org petition (created by a local Florida Keys resident) had garnered over 100,000 signatures[3] in opposition to field trial release plans (Nading 2015). In public forums related to the release, both in person, and online, Keys residents vehemently challenged not only Oxitec's claims of safety, but also the company's motives.

Nevertheless, in March of 2016, against the backdrop of the growing Zika virus outbreak in the Americas, the FDA released its preliminary findings that the proposed Oxitec field trials posed no significant risk to human health or the environment (US Food and Drug Administration 2016b), and solicited public input on

[3] The number of signatures on this petition was at 170,811 in December 2017. Kay (2012) found that the majority of these signatures were from non-residents of the Florida Keys.

its preliminary assessment during a 60-day commenting period. Upon reviewing 2,641 online public comments, the FDA released its final assessment that August (US Food and Drug Administration 2016a), supporting the investigational use of genetically modified mosquitoes in the Florida Keys. Field trial plans were put to a non-binding vote in the November 2016 elections and were backed by 58% of voters in greater Monroe County. Sixty-five percent of Key Haven voters, however, opposed the plans (Atkins 2016).

In light of these divided polls, officials from the Florida Keys Mosquito Control District made the decision not to move forward with the trials. As part the Executive Office of the President's *Update to the Coordinated Framework for the Regulation of Biotechnology* (US Food and Drug Administration 2017b), regulatory oversight of genetically modified mosquitoes was transferred from the US Food and Drug Administration to the US Environmental Protection Agency (US Food and Drug Administration 2017a) in late 2017. In December of that same year, Oxitec applied for an experimental use permit from the EPA seeking approval for field trial releases at an alternate site in the Florida Keys. Oxitec subsequently withdrew this application in November 2018, citing that the company would be replacing OX513A with their newly developed OX5034 *Aedes aegypti* mosquitoes (Oxitec, Ltd. 2018). A press release from the Florida Keys Mosquito Control district on November 29, 2018 indicated that Oxitec would be submitting an application for an OX5034 Experimental Use Permit to the EPA in the following months (Florida Keys Mosquito Control District 2018).

The Constructionist Approach to Controversies: Social Problems and Claims-making

At the heart of the Florida Keys controversy are conflicting claims about the existence of some social problem. Under the constructionist view, external conditions, such as the risk of disease, the trustworthiness of scientists, or unintended consequences of new technologies, are *social problems* only to the extent that they are defined and recognized as such. In Spector and Kitsuse's (1987:73) words, "social problems are what people think they are," and emerge through the activities of claims-makers. Such claims-making activities are always rooted in interactions between individuals and groups (Spector and Kitsuse 1987). Thus, the meaning of objects and conditions resides not in objects and conditions themselves, but rather emerges through the definitional processes of social interaction (Blumer 1969). If, during the process of interaction, a confusion and/or misunderstanding of meaning arises, then "communication is ineffective, the interaction is impeded, and the formation of joint action is blocked" (Blumer 1969:9).

In the tradition of social constructionist and symbolic interactionist perspectives, a growing body of literature examines the ways in which animals are constructed as social problems through claims-making activities and social interactions (Arluke and Sanders 1996; Best 2018; Fine and Christoforides 1991; Goedeke 2005; Jerolmack 2008; Markwell and Cushing 2016). Best (2018) observes, in his review of the literature, four categories under which animals are situated as social problems: 1) as pests that cause harm to people or social arrangements, 2) as endangered species that are threatened by humans and in need of protection, 3) as

invasive species that threaten ecological order, and 4) as anthropomorphized deviants that behave in undesirable ways. These categorizes, and their accompanying animal representatives, are social constructions that "impose an analytic order on the natural world, by lumping and splitting fauna into particular types of beings" (Best 2018:2). And, as Arluke and Sanders (1996) remind us, social constructions are inseparable from moral constructions, with constructs relying on binaries and oppositions for their meaning.

In his now classic work on the problematization of pigeons in urban environments, Jerolmack (2008) explores how the nature/culture binary informs the "complex spatial expectations" (Philo and Wilbert 2000:22) that humans rely upon in their construction of some animals as social problems. Drawing on Philo and Wilbert's (2000:11) notion of the 'imaginative geography of animals,' Jerolmack traces the ways in which "our social and moral evaluations of animals are contingent on where they are found" (Jerolmack 2013:72). Animals that defy or transgress the 'socio-spatial order' (Philol 1995:656) forced upon them, are typically experienced as a form of symbolic pollution, or, in Douglas' (1966) words, 'matter out of place.'

Somewhat surprisingly, the sociological literature on problem animals, has been slow to extend constructionist approaches to 1) examining the ways in which the meaning of hybrid organisms, such as genetically modified animals, emerge through the claims-making activities of social interactions and 2) exploring how claims-makers engage in various socio-spatial boundary negotiations to legitimize/delegitimize transgenic organisms as 'solutions' to other social problems (i.e. to the problem of vector borne disease in the case of the production and application genetically modified

mosquitoes). This paper attempt to address this gap by applying an interactionist perspective to analyzing contentious town hall meetings in the Florida Keys, in which a multitude of stakeholders with varying levels of authority and expertise debate field trial releases of genetically modified mosquitoes. Our analysis is greatly informed by the work of other social scientists who have explored discourses surrounding transgenic mosquitoes and the boundary politics surrounding anomalies and hybrid organisms in general. We summarize this work in the following sections.

The Ontological Fluidity of GM mosquitoes

The hybridity of transgenic mosquitoes problematizes traditional classification systems and frameworks for organizing natural and social worlds, as their development and application are contingent on the destabilization of myriad boundaries. Metzler and Webster (2011):649) use the term 'bio-objects' to describe such boundary disrupting organisms that are developed in laboratories, for the purpose of knowing and/or enhancing life, and subsequently leveraged, stored, circulated and/or exchanged in new spaces. In the case of genetically modified mosquitoes, species boundaries are transgressed by way of transplanting gene fragments from other organisms (i.e. Cabbage looper moth, vinegar fly, mushroom coral, E. coli bacteria, and Herpes Simplex Virus 1) into mosquito DNA to achieve the RIDL (lethal gene) construct (Glandorf 2017). Field trials, aimed to assess the efficacy of GM mosquitoes in suppressing local mosquito populations, problematize the boundaries of the laboratory, as experiments are carried out in open environments and residential neighborhoods (Reis-Castro 2012). The boundary between science and industry is complicated through the process of bio-objectification, in that long-term population

suppression of wild populations requires a continuous "lock-in" cycle of "production" and "consumption" of GM mosquitoes that benefits the commercial interests of Oxitec (Reis-Castro 2012:637). Moreover, Oxitec field trials necessitate an overlap between scientific experimentation and public health policy (Reis-Castro 2012), making "the point at which the autonomy of science ends and the role of political decision-making begins" (Jasanoff, 1987:200), unclear.

As Graham (2002:5) explains, "it is not only a question of coming to terms with the economic and cultural impact of new technologies, but of engaging with their capacity to stir up questions of ontology." Like all transgenic organisms, genetically modified mosquitoes are inextricably entangled in the forms of life (i.e. social, political, and symbolic systems) that usher them into existence (Helmreich 2009). They are both materializations of imagined technoscientific futures, "imbued with hopes" and promises (Metzler and Webster 2011:649), and manifestations of political economic relationships, global capitalism (Nading 2015), and an Anthropocene 'faith' in technofixes (Haraway 2016). At the same time, genetically modified mosquitoes engender new human-nonhuman-environment relations, new forms of governance over these entangled relations (Helmreich 2009), and new ways of *being and relating.* With the development of the OX513A genetically modified *Aedes aegypti*, the mosquito itself *becomes* something other than disease vector. The mosquito is transformed into a 'living technology' (Reis-Castro 2012), a 'flying public health tool' (Beisel and Boëte 2013), a form of 'biocapital' (Helmreich 2008; Rajan 2006), and an ally (rather than enemy) to humans.

Genetically Modified Organisms as Matter Out of Place

Cultural anxieties surrounding genetically modified organisms can be explained, in part, by the ontological ambiguity, fluidity, and perceived unnaturalness of hybrid beings. As Kwieciński (2009:1188) observes, GMOs "break[s] the boundaries of fixed, neat categories and thus pollute the entire system of ordering the universe." Risk evaluations of GMOs, at both the institutional and the individual level, requires that they are first defined and characterized according to pre-existing categories, arrangements, and relations. For Douglas and Wildavsky (1983), risk perception is a social process, and risks are selected according to their potential to disrupt normative social arrangements, relations, and symbolic ordering systems. This is not to say that hazards are not real, only that they are not perceived as risks until something of socially-mediated value is at stake. Thus, debates over the risk of genetically modified organisms cannot be understood solely as matters of disagreement over technical evaluations and measures. Rather, concerns regarding GMO's are "inseparable from issues relating to power, justice and legitimacy" (Tansey and O'riordan 1999:71), group identity, and collective desires to maintain social and symbolic orders.

Smits (2006:494) explains, "Cultural categories form a precondition for our perceptions of phenomena. At the same time, perception often struggles with those categories." Anomalous phenomena that defy classification, or occupy mutually exclusive categories for ordering material and social relations, trigger cultural unease and are often experienced as a special type of danger: dirt (Douglas 1966). For Douglas (1966), dirt is simply 'matter out of place,' or phenomena that "is not in its

right place in the symbolic order" (Smits 2006:494). Rhetorical and representational practices of discourse may work to either normalize GMOs and transform them into 'matter in place' (Smits 2006), or highlight their unnaturalness and incompatibility with existing symbolic categories and thus stabilize them as 'matter out of place'.

It is important to emphasize here that attempts to control the representation of GMOs as matter in, or out, of place are always embedded with normative considerations, moral prescriptions, and both group and individual interests (Jasanoff, 2011). Though some scholars have argued that the opposition to, and the disgust elicited by, genetically modified organisms stems from an intuitive, psychological tendency to evaluate anomalous phenomena according to cultural categories (Kwieciński 2009; Tagliabue 2016), we caution against such narrow interpretations here. Smits (2006:490) notes that anomalous phenomena are, at times, greeted with 'fascination' rather than 'abhorrence,' and that the connotations surrounding boundary disrupting technologies (and their perceived unnaturalness) may change over time, depending on how they are made to fit into existing cultural categories. We argue that, rather than relying simply on emotional and psychological intuitions, claims-makers may exert varying degrees of control over this process, and engage in complex boundary negotiations in efforts to define, and redefine, the categories used to evaluate new technologies. Moreover, moral decisions surrounding animals, are not rooted solely in the minds of individual humans who come in to contact with them. Rather, they are based on the interactional, discursive accomplishments of groups, who draw from various moral vocabularies, rhetorics, and narratives to construct a plan of action (Young and Thompson 2017).

Representation and Boundary Work

Cultural perceptions of transgenic mosquitoes embed, and are embedded, in the representational practices of discourses. Practices of representation are expressions of "concepts, images, emotions and so on in symbolic form" and tap into "wider discourses of meaning" (Graham 2002:25). Representation is both a meaning-making process, whereby natural and social phenomena are contextualized in culturally specific frameworks and relations, *and* a rhetorical process that legitimates or subverts values, relations, and imagined futures (Graham 2002). For example, the meaning of popular, Frankenstein-based representations of genetically modified organisms in Western contexts, extends from culturally specific narratives and associations. At the same time, such representations situate GMOs into "wider discourses of meaning" surrounding scientific hubris, unintended consequences, etc. (Graham 2002).

Representation is closely intertwined with the concept of framing (Goffman 1974), in that certain representations work to construct specific discursive frames (Avraham and First 2010) that may be employed to mobilize collective action around a perceived social problem (Benford and Snow 2000). As such, representations (and the frames they activate) are the building blocks for Mills (1940) vocabularies of motive, or, the language that people use to account for their motivations and behaviors. Benford (1993:200) explains that, "vocabularies of motive provide participants with 'good reasons' for identifying with the goals and values" of [a] movement and for taking action on its behalf."

In public controversies over technoscientific issues, competing representations of science, and its products, are often reflections of broader concerns over boundaries

(between nature and culture, science and industry, laboratory and society), and are leveraged by groups of stakeholders in their efforts to sway policy and regulatory decisions. Attempts to control the representations of GM mosquitoes, and the often mutually-exclusive categories by which they are evaluated, can be considered a form, of what Gieryn (1983; 1999) calls, boundary work. Originally used to describe how scientists demarcate science from non-science and/or expand the authority of science through rhetoric and practice (Gieryn 1983: 782), the concept of boundary work is also useful for understanding how claims-makers in science controversies "protect their favoured definitions" of concepts and terms (Hobson-West 2007:29).

Theorizing boundary work as representation (Riesch Hauke 2010), suggests that taken-for-granted entities (species for example) and binary categories (nature/culture) are better understood as outcomes of the rhetorical practices of boundary work—often with social, political and commercial interests in mind—than as ontological realities. Modernity, at least as the Western world knows it, is premised on the separation, or purification, of nature and culture (Latour 1993). Yet, the modernist project is upheld by the merging of the two, which has resulted in an explosion of hybrids that defy and undermine modernity's "ontological stability" (Graham 2002:33). The institution of science both sustains and is sustained by modernity's nature/culture divide, even as it produces hybrids that threaten its very foundations. Boundary work, in the form of rhetoric and representation, is needed to either problematize hybrids by forcing them into modernity's dichotomous categories, or justify and legitimize their boundary transgressions.

How genetically modified organisms are represented, in both popular and scientific discourses, directly impacts issues related to their regulation and governance. As Nading (2015:26) notes, "both proponents and opponents of Oxitec's work oscillate between a view of global health GMO's as environmental technologies, like modified seeds, and a view of those same organisms as biomedical technologies, like pharmaceuticals." These representational oscillations complicate issues pertaining to regulation as they require input and oversight from multiple regulatory agencies, each with different "terms of reference" and "disciplinary capabilities" (Brown and Michael 2004:208). In the U.S., for example, the decision to transfer regulatory oversight of transgenic mosquitoes from the FDA to the EPA in late 2017 paralleled a conceptual and rhetorical shift in the treatment of GM mosquitoes as 'drugs' to the treatment of GM mosquitoes as 'pesticides.' The ontological elusiveness of hybrid life forms makes them especially hard to reconcile with existing (and outdated) regulatory frameworks, as well as cultural categories. Determining how and by whom they should be regulated, then, is a matter of both representation and boundary work.

Methodology

The overarching goal of the ensuing qualitative analysis is to extend the interactionist perspective on social problems to better understand the nature of the controversy over field trial releases of genetically modified mosquitoes in the Florida Keys. Our analysis is focused specifically on 1) mapping conflicting claims and representations of genetically modified mosquitoes that were put forth by participants in hybrid forums as they articulated their motives for either supporting or opposing field trial plans, and 2) exploring the rhetorical effect of these representations in

legitimizing/delegitimizing genetically modified mosquito as a 'solution' to other social problems (i.e. to the problem of vector borne disease).[4] To this end, we applied a discourse analysis to two town hall meetings that were held in the Florida Keys in 2012 and 2014 to document the "recurrent interpretive practices" (Gilbert and Mulkay 1984:4) employed by participants in these discussions.

As a methodological tool, discourse analysis seeks to understand the function of these interpretive practices in various contexts (Fairclough and Wodak 1997; Jankowicz 2005), and the "performances, linguistic styles, and rhetorical devices used in particular accounts" (Snape and Spencer 2003:12). Sociological discourse analysis integrates three different levels of analysis: textual, contextual and interpretive (Ruiz 2009). At the textual level, the structure and composition discourse is characterized, described, and/or transcribed, with a focus on individual utterances. The contextual level directs attention to the "the space in which the discourse has emerged, and in which it acquires meaning" (Ruiz 2009:12) to better understand the function of discursive events. Finally, the interpretive level attempts to elucidate the broader social meanings of discourse—as information, ideology, and social product. It is important to note here that discourse analysis rarely unfolds from one level to the next in a linear fashion. Rather, analysis typically proceeds in a circular or bidirectional manner, with the researcher frequently carrying out multiple levels of analysis simultaneously (Ruiz 2009).

[4] For an alternate reading of/approach to the Florida Keys Controversy (including an analysis of town hall meetings) see Herndl and Zarlengo's (2018) article in which they discuss the importance of constructions of place and space, and affective attachments to the materiality of place, to divergent risk assessments.

Audiovisual recordings of the town hall meetings were accessed from the Florida Keys Mosquito Control District website and YouTube in May 2017. Approximately 4 hours and 24 minutes of footage was transcribed between June and December 2017 with the help of an undergraduate research assistant in the Science Education and Society Research Program at the University of Rhode Island and saved into Microsoft Word documents. Intelligent verbatim transcription was utilized, as transcribers attempted to reproduce participant statements word for word, but omitted unnecessary repetitions, fillers, and hesitations for the purpose of clarity and readability (Hadley 2017).

We employed multiple coding approaches, over two phases of analysis. During, the initial phase, first round descriptive codes (Miles, Huberman, and Saldaña 2013; Saldana 2015) were inductively generated, and assigned to passages in the transcripts for the purpose of summarizing the major claims put forth in the debates, capturing divergent representations of genetically modified mosquitoes, and identifying moments of boundary tensions in discussions. We reviewed first round codes, and their corresponding passages multiple times, and annotated them with analytic memos that reflected on the rhetorical effects of particular claims and representations. Overlapping, or similar codes were merged to create a thematic inventory of claims, representations, and relevant boundaries. During second round coding, we revisited the transcripts and recoded them with the thematic codes.

The town hall meetings used in this analysis constitute hybrid forums in that heterogeneous groups of claims-makers (scientists, public officials, institutional representatives and laypeople) with varying levels of expertise and authority, were

present and participated in deliberations. (Callon, Lascoumes, and Barthe 2009). Each meeting commenced with an introduction to the panel and invited audience members, who were in attendance to provide information about GM mosquitoes and field trial plans, and to address public questions. After an information session led by the panel, the floor was opened for public questions and comments.

Most comments in support of the Oxitec field trials were offered by scientists and other officials on the expert panel. The combined number of audience commenters for both meetings totaled 45 (14 for the 2012 meeting, and 31 for the 2014 meeting). Only one audience member, a scientist, offered explicit support for the field trial plans. However, we suspect that the views presented in the forum and analyzed in this study may not necessarily be reflective of the larger Florida Keys community, as town hall meeting attendance was likely motivated by feelings of either strong support or strong opposition to the field trials.

In the following sections we present a subset of our findings. We first review the conflicting claims that underlie participants' efforts to legitimize or delegitimize the use of genetically modified mosquitoes. We then explore how various representations of genetically modified mosquitoes, and the science behind them, work to rhetorically position OX513A as matter in, or out of place and serve various boundary-related functions.[5]

[5] Participant statements and interactions are included for illustrative and exploratory purposes. Names have been omitted to protect confidentiality. Additionally, some quotes were modified slightly for the purpose of clarity and readability. At times, a minor editing of participant statements was necessary to clarify context/meaning and was indicated through the use of brackets [ ]. Longer quotes were occasionally condensed by removing extraneous or repetitive statements, as indicated with a series of three periods between quotation markings.

Conflicting Claims in the Florida Keys Controversy

In both the 2012 and 2014 town hall meetings, opening claims by Oxitec and FKMCD scientists painted a grim picture of the future. The global threat of diseases like dengue fever, malaria, yellow fever, and chikungunya was rising with the transcontinental spread of invasive *Aedes aegypti* mosquitoes. It was only a matter of time before the Florida Keys (which had already been hit with an outbreak of dengue fever in 2010), experienced yet another vector borne disease crisis. Current vector control strategies were costly, harmful to local ecosystems, and largely ineffective at suppressing mosquitoes populations to the extent needed to prevent future disease outbreaks. Yet, Oxitec's genetically modified mosquito offered a solution. OX513A had outperformed current vector control methods (as illustrated through a series of PowerPoint slides of graphs and figures) in reducing local populations of mosquitoes in field trial tests in Malaysia, the Cayman Islands, and Brazil, and was touted as a more environmentally friendly and cost effective strategy for mosquito suppression. Throughout the meetings, FKMCD and Oxitec scientists ensured the public that GM mosquitoes were safe to both humans and local ecosystems, and that, due to the insertion of self-limiting genes, OX513A would not persist in the environment.

In the remaining minutes of the 2014 town hall meeting, an audience member (who identified himself as both an environmentalist and scientist) offered the following statement which neatly summarized the FKMCD and Oxitec's justification for releases of GM mosquitoes:

> *"Now we have an opportunity to do well, by doing good. To think with our heads, and our hearts. Key Haven can reduce the cost of their mosquito*

control program, reduce the risk of future dengue fever outbreaks, and take a leadership role in global health. It is truly an opportunity to think globally and act locally to steward this program." (Catherine 2014)

Indeed, imaginaries of global health security (Lakoff 2015) and risk management emerged at the intersection of crisis narratives, economic priorities, global leadership opportunities, and notions of 'public good.' During the meetings, the use of genetically modified mosquitoes was frequently legitimatized through anticipatory discourses surrounding future pandemics, as well as references to past vector-borne disease outbreaks in the Keys:

"Dengue is increasing worldwide…and it's increasing almost exponentially. And so, we want to provide the technology that will prevent it from coming here. If we control the mosquito, we prevent dengue from coming here. So we are actually providing something that's actually helping to prevent it coming back to the Keys." –Oxitec scientist (Catherine 2014)

For expert health officials and scientists, genetically modified mosquitoes were solutions to two invasional problems: disease invasion and invasive species. One Oxitec scientist described the threat of dengue fever as follows:

"What happens is the insect will come in. It will be resident in the town, and country. And then, when someone comes in carrying the fever in their blood, the insect will bite them, and bite somebody else. And so, dengue fever is spread." —Oxitec scientist (Florida Keys Mosquito Control District 2012)

Another scientist explained, with regard to dengue prevention:

> *"It's incumbent upon us to investigate ways to control the mosquito because we cannot control the virus. We have no way of controlling if an infected individual comes in and serves as patient zero for another outbreak."*
>
> —FKMCD research scientist (Catherine 2014)

In both examples above, the problem of vector borne disease threats were linked not only to mosquitoes, but also to *other* people and *other* places. Disease was depicted as problem of multiple invasions that occur at the site of corporeal borders *and* geographic borders, and scientists frequently attributed the difficulties of vector control (and by proxy disease control) to the invasiveness of *Aedes aegypti* itself.

As evidenced by opening statements in both meetings, the purpose of the forums was to provide technical information to the public, answer technical questions, and get a better understanding of public concerns. For the FKMCD, impending disease crises warranted technocratic decision-making, based on technical risk evaluations. When asked by a resident whether or not the decision to release GM mosquitoes would be brought to a public vote, the director of the FKMD explained:

> *"The people that make these decisions, I want to be people who have the scientific background to evaluate risk. And that's really what this is all about. Is the risk of any future mosquito borne disease worse than the risk of a new technology?"* (Florida Keys Mosquito Control District 2012)

For many residents in attendance, scientists' claims that global (and local) health security could be achieved through the use of genetically modified mosquitoes were undermined by scientists' failure to provide data on the effect of field trials on actual disease suppression rates and a lack of long term studies and independent

assessments on the impacts of GM mosquitoes on human and environmental well-being:

> *"We live in the Florida Keys. It's a very fragile environment. I think what we're most concerned with, other than what it's going do to humans, which is a big concern, is what long term studies? I mean you mentioned Brazil. You mentioned some other areas. The Cayman Islands. How long were those studies? Nine months? To us, that's not enough time."* –Resident comment (Catherine 2014)

Residents frequently evoked past failures of science and runaway science (Bauer and Gaskell 2002) narratives to "warn against risks or hazards that might accompany innovation that is pushed too hard or too fast" (Jasanoff and Kim 2009:123).

> *"…I'm not a scientist but I've seen enough failed science experiments in this country involving the environment to make me very wary of anything, especially something that people aren't able to give facts on."* . . . *"But my concern is too, that these other failed experiments where we've put things, we've killed things, in the environment, and then we've tried to put back. And you know it just doesn't work. We're constantly trying to play God or something. I don't know exactly how to put it but it has failed miserably, many times."*-Resident comment (Catherine 2014)

Many residents were especially critical of the regulatory process, Oxitec's for profit-motives, and scientists' narrow measures of risk assessment. They felt that their voices were being silenced and at times referred to themselves as unwilling 'guinea

pigs' in a potentially dangerous experiment (Catherine 2014; Florida Keys Mosquito Control District 2012). Residents called for stricter scientific standards and more democratic forms governance that included ethical considerations in policy decisions. Ethical concerns surrounding experimentation, however, did not always apply to human populations living outside of the U.S. For example,

> "*Why are we being the guinea pigs in Key west when, as your documents showed, your cases of fever are primarily in Africa, Central America, and other places around the world? I'm just wanting to know why we were chosen as the place to do this study."*—Resident comment (2012 Meeting)

At times, statements such as these made it unclear whether public participants opposed *all* Oxitec field trials, or just field trials that would be carried out locally.

Representations of Similarity and Difference

In their efforts to deproblematize genetically modified mosquitoes, downplay potential risks, and support claims that GM mosquitoes could be employed as an effective solution to the threat of vector-borne disease, we found that scientists in the town hall meetings leveraged somewhat conflicting representations. Associative argumentation (Myerson and Rydin 1996) and switching (Brown and Michael 2001) were common rhetorical tactics used by claims-makers to legitimize genetically modified mosquitoes, and relied on representations of GM mosquitoes as both similar *and* different to their wild counterparts. In line with Burchell's (2007:56) observations in his study on the rhetoric surrounding agricultural GMOs, we found that, on the one hand, the GM mosquito, and its associated nature/culture boundary transgressions, were normalized through representations of similarity. Representations of similarity

worked to situate the genetically modified mosquito within a genealogy of traditional breeding practices and technologies, and emphasized their likeness to their "existing non-GM equivalents" (Burchell 2007:56). On the other hand, through representations of difference, the GM mosquito was promoted by claims-makers as unique and superior to their non-GM counterparts. This associative argumentation, and rhetorical switching between discourses of similarity and difference, effectively serves different purposes related to regulation, commercialization, and public engagement. Discourses of similarity downplay novelty to satisfy equivalence-based risk assessments and public concerns, while discourses of difference emphasize novelty (and applicability) for the purpose of patenting and commercialization (Burchell 2007).

For example, during opening statements during the 2012 town hall meetings, one Oxitec scientist in attendance described the company's technology as "pioneering a new approach" (Florida Keys Mosquito Control District 2012). In subsequent statements, the same scientist asserted:

> *"Now in many ways this isn't new. Actually, what this is is a new twist on an old story because we've actually been using…sterile insects for about 50 years, and this has been pioneered here in the U.S. And it's actually what was the driver, the base concept, behind what we're doing. So what's been happening for the last 50 years is, particularly the USDA, has been using radiation to actually radiate insects to the point at which they are in effect sterile. They won't produce the next generation but they're still fit enough to go out and mate. And that was started with the first release of one called the New World Screw worm, which is a nasty insect that lays eggs in the wounds*

of cattle. That [release] was actually in Florida." (Florida Keys Mosquito Control District 2012)

When asked to specifically comment on the similarities *and* differences between Oxitec's technique and the sterile insect technique (S.I.T.) in the 2014 meetings, another Oxitec scientist pointed out:

> *"S.I.T. is not based on genetic modification…it doesn't work with mosquitoes because mosquitoes are too fragile. The irradiation process actually makes them too unfit, sick if you like, to actually compete and be effective. And that's one of the reasons that we've actually come forward with this new technology. As an S.I.T. based method to be able to control this mosquito."* (Catherine 2014)

Here, scientists' comments paint Oxitec's technology as both novel *and* conventional, and position it within a linear continuum of technologies and innovations. The rhetorical effects of association and switching, in combination with appeals to American innovativeness, effectively normalize transgenic methods for insect control by both aligning them with existent, socially-acceptable techniques, and casting them as superior twists on old ideas. Of course, we are not the first to notice these rhetorical shifts between novelty and convention in GM mosquito discussions. For example, in their analysis of discourses surrounding the use Oxitec's transgenic mosquitoes in Brazil, Reis-Castro and Hendrickx (2013) trace how representations of genetically modified mosquitos as emblems of hope and progress are grounded in rhetorical comparisons. Building on Holmberg and Ideland's (2009) concept of *ordinary treasures*, Reis-Castro and Hendrickx (2013) show how Oxitec's technology

is framed as both a normal, inevitable extension of preceding scientific innovations and a novel solution to a nation's problems. Reis-Castro and Hendrickx (2013) also note that the GM mosquito *itself* is made 'ordinary' through comparisons to wild type *Aedes aegypti* mosquitoes that emphasize their phenotypic and behavioral similarities. Again, we notice similar patterns in how Oxitec described their mosquitoes in the Florida Keys town hall meetings. When pressed to comment on what might happen if genetically modified female mosquitoes, with the capability to bite humans, were inadvertently released with non-biting GM males, an Oxitec scientist at the 2012 meeting explained:

> *"…the modified proteins that we produce are not detected in the salivary glands or saliva [of mosquitoes] so they're not injected into people. And furthermore, from a more human or anecdotal thing, I have been bitten repeatedly by these mosquitoes and so have the people in the laboratory and they are the same as a normal mosquito."* (Florida Keys Mosquito Control District 2012)

And…

> *"The genetically modified females are essentially the same as the wild type. They have a specific piece of DNA inserted which is completely characterized in sequence. It has two genes on it and we know the properties of those two genes. Apart from that, the backbone is the same….So they are, other than the modification essentially the same as wild type ones in other respects. Life history characteristics. Behavior. Interactions."* (Florida Keys Mosquito Control District 2012)

These statements follow the regulatory logic of 'substantial equivalence' and are important for institutional risk considerations. From a regulatory standpoint, GM products are deemed safe "if they are shown to be substantially equivalent to"—or, in our scientists words, 'essentially the same' as—"their non-GM counterparts" (Burchell 2007:65).

We observed that scientists' discursive positioning of GM mosquitoes (and their DNA) as matter *in* place (through associative argumentation and switching) was also accompanied by representations of wild type *Aedes aegypti* mosquitoes as matter *out* of place. During the 2014 meeting, the FKMCD director deemed *Aedes aegypti* as the "cockroach of the mosquito world," (Catherine 2014) whose eradication would pose no threat to ecosystem health or food web dynamics. In addition to managing the risk of vector-borne diseases, GM mosquitoes were envisioned (or at least promoted) as part of a larger ecosystem restoration project that involved removing invasive, out of place, *Aedes aegypti* populations:

> *"So this mosquito [wild Aedes aegypti] is not native to the Keys. So we are trying to actually restore the environment here to what is was before. So that's what the mosquito control district is doing to restore the environment, but also to control disease."*-Oxitec Scientist (Catherine 2014)

Here, GM mosquitoes are depicted as solutions to two invasional problems: disease invasion *and* invasive species. In representing wild type *Aedes aegypti* as invasive, they are, like GM mosquitoes, situated as 'nature-culture hybrids' (Larson 2010:31). Larson (2010:31) explains:

"While we tend to think in neat categories of natural entities versus human creations IS [invasive species] contain inextricable elements of both. They are 'natural' in that they are species like any other. They are 'cultural' in that they have been brought somewhere new by humans, whether intentionally or not."

The language of invasion (and invasive species) in GM mosquito discussions has a most interesting rhetorical effect; If the GM mosquitoes could be viewed by opponents as 'unnatural' or out of place, so too should their wild counterparts, by virtue of their invasive geographies. In combination with conflicting representations of GM mosquitoes as both like and unlike their wild counterparts, representations of *wild* type *Aedes aegypti* mosquitoes as out of place and invasive to the Florida Keys (see Nading 2014) work to blur the boundaries between the natural and the unnatural.

Representations of GM Mosquitoes as Pollution and Monstrosity

In an attempt to undermine scientists' claims regarding the safety, normality, and environmental-friendliness of genetically modified mosquitoes, representations of genetically modified mosquitoes as abominations and contaminants were frequently leveraged by Florida Keys residents during the meetings. This was unsurprising given that monster and pollution metaphors often serve as symbolic expressions of cultural unease surrounding hybrids (such as GMOs), and their associated boundary transgressions (Bloomfield and Vurdubakis 1995; Graham 2002). The emerging field of monster studies in the social sciences, urges us to see monsters as boundary-creatures (Smits 2006:493), or perhaps more aptly, boundary-*crossers*, that emerge "when a phenomenon fits simultaneously into two categories considered to be mutually exclusive" (Smits 2006:494). The danger of monsters extends from their

perceived *out-of-placeness*, and their ability to pollute or contaminate socially constructed categories and symbolic boundaries between the natural and unnatural. Smits (2006:12) writes:

> *"Monsters serve both to mark the fault-lines but also, subversively to signal the fragility of such boundaries. Things are monstrous in the extent to which they destabilize demarcations by which cultures have separated nature from artifice, the human from non-human, normal from pathological. Hybrid creatures reveal the 'leakiness' of corporeal boundaries."*

With regard to biotechnology and its products, associations with Frankenstein's monster[6] are amongst the most pervasive and familiar, and are used frequently by GMO-opponents as expressions of moral repugnance and fears of science out of control (Smits 2006). We noticed an interesting iteration of the Frankenstein metaphor in public comments during the 2014 town hall meeting, as one participant asked:

> *"Don't we have time for further education seeking healthier more symbiotic relationships that are gonna help us with this issue [of mosquito control]? What about the introduction, rather than breeding more of these males, of these robo-frankenmosquitoes, why not introduce dragon flies, natural predators? Things of this nature, that aren't going to enter our food chain and damage our fish, the food that we eat. I'm tired of eating chemicals, I'm tired of being showered with chemicals."* –Resident comment (Catherine 2014)

[6] In his essay, *Love your monsters*, Latour observes: "It is telling that even as we warn against such hybrids, we confuse the monster with its creator. We now mostly refer to Dr. Frankenstein's monster as Frankenstein. And just as we have forgotten that Frankenstein was the man, not the monster, we have also forgotten Frankenstein's real sin."

The use of the term "robo-frankenmosquitoes" effectively captures public anxieties surrounding the monstrosity of biotechnology's hybrids, and the prefixing of *robo* calls sharper attention to the violation of boundaries between nature and technology. More interestingly, perhaps, is the participant's suggestion that scientists' should consider controlling mosquitoes with *things of this nature*. While rejecting the unnaturalness of GM mosquitoes, the participant also seems to recognize that a "diversity of contested natures" may exist (Macnaghten and Urry 1999:1). The association between GM mosquitoes with chemicals effectively leverages a pollution claim to highlight the inherent (and insidious) risks that these monsters may pose to the physical health and structural integrity of ecosystems. Another resident in the 2014 meeting observed:

> *"Mosquitoes are a living thing. And the GMO, it's made in a laboratory. It's not a natural thing. So I think that we really have to look at where we're going with chemicals and all the stuff that's involved in creating these mosquitoes. And how many more chemicals do we want to use in our food chain. And just in life, we've been throwing chemicals around all the time, and we don't need them. We are grass roots people and we need to have a say in what's going on."* (Catherine 2014)

In addition to explicitly pointing out the unnaturalness of GM mosquitoes, the participant also considers how hybrid beings problematize the boundaries of life itself. Again, a reference to chemicals is used to point out the polluted, or dirty, nature of manufactured life forms that transcend laboratory boundaries. GM mosquitoes are seen not only as ecological contaminants, but also as threats to an established, "grass-

roots" way of life, echoing Douglas' (1966) observations that risks are socially selected based on their capabilities to disrupt both classifications of the natural world, and social arrangements, relations, and identities.

Opponents in the forum, also took issue with scientists' narrow definition of invasiveness:[7] Some commenters suggested that GM mosquitoes could be considered invasive in their own right:

> *"Now, genetically modified, by its terminology, indicates that it's changed. So the species is therefore changed. Which indicates to me that it's not the same species, which indicates to me also that this could be an invasive species once released and we have enough of those here already"*—Resident comment (Florida Keys Mosquito Control District 2012)

At the forefront of many opponents' concerns, were issues related to the containment of GM mosquitoes and their potential to transgress geographical and corporeal borders:

> *"I don't feel like I have a voice here. I am being told what to do, and I am being put at risk for a [GM] mosquito biting me. I don't put any chemicals in my body, and I am taking an Oxitec mosquito into my body, maybe on a daily basis, that flew in from Key Haven. They have wings. They fly."* -Resident comment

Here, health risks associated with the mobility of mosquitoes and modified genetic material intersect with issues related to personal autonomy and feelings that residents

[7] Nading (2015) notices a paradox in Oxitec's vector control strategy that is relevant to here. He explains that, "the attempt to control an 'invasive' species actually involves an invasion, first at the level of the genome, and later at the scale of the landscape" (32).

are being left out of the decision-making process. Again, for the participant, GM mosquitoes are synonymous with chemical pollution. The mosquito's ability to penetrate corporeal borders and elude geographic containment is special cause for concern, and anxieties over the boundaries of the body are accompanied by anxieties over the loss of personal freedom and choice. As Douglas (1966) explains:

> *"The physical experience of the body, always modified by the social categories through which it is known, sustains a particular view of society. There is a continual exchange of meanings between the two kinds of bodily experience so that each reinforces the categories of the other." (*p. 69)

Thus, when social and natural categories are dissolved by new technologies, concerns over their impact often manifest, symbolically, in corporeal concerns.

Representations of Contaminated Science

Throughout the meetings, opponents' concerns over the unnaturalness, out-of-placeness, and contaminating potential of GM mosquitoes mirrored concerns over autonomy, consent, and Oxitec's for-profit motives. For many participants present in the meetings, Oxitec's financial interests in field trial releases both eroded the company's trustworthiness and undermined their claims to safety:

> *"I haven't seen enough third party objective research to really substantiate the claims of success that you've had in other countries. This is a proprietary patented product. Who else has had access to research your product without doing wild experimentation? I understand that there's been research by collaborators, but collaborators, by definition is not an objective term. I'm*

really talking about independent third party objective research."-Resident comment (Florida Keys Mosquito Control District 2012)

Reiterating findings by Harambam and Aupers (2015:471) in an unrelated study on vaccine controversies, opponents questioned not only the scientific evidence that was presented during the meetings, but also "the institutional and social positions on which this authority [was] based." One participant asked:

"I would like to know what peer reviews you have that are not funded by your company. Also, are you funded by the Bill and Mel Gates foundation? I read somewhere you're your company is losing 2.7 million a year since it's been founded. You obviously have many investors, one of them being a Boston banker that you're set to pay back a debt to at the being of the 2013, I just wanna know, is that true?" –Resident comment (Florida Keys Mosquito Control District 2012)

Opponents' representations of GM mosquitoes as unnatural and out of place in the symbolic order, converged with representations of Oxitec's methods as contaminated and out of place in the community. At several points in the meetings, participants noted that scientific ideals of objective, disinterested research and risk assessments were polluted by for-profit motives:

"Can we slow down a little bit until we get the regulatory controls in place, until we learn more about this company with a proprietary patented product, with profit motive involved? We'd just like some more answers before the mosquito control board makes a decision on our community's best interest and behalf, on a public safety, public health and safety level, and on an

environmental level. Not just the bees and the birds and the butterflies, and everything... the bats, the carnivorous plants, anything that feeds on mosquitoes, in the food web, in the wild, but on a public safety level as well. We have so many unanswered questions, that I don't feel that all of my questions are being answered." –Resident comment (Florida Keys Mosquito Control District 2012)

At the heart of public questions surrounding company funding, peer review, independent assessments, and technical risk evaluations were concerns over the proper demarcation of commercially-motivated science from, what opponents deemed to be 'purer,' more objective forms of science. As Stern (2004) notes, public criticisms of commercial science are firmly grounded in a widespread faith in the capabilities of 'proper,' disinterested science. She explains that "the standards against which [scientists] are measured are derived from idealized conceptions of the potential of science to achieve more or less anything" (2004:352). Residents' familiarity with the peer review process and scientific criticisms of Oxitec's methods presented challenges to expert authority throughout the meetings. At the same time, and in a somewhat paradoxical manner, these challenges simultaneously reinforced the authority of the *institution* of science, by perpetuating representations of its idealized form.

Conclusions

Like other well-documented public controversies surrounding technoscientific issues, the town hall discussions were marked by considerable disagreements between claims-makers about what constitutes evidence, what *types* of evidence are relevant to debates (Scott 2016), and "what kinds of research should be carried out in order to

support or undermine a claim" (Hicks 2015:2). Hicks (2015:2) defines such controversies, rooted in divergent understandings of evidence and knowledge, as 'epistemologically deep.' Indeed, in the case of the GM mosquito controversy, technical risk assessments were defended, and hotly disputed, in the hybrid forum discussions. Yet, epistemological disagreements were also accompanied by a lack of consensus regarding how to best situate GM mosquitoes into established cultural frameworks and categories for ordering the world. As such, this controversy is also *ontologically* deep, with interlocutors unable to come to an agreement on a most basic question: "What *is* this thing?" (Jasanoff 2011:61).

In our analysis, we found that claims-makers on both sides of the debate leveraged divergent representations of genetically modified mosquitoes as matter in, or out, of place in attempts to identify their place in symbolic ordering systems, define their risks, and, perhaps most importantly, to undermine counterclaims and persuade others. For proponents, the risks of GM mosquitoes could be properly understood through equivalence-based assessments with other organisms and technologies. By problematizing dichotomous representations of GM mosquitoes (and their wild counterparts) as natural/unnatural through associations and comparisons, statements by FKMCD and Oxitec also effectively obfuscated GM mosquito boundary transgressions by redefining the categories by which their in—or out—of placeness was evaluated in the first place. For opponents, the risks of Oxitec's field trial plans could not be known, in part, because GM mosquitoes could not be made to fit neatly into socially accepted frameworks for classifying beings and relationships. Representations of GM mosquitoes as an unnatural, out of place, source of pollution

were emblematic not only of concerns over the appropriate boundaries between organisms, but also the boundaries between science and the rest of society.

Along the same lines, conflicting representations of genetically modified mosquitoes were backgrounded by very different understandings of what social problems were relevant to the debate in the first place. For scientists, the threat of vector borne disease in the Florida Keys was taken for granted as the most pressing problem, to which the genetically modified mosquito offered a solution. Opponents of the Oxitec field trial releases capitalized on the fact that Florida was not, at the time of the meetings, experiencing a vector borne disease outbreak, to undermine scientists' claims and construct the genetically mosquito as a dangerous product of scientific hubris, with the potential to wreak havoc on human health and local ecosystems. Admittedly, we were somewhat unsurprised to find that the rhetorics of support and opposition to field trial releases were well-familiar, and grounded in worn-out narratives, metaphors and imagery so characteristic of contemporary debates surrounding genetically modified organisms in the United States. This finding, however, is not insignificant, in that it reveals that claims-makers on both sides of the debate, drew from well-established, if not ambivalent, representations of other transgenic organisms (i.e. crops) and biotechnology in general, to attach meaning to genetically modified mosquitoes.

We would be remiss not to mention that the long history of antagonism between humans and wild mosquitoes undoubtedly contributes to how the meaning of the genetically modified mosquito is socially constructed in different contexts (see Beisel and Boëte 2013; Nading 2015; Reis-Castro and Hendrickx 2013). In many

ways, the creation of Oxitec's genetically modified mosquito destabilizes taken for granted, collective meanings of the wild type *Aedes aegypti*. Through both the material laboratory practices that produce them and the anticipatory discourses of progress and salvation that surround them, Oxitec's genetically modified mosquito reveals new and unexpected possibilities for transforming a problematic animal into its own solution. Yet, for the genetically modified mosquito to fulfill its mission, the boundaries of the laboratory must be extended in to fields, neighborhoods and backyards. The boundary between science, politics, and commerce blurred. The border between nature and culture dismantled (or a least relocated). Moreover, transgenic vector control strategies stand in direct opposition to classic public health policies that advocate for total mosquito avoidance. Beisel and Boëte (2013:53) remind us that the success of Oxitec's approach:

> *"…will depend on the population's willingness to be bitten. Instead of teaching people to avoid mosquitoes, we would need to encourage them to share blood with former disease vectors. The population's health does not build on people's careful attitude towards pathogens and their vectors anymore. On the contrary, it relies on people actively coexisting with mosquitoes, and on fostering the survival and spread of the GM mosquitoes."*

Still, the extent to which the persistent and near universal status of the wild mosquito as a problematic species shapes public perception of transgenic mosquitoes, has yet to be explored.

That the study presented here was limited to examining audio video recordings allows for little more than a description of a *subset* of the claims, representations and

boundary negotiations that emerged (and continue to emerge) in discussions surrounding releases of genetically modified mosquitoes in the Florida Keys. Still, our findings do point to the ways in which the meaning of genetically modified mosquitoes arises from interactional discourses surrounding the complex and intersecting imaginative geographies that underlie collective understandings of disease distribution, definitions of invasiveness, the porosity of bodily borders, the boundaries of the laboratory and its practices of experimentation, and the appropriate territories that the authority of science can lay claim to. Future analyses of claims-making activities surrounding releases of genetically modified mosquitoes could better contextualize the ongoing controversy by incorporating data from gleaned from media coverage and ethnographic interviews. The continued mapping of representations of genetically modified mosquitoes, and claims made by a larger, more diverse set of stakeholders, would further our understanding of how the ambiguous and ambivalent meaning of transgenic animals, as well as their wild counterparts, emerges and changes over time through social interactions, claim-making activities and boundary negotiations. Such studies might also work to put the symbolic interactionism perspective in closer conversation with the science and risk communication literature.

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Supplemental Materials

Below, I outline the steps in my research process for Chapter 2.

1. Town hall meetings were accessed online from YouTube and the Florida Keys Mosquito Control District website in 2016 and transcribed in 2017.
2. Claims-makers in the town hall meetings were identified and are listed in the table below.

Supplemental Table 1. Claims-makers and stakeholders present at the 2012 and 2014 Town Hall meetings

2012 Claims-Makers	**2014 Claims-makers**
Executive Director, Florida Keys Mosquito control district (entomologist)	Executive Director, Florida Keys Mosquito control district (entomologist)
CEO, Oxitec	Director of Research, Florida Keys Mosquito Control District (entomologist)
Chief Scientist, Oxitec	Operations Director, Florida Keys Mosquito Control District (entomologist)
Public relations professional/biologist, Florida Keys Mosquito Control District	Scientist, Oxitec (molecular biologist)
Head Physician, County Health Dept.	Scientist, Oxitec (invertebrate ecologist)
Florida Keys Residents in Attendance	Public Outreach Professional, Oxitec (ecologist)
	Florida Keys Community Advisor, (biologist)
	Florida Keys Community Advisor
	Florida Keys Rotary Club Member
	Researcher (entomology)
	Inspector, Florida Keys Sheriff's Office
	Food and Drug Administration, representative/policy advisor
	Center for Disease Control Representative
	Florida Keys Residents in Attendance

3. Town hall transcripts were re-read in late 2017, with a critical eye and summarized. Resident-scientist interactions were interpreted and contextualized using my comprehensive exam literature in the fields of science/risk communication, public engagement, and science policy. This critical interpretation and the recommendations that emerged from it form the basis of Chapter 1 in this dissertation as well.
4. In 2018, my growing interests in the fields of rhetoric, symbolic interactionism, and science and technology studies led me to revisit the town hall meetings and conduct a more closely focused analysis of rhetorical techniques, claims-making, and instances of boundary work in the meetings.
5. For the purpose of this research, I adopted the methods of discourse analysis. As mentioned in Chapter 2, discourse analysis looks to the interpretive practices employed by interlocutors in various contexts (Fairclough and Wodak 1997; Jankowicz 2005), and attempts to identify the "performances, linguistic styles, and rhetorical devices used in particular accounts" (Snape and Spencer 2003:12).
6. Following the tradition of this methodology (Ruiz 2009), my interpretation spans three levels of analysis: textual (structure and composition), contextual (meaning and context) and interpretive (broader social meanings and effects). At the textual level, I attempted to identify representations of GM mosquitoes put forth by meeting participants, as well as accompanying claims regarding their risks and benefits. At the contextual level, I attempted to explicate the rhetorical functions of these claims and representations. Finally,

at the interpretive level, I use multiple theoretical perspectives to shed light on how conflicting claims and representations work to legitimate or contest various symbolic, physical, and social boundaries. The conceptual movement between these levels was not linear. Rather, it required an iterative and circular process, whereby interpretations at one level were continuously being informed and modified by interpretations at the other levels. Detailed notes and memos were recorded throughout this process to capture changing interpretations and convergence of meanings at each level.

7. Claims, representations, and boundary tensions were captured during first-round coding, whereby descriptive codes (summarizing topics) and in-vivo codes (truncated verbatim statements) were written in the margins of printed transcripts. These claims, representations, and boundary tensions were then categorized, based observances of similarity and difference to reveal overarching themes in participant statements. During second coding cycle, focused coding was used to identify instances of these themes in the transcripts. Summaries of themes pertaining to representations and claims are presented in the tables below.

Supplemental Table 2. Conflicting representations in supporter vs. opponent discourse

Representations mobilized by supporters	**Representations mobilized by opponents**
GM mosquitoes as environmentally friendly solution	GM mosquitoes as pollution, environmental contaminants
GM mosquito as precise, self-limiting technology	GM mosquito as uncontainable, invasive
GM mosquito as normal, yet improved, similar but different	GM mosquito as unnatural monster, abomination

Supplemental Table 3. Conflicting Claims in supporter vs. opponent discourse

Supporter Claims	**Opponent Claims**
Mosquito diseases are a problem	Not currently a problem
Not effective	Effect
Scientists agree GMMs are safe	Disagreements over safety
Evaluations rooted in science	For-profit motives undermine evaluations

Supplemental Table 4. Boundary tensions identified in town hall discourses

Science/policy, Science/industry, Lab/field boundary, Nature/Culture, Corporeal Boundaries, Boundaries of evidence, authority and expertise Sci comm/Marketing and Public Relations

8. Interpretations were further developed through my theoretical frameworks.

Example) Quote	**Codes Applied**
I don't feel like I have a voice here.	Boundaries of authority
I am being told what to do, and I am being put at risk for a [GM] mosquito biting me. I don't put any chemicals in my body, and I am taking an Oxitec mosquito into my body, maybe on a daily basis, that flew in from Key Haven. They have wings. They fly."	Unknown risks GMMs as pollution/contaminant Corporeal Boundaries GMM's uncontainable

Interpretation: "Here, health risks associated with the mobility of mosquitoes and modified genetic material intersect with issues related to personal autonomy and feelings that residents are being left out of the decision-making process. Again, for the participant, GM mosquitoes are synonymous with chemical pollution. The mosquito's ability to penetrate corporeal borders and elude geographic containment is special cause for concern, and anxieties over the boundaries of the body are accompanied by anxieties over the loss of personal freedom and choice. As Douglas (1966) explains, *the physical experience of the body, always modified by the social categories through which it is known, sustains a particular view of society. There is a continual exchange of meanings between the two kinds of bodily experience so that each reinforces the categories of the other (*p. 69)' (Chapter 2 Dissertation).

CHAPTER 3

SHAPING GM MOSQUITO DISCOURSE THROUGH SHARING: THE FRAMING AND GATEKEEPING OF INFORMATION ON SOCIAL MEDIA

In preparation for submission to Science Communication

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Keywords: *GM mosquitoes, social media, framing, gatekeeping*

ABSTRACT

This article examines trends in social media sharing of online articles related to genetically modified mosquitoes during a period of heightened discourse on field trial plans in the United States. We compare the availability of specific risk-benefit frames found in the most frequently shared articles on GM mosquitoes on social media, with those found in reputable elite and emerging news sources (as observed by Wang and Guo 2018). We also provide metrics on the types of articles that were most frequently shared, and their source origination. Our findings reveal that the issue attention cycle and framing of GM mosquito discussions on social media diverged from that of mainstream media. Additionally, we find that the sharing of articles from sources with mixed to low levels of factual reporting on social played a major role in perpetuating misinformation on GM mosquitoes.

Introduction

In recent decades, advances in genetic engineering have offered up new possibilities for addressing looming threats of climate change, food insecurity and infectious disease. One of the most promising, and controversial, applications of genetic engineering involves genetically modified mosquitoes, which are manipulated in the laboratory to carry genetic constructs that work to suppress wild populations of mosquitoes, or transform them so that they are incapable of transmitting disease (Reis-Castro 2012). First developed in 2002 by Oxitec Ltd., field trial releases of genetically modified mosquitoes have since taken place in locations such as Panama, the Grand Caymans, Brazil, and Malaysia. The success of Oxitec's early field trials in reducing mosquito populations has resulted in an increase in research and application of GM mosquitoes worldwide, by a variety of scientific institutions and public health organizations.

For all of their promise in reducing the global burden of diseases such as dengue, malaria, yellow fever, and Zika virus, genetically modified mosquitoes have also sparked considerable controversy and social movement action worldwide. The long term impacts of GM mosquitoes are still unknown, and their applications raise myriad ethical, legal, and social questions (Resnik 2018). Justifications for GM mosquito releases must be based on careful considerations of both benefits and risks, along with the approval of communities where releases are to take place. Like any new technology, public support for GM mosquitoes is, at least to some degree, influenced by how benefits and risks are communicated.

The advent of Web 2.0 has brought about radical changes in the communication of scientific advances—as well as public engagement with science and technology. Individuals are increasingly obtaining information about science-related issues in online environments (Brossard 2013), and social media have become important sites for disseminating science news, and mobilizing support for (or opposition to) scientific research and policy (Schäfer 2012). As Wang and Guo (2018, 938) note, "social media have also opened the gate to non-elite voices including individual and organizational activists, bloggers, and concerned citizens" (paraphrasing Hopke and Simis 2017; Newman 2017). Moreover, through activities such as "sharing," "liking," and "commenting" social media users can effectively act as alternative science communicators (Maeseele 2014) and influence public discourse and attitudes on contested scientific innovations, such as GM mosquitoes, by amplifying or attenuating attention to various risks and benefits (Chung 2011).

This article examines trends in social media sharing of online articles related to genetically modified mosquitoes during a period of heightened discourse on field trial plans in the United States. Grounding our analysis in framing theory and gatekeeping, we map the amplification and attenuation of various risk/benefit frames (as they pertain to GM mosquitoes) through article sharing over a one-year time period. We compare the availability of specific frames found in the most frequently shared articles on GM mosquitoes on social media, with those found in reputable elite and emerging news sources (as observed by Wang and Guo 2018). Additionally, we speculate on the impact that this social media sharing may have had on shaping the discourse surrounding controversial GM mosquito field trial plans in the Florida Keys, and

discuss the implications of our findings for understanding the new media ecology of science communication at large.

Literature Review

GM Mosquitoes as an alternative form of vector control

Each year, more than a million human lives are lost to mosquito borne illnesses such as malaria, dengue, and yellow fever, making vector control a major public health priority (Caraballo and King 2014). Traditional mosquito control strategies have focused largely on eradicating mosquitoes through the use of insecticide sprays in conjunction with various environmental management techniques. The benefits of insecticides for reducing mosquito borne diseases are offset by their negative effects on the health of humans and non-target organisms, as well as the evolution of insecticide resistance in mosquito populations. As a result, recent decades have witnessed a growing interest in the development and implementation of more sustainable and environmentally friendly alternatives to insecticide use (Benelli, Jeffries, and Walker 2016).

The genetic control of mosquito populations is one proposed alternative. Currently, several genetic control techniques exist, and include the Release of Insects with Dominant Lethality (RIDL), the Incompatible Insect Technique (IIT), and genetic replacement systems. First developed by Oxitec Ltd. at the turn of the century, the RIDL technique rests first on modifying laboratory-reared mosquitoes to carry genes that prevent the production of viable offspring, and then releasing modified males (who are homozygous dominant for these ‘self-limiting’ genes) into wild populations. Over time, releases of genetically modified males effectively suppress wild population

numbers since the majority of offspring they produce with wild-type females die before reaching adulthood (Alphey et al. 2013). The Incompatible Insect Technique (IIT), as typified by Mosquito Mates' Wolbachia-infected mosquitoes, works similarly[1]. Using IIT, the Wolbachia bacterium is introduced into laboratory reared males. Once released into wild populations, Wolbachia-infected males work to suppress populations as a result of cytoplasmic incompatibility between their sperm and the eggs of wild-type females (Dobson, Rattanadechakul, and Marsland 2004). In contrast to the RIDL and IIT techniques, genetic replacement systems are capable not only of suppressing mosquito populations through the propagation of traits that affect reproduction, but also of genetically transforming entire populations of wild mosquitoes to be disease resistant. For example, when disease-refractory genes are paired with gene drives that disrupt conventional rules of Mendelian inheritance, releases of genetically modified/engineered mosquitoes can induce rapid and widespread changes in mosquito populations— with refractory varieties outperforming and replacing wild types (Marshall and Akbari 2015).

In both laboratory and open field trials settings, the aforementioned genetic control strategies have demonstrated success in reducing mosquito populations (Carvalho et al. 2015; Valdez et al. 2011; Lacroix et al. 2012; Kyrou et al. 2018), often beyond what is capable with traditional insecticides. Despite these successes, however, concerns remain. Bioethicists warn of unintended consequences of open releases and off-target effects on local ecosystems, food web disruptions, and the potential for

[1] While many entomologists do not classify Wolbachia mosquitoes as "genetically modified," since infection with the bacteria requires no modifications to the mosquito's genome, they are frequently referred to as such in popular media. Based on this observation, along with the fact that they can be used as a tool for genetic control of wild populations of mosquitoes, we made the decision to include them in our analysis.

increased disease prevalence—should releases fail to suppress populations, or if vacated niches left by eradicated mosquitoes are occupied by other vectors (Resnik 2018; Macer 2005). Additionally, some genetic control strategies require continuous releases of modified mosquitoes and raise questions regarding long-term cost-effectiveness compared to more traditional methods of vector control (Meghani and Boëte 2018; Alfaro-Murillo et al. 2016). The uncertainties and ethical issues raised by releases of genetically modified mosquitoes require nuanced risk assessments and discussions that move beyond technical evaluations to include social considerations as well. Engagement and support of communities where releases are set to take place are crucial to the success, and ethics, of releases. Ethical questions, however, are complicated by disagreements over the appropriate level at which consent is needed for field trials. As Resnik (2018, 26) asks: "Should individuals have the right to decide whether they will be exposed to GM mosquitoes?" And, "how should such a right be balanced against the community's interests in promoting public health?"

Contested Field Trials in the Florida Keys

The aforementioned questions were at the heart of a recent controversy surrounding field trials of genetically modified mosquitoes in the Florida Keys. As early as 2010, the Florida Keys Mosquito Control District (FKMCD) began working with Oxitec Ltd on plans to conduct a test release of genetically modified *Aedes aegypti* mosquitoes in the region. Public discussions on the Florida Keys field trials commenced in between 2011 and 2012, and focused mainly on using GM mosquitoes as a tool to control dengue fever. Between 2012 and 2013, at least four surveys were conducted by the FKMCD and unaffiliated researchers in the Keys to assess public

awareness and support for the Oxitec field trials (Florida Keys Mosquito Control District 2013; Florida Keys Mosquito Control District 2012; Ernst et al. 2015; Cobb 2013). Face to face surveys administered to residents on Key Haven, the proposed site of release, indicated that 78% of residents viewed genetically modified mosquitoes as safe or very safe, and 59% stated that they supported field trials (Florida Keys Mosquito Control District 2012). However, overwhelming disapproval was voiced by some residents and activists during town hall meetings in Key Haven and online (Herndl and Zarlengo 2018; Phillips 2017, Taylor and Dewsbury 2019), and a local Key Haven real estate agent collected over 170,000 signatures of opposition (mostly from non-residents) through a Change.org petition (Klingener 2016). Though environmental and health risks of GM mosquitoes were widely cited as concerns by opposing groups, much of the discourse centered on the ethical aspects of conducting experiments with GM mosquitoes without the informed consent of individual residents (Neuhaus 2018; Herndl and Zarlengo 2018, Taylor and Dewsbury 2019).

Despite the growing public controversy, Oxitec submitted its draft environment assessment of field trial plans to the FDA between 2014 and 2015. In late 2015/early 2016, GM mosquito discussions intensified, as Oxitec's genetically modified mosquitoes were promoted as a possible solution to the emerging Zika virus crisis in the Americas. Wang and Guo (2018, 939) observe that, "as public awareness about Zika grew, more people joined the conversation about finding solutions to Zika, including recognizing the benefits and risks of using GM mosquitoes." The FDA presented its finding that Oxitec's mosquitoes posed no significant risk to humans and/or the environment in March 2016, and invited the public to post concerns during

a 60 day commenting period on the FDA's website. Between March- May 2016, 2,641 public comments were posted—the majority of which were in opposition to field trial plans (Bloss et al. 2017). The FDA released a final approval of the field trials in August of 2016, and the release plans went to a non-binding vote in the November elections of the same year. Though voter support throughout the Keys was nearly 60%, only 38% of residents living in Key Haven approved. Due to poor support for the plan in Key Haven, the Florida Keys Mosquito Control District Board made the decision not to go forward with the field trials. Oxitec subsequently applied for an experimental use permit with the Environmental Protection Agency (EPA) to conduct field trial releases at an alternate location [2] in December 2017, but later withdrew this application.[3]

Frames and Gatekeeping in New Media Environments

Policy decisions over new technologies (such as GM mosquitoes) are largely informed by, and structured around, how various risks and benefits of these technologies are framed. Frames can be defined as a "schemata of interpretation" (Goffman 1974), or "central organizing ideas for making sense of relevant events, suggesting what is at issue" (Gamson and Modigliani 1989, 3). In the policy arena, frames highlight particular options for action, and reflect different interests, agendas, and concerns of actors and groups (Ribeiro et al. 2018). Frames are often simultaneously diagnostic, prognostic, and motivational (Snow and Benford 1988).

[2] In late 2017, clarifications to the US' Coordinated Framework for the Regulation of Biotechnology (US Food and Drug Administration 2017) transferred oversight of GM mosquito products to the EPA.
[3] A press release by Oxitec on November 29, 2019 cited that the company had withdrawn the application because it was transitioning to the use of a newly developed genetically modified mosquito, and would be applying for another experimental use permit with the EPA. At the time of this publication, that application had yet to be submitted.

Accordingly, they are used to identify problems and their causes, to assign blame and attribution for the problem, and to mobilize, justify, and legitimize certain courses of action (Herring 2008; Entman 1993; Benford and Snow 2000).

Struggles to control the framing of issues are central to controversies, as frames are negotiated within, and contested, between various interest groups (Stewart et al. 2017). During controversies, frames "provide(s) meaning to an unfolding of a series of events, suggesting what the controversy is about and the essence of an issue" (Nisbet and Huge 2006). In the social movements theory literature, the production and diffusion of frames that redefine or challenge the hegemonic meaning (Hwong et al. 2017) of ideas, objects, events, etc. are referred to as "collective action frames" (Benford and Snow 2000; Snow and Benford 1992). Like other types of frames, collective action frames serve as "cognitive screens" (Herring 2008) and are used by social movement groups to highlight the "seriousness or injustice" of a condition or situation (Snow and Benford 1992, 137), and thus mobilize action.

The power of news media in structuring the terms of policy and risk discourse has long been recognized by communication scholars. As Cohen (1963 cited in Nisbet 2014) reminds us, the press "may not be successful most of the time in telling people what to think, but it is stunningly successful in telling its readers what to think about." News media not only set the agenda for *what* issues are elevated to the status of 'newsworthy' (Golan 2006), but also guide audience's attention to certain issues, over others, through framing. The new media environments of Web 2.0, however, are undermining traditional 'gate-keeping' capabilities of mainstream new sources in framing and disseminating information. The advent of social media allows for the

rapid construction and circulation of new frames through sharing (and other social media functions) (Stewart et al. 2017), or for the amplification of existing frames through the dissemination of selected media sources. Through frame amplification via social media engagement, interested publics can emphasize certain aspects of an issue or event, thus "bringing into sharper relief and symbolizing the larger frame or movement of which it is a part" (Benford and Snow 2000, 623).

With regard to science communication and policy, changes in the media landscape are resulting in changes to traditional power relations between experts and lay audiences. In addition to producing and curating science-related content, social media users can also assume gatekeeping[4] roles by deciding what types of science-related information to share with online communities—thus controlling and amplifying specific messages and frames (Hwong et al. 2017). Given the increasing percentage of the general public that obtains news from social media (Shearer and Grieco 2019), science communication scholars should be especially interested in how social media sharing of science news influences the availability and accessibility of particular frames (especially as they pertain to the risks and benefits of new policies and technologies). To date, however, there is a dearth of studies that looks at the effects of social media engagement and networked gatekeeping (Meraz and Papacharissi 2013) on the frame dynamics of science-related information.

[4] We use Meraz and Papacharissi (2013: 4) definition of gatekeeping here, as "a theory of information control that attempts to explain how information is filtered curated and disseminated."

Relevant research on GM mosquitoes and Framing

In a 2018 study, Wang and Guo used both manual and automated content analysis to examine the framing of GM mosquito discussions in online news and Twitter over one issue-attention cycle (October 2015 to January 2016). Using Downs' (1972) five-stage framework for understanding "how an issue usually emerges and then fades from the center of public attention" (Wang and Guo 2018, 940), the authors divide GM mosquito debates in the U.S. into the following stages, based on the number of online news articles and tweets on GM mosquitoes by date/issue event:

- The pre-problem stage (1), or the time period during which the issue of GM mosquito field trials emerged, but before Zika was declared a public health emergency. (October 2015-January 2016)
- The stages of alarmed discovery and euphoric enthusiasm (2) and the stage of realizing the cost of significant progress (3), which started when Zika was declared a public health emergency on January 31, 2016, and lasted until the first week of August 2016 (right before the FDA announced its approval of GM mosquitoes).
- The decline of public interest stage (4), which started when the FDA approved GM mosquito use in the Florida Keys on August 7, 2016 until the public referendum on GM mosquitoes on November 12, 2016.
- And, the post-problem stage (5) that commenced following voter rejection of GM mosquito use in the Florida Keys, when the issue of GM mosquitos in the media began to be replaced with other issues.

In addition to analyzing the issue-attention cycle, the authors mapped the types of benefit and risk frames found in online news articles and tweets to reveal how GM mosquito discussions changed over various stages of the issue attention cycle online, and how the frame-setting role of both media entities changed over time (and influenced each other). The major findings of the study were that: 1) discussions on Twitter tended to be more benefit-oriented, whereas news-coverage tended to be more balanced, 2) Twitter played a major role in framing the discourse on GM mosquitoes early on in discussions, while online news gained framing traction later on in debates as public awareness of the issue grew, 3) frame-setting trends on Twitter initially drove the agenda of media coverage on GM mosquitoes, but later a more reciprocal relationship developed between the two entities, 4) despite Twitter's influence on the issues covered by online news, both entities employed different frames in their coverage of GM mosquitoes, and finally 5) online news eventually became more influential in framing discussions on Twitter as coverage of GM mosquitoes progressed through the issue-attention cycle.

For the purpose of our study, we hone in on Wang and Guo's specific findings regarding the frames found in online news *only*, as these findings serve as an important point of comparison for the research that follows. In their study, Wang and Guo manually coded 464 fact-based, online news articles from elite and emerging media to identify the presence/absence of various benefit (health, environmental, economic, cost-effectiveness) and risk (health, environmental, cost-effectiveness, ethical, experimental) frames. A frame-orientation index was then applied to each article to determine whether each article was benefit-oriented, risk-oriented, or

neutral/double-sided. [5] The authors found that the most common frames in online news were related to health benefits (found in 80.60% of articles), followed by environmental and health risks (50% and 41.34% respectively). The majority of online articles were neutral/double-sided (67.67%). Benefit-oriented accounted for 24.14% of the sample, while only 8.19% of the articles were risk-oriented.

Research Questions and Methodology

Questions

Our study attempts to build on Wang and Guo's findings regarding online news, to address several questions that fall outside of the scope of their study. First, how did social media sharing change over the issue-attention cycle? Second, what types of articles on GM mosquitoes were most commonly shared on social media? Finally, what frames were most likely to be encountered, and shared, in articles on social media and how did the framing of the most commonly shared articles on social media compare to the framing of fact-based articles included in Wang and Guo's study?

Data Collection and Cleaning

To identify the most commonly shared articles at the height of GM mosquito discussions, we utilized an online social media analysis tool called BuzzSumo© (buzzsumo.com) in December 2016. BuzzSumo reports metrics on article links shared[6] on popular social media platforms such as Facebook, Twitter, LinkedIn,

[5] Wang and Guo's codes and frame-orientation index are discussed further in the methods section of our paper.

[6] At the time of our study, BuzzSumo provided metrics on shares. In late 2017, BuzzSumo changed its algorithm to provide metrics on engagements, defined as the sum total of likes, shares, and comments (BuzzSumo©, personal communication 2019).

GooglePlus, and Reddit. We ran two searches using the terms "genetically modified mosquitoes" and "genetically engineered mosquitoes," for articles shared between November 2015 and December 2016[7]. Two excel spreadsheets with article links and metrics were downloaded from BuzzSumo and merged into one excel document.

The original merged document contained 1462 articles item links. We sorted the spreadsheet data by article title to identify, and highlight, duplicate articles. We attempted to identify the original article (from which duplicates originated) by earliest publication date. We then totaled the shares of all duplicates and recorded it with the original article. At this time, we noticed that many of the articles returned in the BuzzSumo search contained 0 number of shares, and so we highlighted articles these articles as well. We subsequently removed all highlighted duplicates and articles with zero shares from the database (number of removed articles= 742).

Sample

Our remaining data set included 720 unique articles. The 720 article links in our final database ranged in their number of shares, from 1 share to 66,110 shares. Though we provide some descriptive statistics on both the original, cleaned data set in our findings (to answer research question #1), we based our manual content analysis of frames on only a subsample of this data. Our subsample for content analysis included only the top 100 shared articles, which were identified by sorting the remaining data by the total number of shares (ranging from 368 to 66,110 shares,

[7] This aligns with the issue-attention cycle identified by Wang and Guo 2018. However, Wang and Guo's work looks at articles from October 2015 to December 2016, while our sample spans from *November* 2015 to December 2016. This is because BuzzSumo provides data only in one year intervals, determined by the date that search was ran.

standard deviation=8766). To be included in our subsample, the article had to actually focus on GM mosquitoes (a few articles were irrelevant to our search terms), though we did not limit our data based on the type of genetic control strategy discussed (RIDL, ITT, genetic replacement). We excluded videos from the sample, choosing to examine only text- based articles. If an article link was broken or expired, we attempted to find the article using an internet search. If we were unable to find the article, then it was excluded from the final subsample. All articles in the final subsample were in the English language.

Article classification by source type

To answer research question #2, all articles in the final sample (n=100) were classified by source type using the Media Bias Fact Check website (MBFC). MBFC is an independently run, online database that categorizes media sources based on political (and other) affiliations, biased wording, level of factual reporting, and story choices.[8] This website is increasingly being used for scholarly research in the field of communication and media studies (see Shu, Wang, and Liu 2017; Kim et al. 2018; Fairbanks et al. 2018; Ogan et al. 2018). The originating source for each article in our sample was searched using MBFC and then labelled by the following affiliations: Pro-Science, Conspiracy, Left-leaning, Center, Right-leaning, or Undetermined (based on MBFC results). We also noted MBFC classifications on the factual level of reporting by source using the labels: High to Very High, Mixed, Low to Very Low, and Undetermined.

[8] Media Bias Fact Check's methodology for classifying sources can be found at https://mediabiasfactcheck.com/methodology/.

Codebook and Content Analysis

To allow for comparisons in the framing of articles between our subsample of data and the data set used by Wang and Guo (2018) and to gain insights into research questions #3 and 4, we used the authors' original codebook and frame orientation index. We contacted the authors for permission, and for codebook/index specific-instructions that might not have been included in their publication, via email in May 2019. In addition to generously sharing their codebook, the authors were most helpful (and timely) throughout the data analysis period in answering questions pertaining to how codes were to be applied in specific instances and how frame orientation of articles was determined.

Following Wang and Guo's methods and codebook descriptions, the primary author and one research assistant coded the subsample of the 100 top shared articles for presence or absence of specific benefit and risk-driven frames. The Health Benefits frame was listed as present if an article included discussions on the benefits of using GM mosquitoes to reduce mosquito-borne diseases or save human lives. The Environmental Benefits frame was applied if an article mentioned the positive effects that GM mosquitoes might have on ecosystems (i.e. preserving biodiversity, reducing the harmful effects of insecticides). Articles were coded present for Economic Benefits if the financial benefits of using GM mosquitoes for companies, industries or communities were discussed. If an article argued that GM mosquitoes were superior to other strategies for vector control based on cost and/or effectiveness, the article was coded with Cost-Effectiveness Benefits. The Health Risks frame was used if an article noted possible adverse health effects of using GM mosquitoes, including an increase

in disease, or human exposure to genetically modified genes. Cost-Effectiveness Risks were coded if GM mosquitoes were discussed as potentially more costly or less effective than other vector control strategies. The Ethical Risks frame was marked as present if an article discussed the moral implications of eradicating an entire species of mosquito, the ethics of company practices in GM mosquito research, or other ethical and/or legal violations posed by field releases of GM mosquitoes. Experimental risks were determined as present if an article mentioned "experimental flaws and the possibility of unintended consequences" (Wang and Guo 2018, 943). Finally, an "Other Benefits" and "Other Risks" category was used to mark benefit and risk frames that did not have a clear classification or were unspecified. It is important to note that while Wang and Guo's codebook did not include an Economic Risks frame, we found that a few article in our sample *did* discuss possible economic problems, such as the impact GM mosquito releases might have on tourism. To maintain consistency with the original codebook, these discussions were marked as present for "Other Risks."

In addition to frame coding, the original study by Wang and Guo also applied a frame-orientation index score to the articles. The authors determined articles to be benefit-oriented if only benefits were discussed. Articles were classified as risk-oriented if only risks were discussed. Articles were marked as neutral or double-sided if they did not include any benefit/risk frames, or if they included both. We applied the same frame orientation index to the articles in our study.

Inter-coder reliability

Reliability between the two coders was established over two phases. During the first phase, we generated a rich-range subsample of 28 articles in our original

BuzzSumo database, that were to be excluded from our study based on low number of shares. Rich-range samples are purposive, and "involve(s) the selection of a set of cases that typify the full range of variables under investigation" (Neuendorf 2009, 69). Two coders independently coded the rich-range subset until 1) the subset covered the full-range of article source types, 2) each coder had marked at least one article as 'present' for all of the available benefit and risk frames, and 3) each coder had at identified at least one article as benefit-oriented, one as risk-oriented, and one neutral/double-sided. We then calculated Krippendorff's alpha for agreement using ReCal2, an online calculator for inter-coder reliability. Our first round alpha values, for each article, ranged from 0.15 to 1.00, with an average alpha of .73.

After discussing disagreements, and obtaining clarifications about coding from the creators of the codebook (Wang and Guo 2018), we then selected a random subset of 20 additional articles, this time from the subsample of articles to be included in the study. After both coders independently coded each article, we ran another calculation for Krippendorff's alpha. This time, alpha values ranged from .72 to 1.00 with an average of .91[9] Disagreements were again discussed, and one coder coded the remaining articles in the subsample of 100 articles.

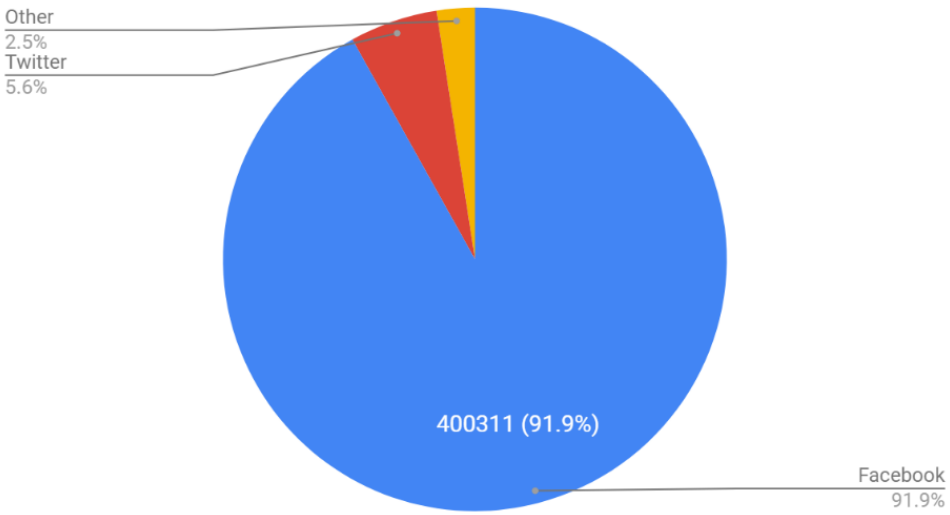
Findings

Research Question 1 Findings: How did social media sharing of GM mosquito articles change over the issue-attention cycle?

[9] In their original study, Wang and Guo's Krippendorff alpha values ranged from .71 to 1.00 with an average of .92.

Over the course of the time period that we examined (November 2015-December 2016), 741 media items (news articles, blogs, videos, forum links) pertaining to GM mosquitoes appeared on social media sites through user sharing. The sum total of shares for these media items was 435,575. The vast majority of these shares (n=400,311, 91.9%) took place on Facebook, followed by Twitter (24,590, 5.6%). Sharing on other social media sites such GooglePlus and LinkedIn accounted for a small fraction of shares—10,674, or 2.5% combined (Figure 1).

Figure 1. Total Shares by Social Media Platform



When sorting and totaling the number of articles shared on social media by date, we notice some similar issue-attention peaks and valleys as Wang and Guo (2018), which correspond with issue-related events in GM mosquito discussions. However, a few striking differences here are worth pointing out. We have included a figure from the author's original paper (Figure 2), alongside our findings (Figure 3), to guide our comparisons.

Figure 2. Number of News articles and Tweets on GM Mosquitoes by Date (Wang and Guo 2018, 944)

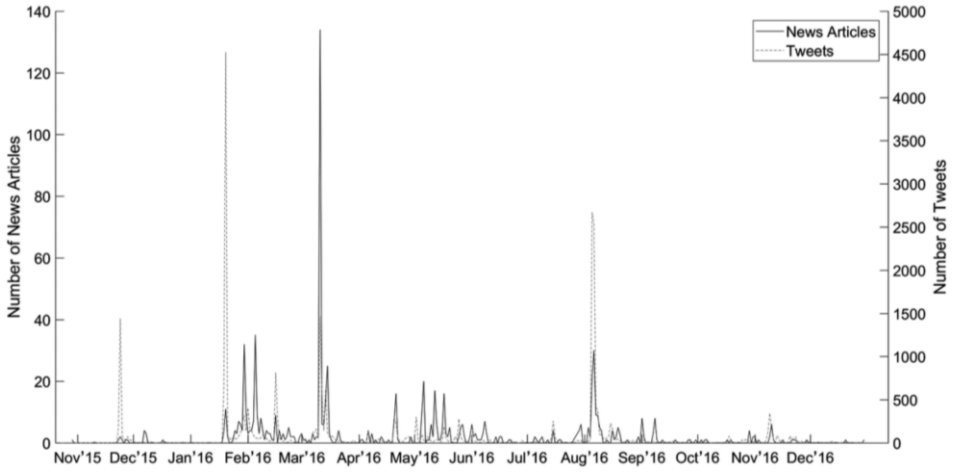
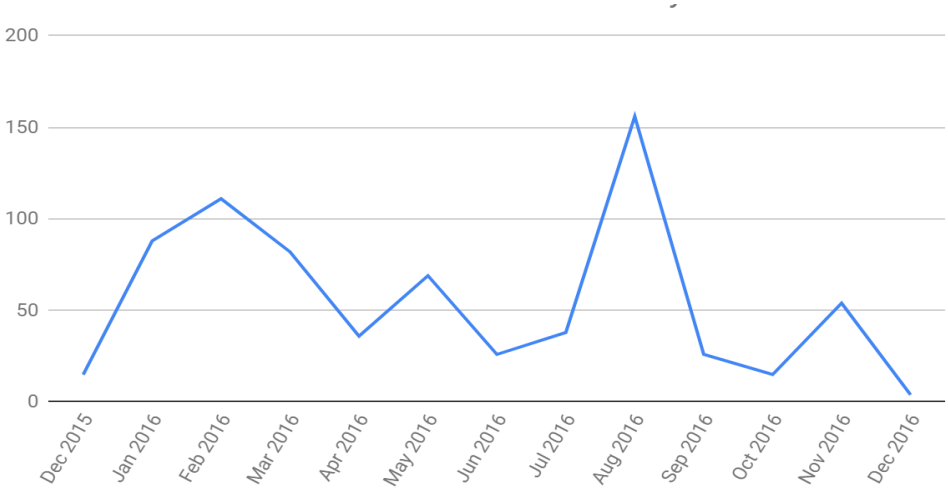


Figure 3. Number of Articles Shared on Social Media by Date Published

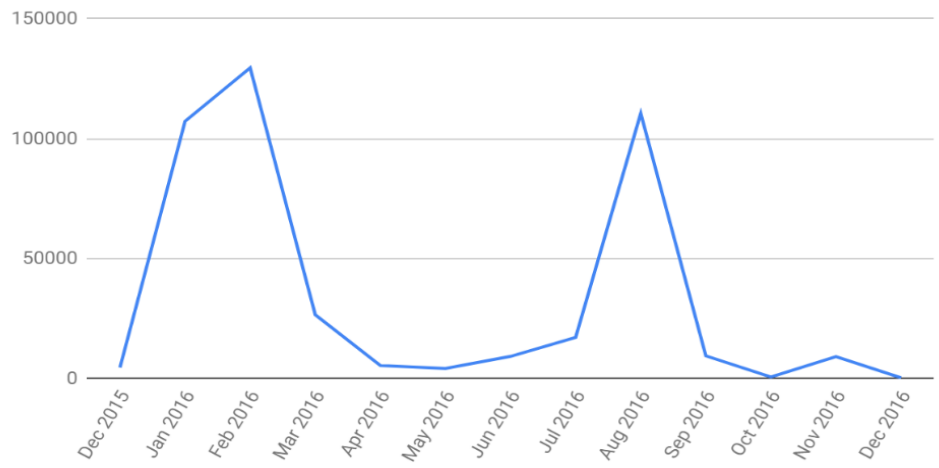


As evidenced by Figure 2, Wang and Guo found that the peak of public attention and discourse surrounding GM mosquitoes was reached in March 2016, around the time that the FDA announced its findings that GM mosquitoes posed no significant health or environmental risks, and invited the public to comment online. However, when we change the proxy for public attention and discourse from the number of media articles and tweets published (Wang and Guo's proxy), to the number of articles disseminated

on social media (our proxy), a slightly different pattern emerges. While articles published between January and March were impactful, in terms of their presence on social media, articles published online in August 2016 (around the time that the FDA announced its final approval of GM mosquitoes) were more likely to make an appearance on social media through sharing.

When we shift our attention from the total number of *articles* shared on social media, to the total number of article *shares* (Figure 4), differences in public attention become much more striking. Our findings indicate that social media sharing of GM mosquito articles did not always correspond with mainstream media attention.

Figure 4. Total Number of Shares by Article Publication Date

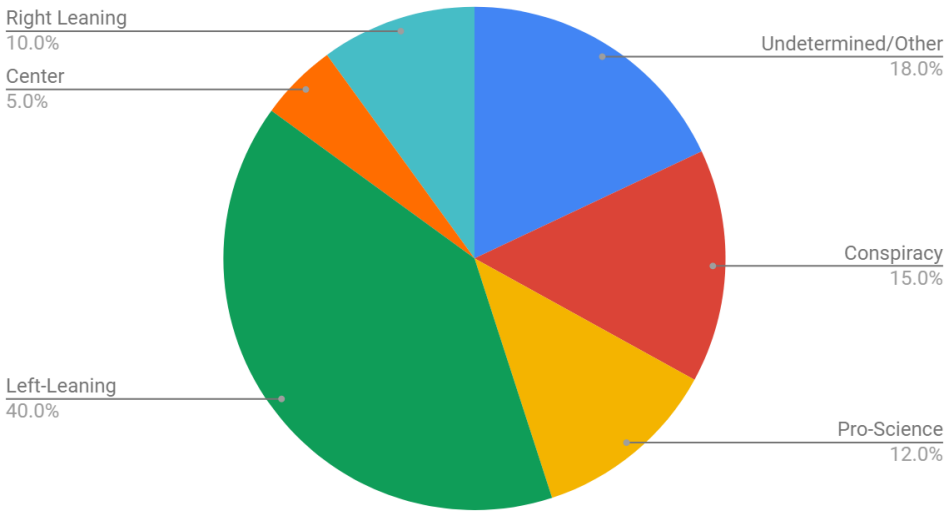


Interestingly, we found that at the height of fact-based, elite and emerging media coverage of GM mosquitoes (March to April 2016), sharing behaviors related to GM mosquito news was in fact quite low, when compared to other stages in the issue attention cycle (as identified by Wang and Guo).

Research Question 2 Findings: What types of articles on GM mosquitoes were most commonly shared on social media?

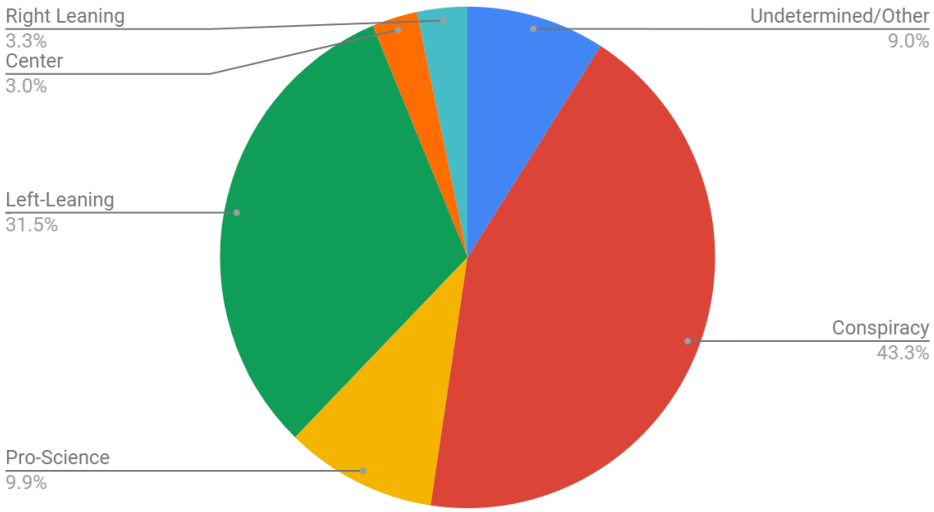
Article source searches on Media Bias Fact Check revealed that the majority of articles in our subsample (n=100) originated from left-leaning news outlets, at 40% (Figure 5). Fifteen percent of these articles originated from conspiracy theory websites, while only 12% of the articles in our sample were from science-specific news sites. Centric and right leaning news sources produced only 5% and 10% of the articles in our sample, respectively. Eighteen percent of the sources from which articles in our sample originated could not be classified using the MBFC tool. This may indicate that new and/or alternative sources played a major role in the production of articles on GM mosquitoes during this time period. It is likely that a closer analysis of media produced by these undetermined sources (as well as source affiliations), would allow for a more specific classification of these undetermined articles.

Figure 5. Source origination of articles shared on social media



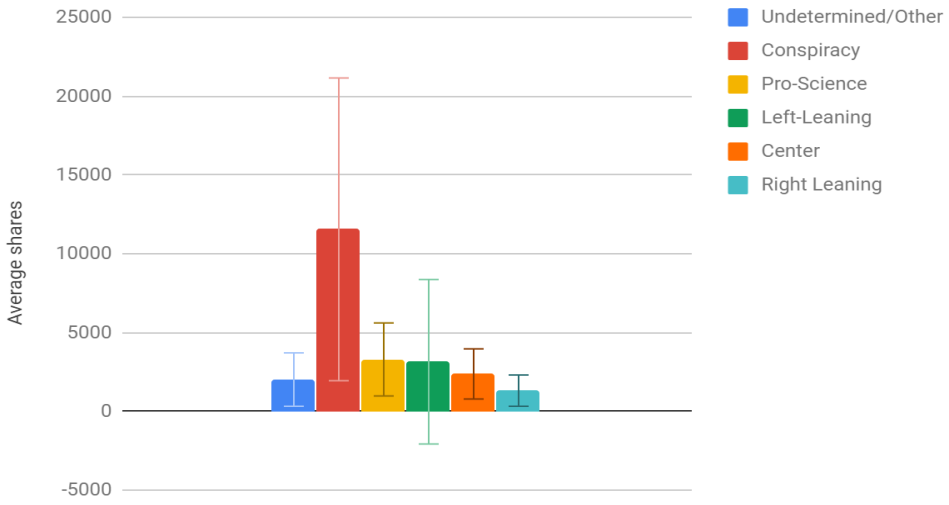
Switching the focus of our subsample from the number of articles by source type to the number of article *shares* by source type, revealed a more alarming finding (Figure 6). In 2016, at the height of discussions surrounding GM mosquitoes, articles from conspiracy theory websites were shared 173,250 times, accounting for approximately 43% of the total article shares (n=399,758).

Figure 6. Number of article shares by source type



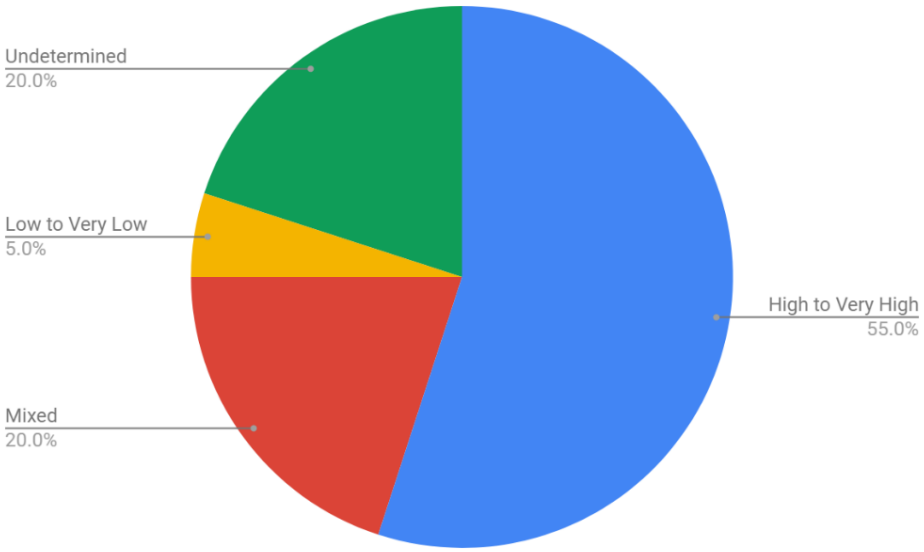
The average number of shares for the articles in our subsample equaled 3,997.58, with a standard deviation of 8,765.69. Figure 7 shows the average article shares by specific source type. On average, articles from conspiracy theory sources were shared 11,550 times. Shares of articles from pro-science articles averaged 3,294. Left-leaning articles were shared an average of 3,147 times, Center and right leaning articles were shared an average of 1,592.86 and 996.22 times, respectively.

Figure 7. Average number of shares of articles by source type



Using Media Bias Fact check to classify article sources by level of factual reporting, we found that the majority of the articles in our sample (55/100) originated from websites with reputations for high to very high factual reporting (Figure 8).

Figure 8. Number of Articles by source level of factual reporting



Articles from sources with low levels of factual reporting made up 5% of the sample, whereas articles with mixed levels of factual reporting (both high and low), made up 20% of the sample. An additional 20% of the articles in the sample originated from websites with undertermined levels of factual reporting.

In terms of number of shares (Figure 9), articles from sources with high to very high levels of factual reporting accounted for approximately 43% of the total shares (173,159/399,758). Articles from sources with mixed levels of factual reporting were shared 78,848 times, comprising about 20% of the total shares. While there were only 5 articles in our sample that were classified as originating from sources with consistently low to very low levels of factual reporting, these articles were shared 108,260 times, making up 27% of the total shares

Figure 9. Number of shares by source level of factual reporting

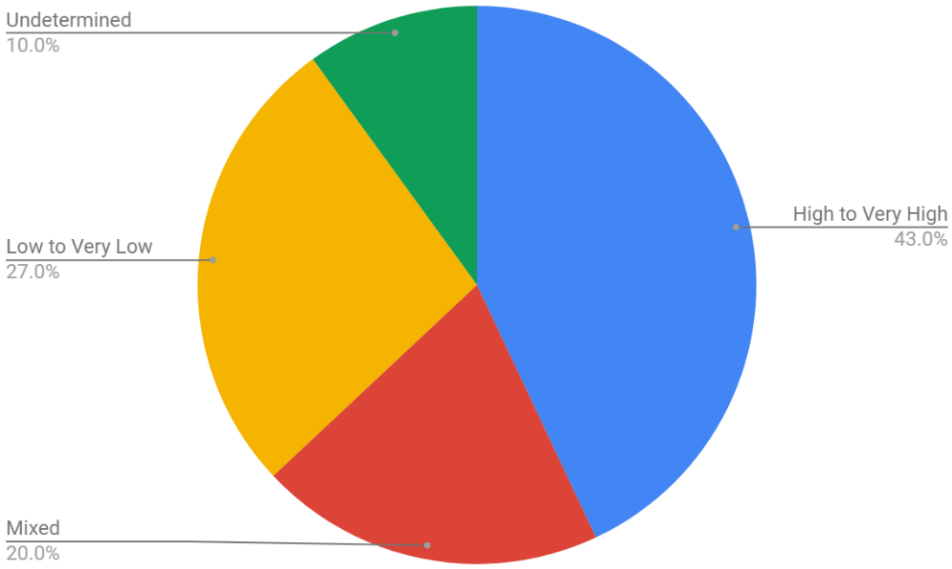
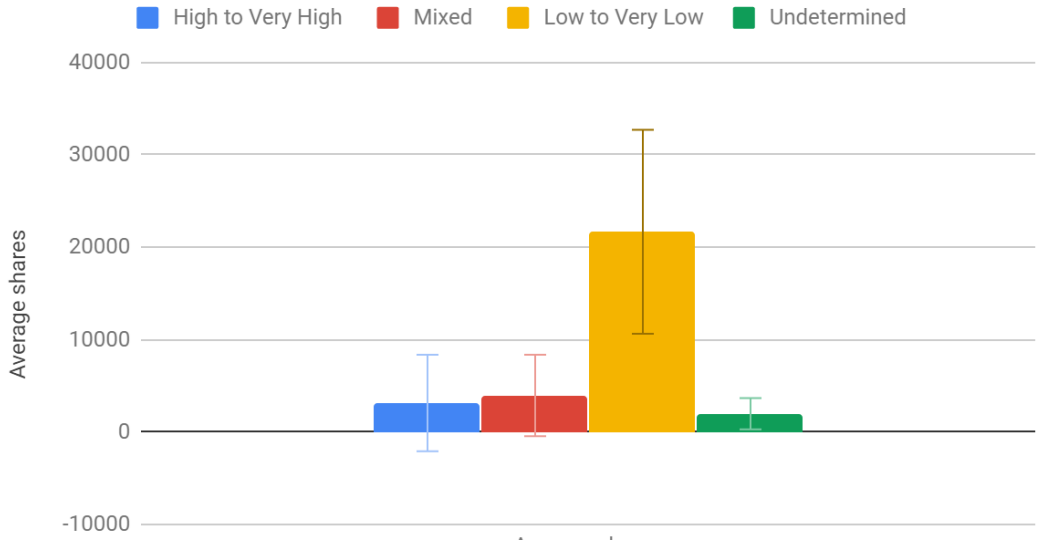


Figure 10 reveals additional, and alarming, trends in how articles on GM mosquitoes were shared, based on the factual reporting levels of their sources. On

average, articles originating from websites with reputations for high to very high levels of factual reporting where shared 3,128.35 times. The average number of shares for articles from sources with mixed levels of factual reporting was comparable, at 3,942.4. However, articles originating from sources with reputations for low to very low levels of factual reporting were shared an astounding 21,625 times, on average.

Figure 10 . Average Shares by Level of Factual Reporting



Research Questions 3 Findings: How did benefit/risk driven framing of GM mosquitoes in our sample compare to benefit/risk framing in Wang and Guo's study?

Table 1 presents our findings on the frequency of frame types, and orientation indices, found in the most commonly shared articles in our subsample, in comparison to Wang and Guo's findings on frame and index frequencies in articles published by fact-based elite and emerging news organizations. Like Wang and Guo, we found that the most commonly shared articles in our subsample focused heavily on the health benefits of genetically modified mosquitoes, with no significant differences between

the data sets. We also found comparable deliberations of the cost-effective benefits of GM mosquitoes between elite media articles and the most shared articles in our database. In their paper, Wang and Guo do not provide data on the percentage of articles that included the environmental benefit frame, presumably because this number was low. However, in our data set of the 100 most shared articles in 2016, we found that 15% of the articles in our sample made reference to the environmental benefits of GM mosquitoes.

Table 1. Framing Differences between Fact-Based Elite/Emerging Media Articles and Most Shared Articles on Social Media

	Elite/Emerging Media (Wang and Guo) n=464	Most Shared Articles (Taylor and Dewsbury) n=100	X^2	p	V
Health Benefits	80.60%	84%	0.62	0.431	0.0332
Cost-Effective Benefits	14.44%	19%	1.32	0.2506	0.0484
Economic Benefits	2.59%	0%	n/a	n/a	n/a
Health Risks	41.43%	26%	8.21	**0.0042**	0.1207
Environmental Risks	50.00%	35%	7.43	**0.0064**	0.1148
Ethical Risks	6.28%	16%	10.65	**0.0011**	0.1374
Experimental Risks	17.24%	26%	4.14	**0.0419**	0.0857
Cost-Effective Risks	13.79%	6%	4.60	**0.032**	0.0903
Benefit Oriented	24.14%	35%	5.04	**0.0248**	0.0945
Risk Oriented	8.19%	12%	1.48	0.2238	0.0512
Neutral /double sided	67.67%	53%	7.79	**0.0053**	0.1175

Though the frequency of benefit frames between the data sets was similar, there were some significant differences in the frequency of risk frames. The articles in our data set focused significantly less on the health, environmental, and cost effective risks of GM mosquitoes, and significantly more on their ethical and experimental risks. Despite these findings, our analysis indicates that the articles included in our sample were more benefit oriented than Wang and Guo's sample, at 35%. Accordingly, the frequency of double-sided/neutral articles in our sample was lower than that in Wang and Guo's study. Though not statistically significant, our percentages show that risk-oriented articles were more common in our data base than in Wang and Guo's.

Looking at changes in frame-orientation by both source type (Table 2) and total number of shares (Table 3), paints a different picture of the data. The majority of articles from Pro-Science and Left-Leaning sources were neutral/double-sided (58.33% and 67.50%). The remaining percentages of Pro-Science and Left-Leaning articles (41.67% and 32.50%) focused exclusively on the benefits of GM mosquitoes, with no mention of potential risks. Articles from right-leaning news sources, though only a small percentage of our sample, tended to be more benefit-oriented, with 50% of these articles classified as exclusively benefit-oriented, 10% exclusively risk-oriented, and 40% as neutral or double-sided. Articles from conspiracy sources were most likely to be classified as risk-oriented, at 60%. Somewhat surprisingly, the remaining 40% of conspiracy articles were classified as double-sided.

Table 2. Frame Orientation of Articles by Source Type

	Undetermined n=18	Conspiracy n=15	Pro-Science n=12	Left-Leaning n=40	Center n=5	Right Leaning n=10
Benefit Oriented	44.44%	0.00%	41.67%	32.50%	80.00%	50.00%
Risk Oriented	11.11%	60.00%	0.00%	0.00%	0.00%	10.00%
Double Sided	44.44%	40.00%	58.33%	67.50%	20.00%	40.00%

While articles with double sided/neutral frame orientations accounted for the majority of shares (at 54.51%), shares of exclusively risk-oriented articles outnumbered those of exclusively benefit oriented articles (24.42% vs. 21.07%).

Table 3. Frame Orientation by Number and Percentage of Shares

	Number of Shares n=399,758	Percentage of Total Shares
Benefit Oriented	84,232	21.07%
Risk Oriented	97,620	24.42%
Neutral/Double Sided	217,906	54.51%

Given that articles originating from sources with known reputations for low and mixed levels of factual reporting comprised such a striking proportion of the total shares of articles in our study, we would be remiss not to mention some of our observations on how misinformation about the health risks GM mosquitoes was spread through sharing. A total of 26/100 articles in our sample were coded for a "health risk" frame, due to some mention of possible adverse effects of GM mosquitoes on human health. Of these 26 articles, 12 of them suggested that the outbreak of Zika virus in the Americas may have been *caused* by Oxitec's releases of

GM mosquitoes in Brazil. This unsubstantiated claim was found in 4/5 of the articles originating from sources with low to very low levels of factual reporting, 5/20 of the articles from sources with mixed levels of reporting, and 3/20 of the articles from undetermined sources. The twelve articles that made this claim were shared 166,898 times. In other words, 42% of the time that the social media users shared articles about GM mosquitoes (166,898/399,758), they also spread misinformation about the health risks of GM mosquitoes

Discussion and Conclusion

Our findings reveal that the issue attention cycle and framing of GM mosquito discussions on social media diverged from that of mainstream media. Patterns of sharing—or not sharing—surrounding selected types of articles on social media resulted in the amplification of attention to certain risks (i.e. ethical and experimental), that were less frequently discussed in elite and emerging fact-based news coverage on GM mosquitoes but were of prime importance to debates over GM mosquito releases in the Florida Keys. We found that both benefit oriented articles, as well as articles from sources with a history of high levels of factual reporting, more frequently made their way to social media than did articles that were risk oriented, and/or from mixed and low level sources. However, our analysis also indicates that exclusively benefit oriented articles and articles from high-fact sources were also shared *less* frequently than exclusively risk oriented articles and articles from sources known to perpetuate unsubstantiated claims and misleading information. Finally, the sharing of information from conspiracy theory websites (and other alternative sources with mixed to low levels of factual reporting), played a major role in perpetuating misinformation on GM

mosquitoes during a period of heightened discourse on their use in controlling the spread of Zika virus. This final finding supports and builds upon previous research on the impact of misinformation (and conspiracy theories) on GM mosquito discussions (and public perceptions of GM mosquitoes) during this time period (see Dorius and Lawrence-Dill 2018; Lynas 2016; Lyons, Merola, and Reifler 2018; Wood 2018).

Our study is unique in that it quantifies the effects that trends in social media sharing had on the framing of GM mosquito discussions. To the best of our knowledge, our study is the first of its kind in that it presents a comparison of frame salience between articles produced by fact-based, mainstream media sources, and those articles that actually were shared on social media. Still, there are several limitations to our study, and its findings, that warrant consideration. First, the salience of specific frames on social media was determined only through an examination of sharing trends. At the time of data collection, BuzzSumo only provided metrics on article share counts. It is possible that opening up the analysis to include other forms of social media engagement with these articles, such as "likes" and "comments," may paint a different picture of GM mosquito framing and issue attention dynamics during this time period. Secondly, while several of our findings were statistically significant (at $p<.0.05$), with regard to comparisons between specific frames present in our sample and those in Wang and Guo's study, the effect size in all cases was low (as indicated by Cramer's V calculations). Though our findings could be criticized on the grounds that we set our significance value too high and our effect size too low, we argue that even these minimal standards are revealing when contextualized against the broader sharing trends that our study reported on. Third, for the purpose of consistency

and comparison, we followed Wang and Guo's methods for frame coding and frame index determination. Because frame orientation was based on the presence or absence of specific benefit and risk frames only (rather than a qualitative analysis of article valence and the ways in which frames interacted to construct larger narratives about GM mosquitoes), nuance and detail was inevitably loss. As a result, many of the articles in our subsample were coded as neutral/double sided under these methods (when in fact they may not have been). Finally, it is unclear who, or *what*, was responsible for the sharing trends we observed, as we were unable to decipher how much of the observed sharing behaviors were attributable to human social media users vs. social media bots.

While limited in its conclusions, this study does call attention to several additional areas in need of further research. Never before has public participation in science policy been so important, and never before have publics had so many opportunities to participate. In the Web 2.0 ecosystem, "sharing" science *is* participating in science communication, as every information receiver now has the capability to become an influential transmitter and/or potential gatekeeper of information encountered online. With the click of a button, individuals can effectively amplify (or attenuate) attention to the risks and benefits surrounding emergent biotechnologies. In discussions of new technologies, ethical considerations are often excluded from expert-based, technical assessments of risk. At the same time, ethical risks, as well as the possibility for immeasurable unintended consequences, are central to public evaluations of these same technologies. Divergent risk evaluations, by scientists and publics, are not adequately captured by mainstream media, as fact-based media

tend to give more weight to expert evaluations. Our study has shown that, through the sharing of selected types of media, publics effectively amplified attention to risks that were frequently left out of mainstream coverage of GM mosquitoes. This was accomplished largely through the sharing of articles originating from conspiracy websites, and sources with low levels of factual reporting. That so many of these articles were classified as "double-sided" in their coverage of the risks and benefits of GM mosquitoes was unexpected, and warrants additional attention. A more rhetoric-based, qualitative approach would undoubtedly result in the reclassification of many of these articles as strictly benefit or risk oriented, rather than neutral/double sided.

Additionally, the overall impact that online sharing of GM mosquito articles, (and their embedded frames) had on the outcomes of field trial debates in the Florida Keys is unclear. Though the proportion of exclusively benefit-oriented articles in our subsample was significantly higher than Wang and Guo's findings, public attention to risks during the height of GM mosquito discussions was likely amplified through the more frequent sharing of exclusively risk oriented articles. Still, the extent to which stakeholders in the Florida Keys debates actually engaged with the articles in our study in attempts to sway public opinion, is uncertain. Though outside the scope of this study, it would be interesting to map the production and sharing of social media content on GM mosquitoes according to geographical location to get a better sense of *who* information gatekeepers in this debate were.

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Supplemental Materials

Supplement Table 1. Wang and Guo's (2018) Original Coding Frame (obtained through personal communication)

Benefit Frames
Health Reducing the mosquitoes carrying the virus, remove the threat of zika on babies and adults, spreading "desirable quality" (e.g., Trials that started in April have reduced wild mosquito larvae by 82 percent in Piracicaba, Brazil; other diseases caused by mosquitoes than Zika; death tolls caused from mosquitoes-borne diseases)
Economic Business (e.g., tourism, local business; Return of the economic benefits from tourism in the affected areas)
Cost-effectiveness Efficiency -- Fixing the problem in a shorter time, in a more efficient way (e.g, until now mosquito control techniques in the United States have only been able to reduce population by about 50 percent. Efficacy trials in Brazil, Panama, and the Cayman Islands showed that this approach has helped reduce the Aedes aegypti population by more than 90 percent according to Oxitec)
Environmental: Positive outcomes on the ecosystems (e.g., biodiversity)
Other benefits that do not belong to any previous category
Risk Frames
Health Risk (e.g. allergies, another species carrying viruses affecting humans, frankenstein/spiderman/genetic risk: altered genes in human if bitten by a genetically modified mosquito)
Ethical risk (e.g, will we choose to remove a whole species for our own convenience in the future; ethical issues of the company releasing the genetically modified mosquitoes; misconduct of the government; legal violation)
Cost-Effectiveness Risk (e.g., not efficient, not sustainable for a large scale)
Environmental Risk (e.g, other species carrying viruses, ecological balance, making those feed on them die; mosquitoes are part of the fragile and unique ecosystem of the Keys; removing mosquitoes will destroy biodiversity of the community (e.g., There are areas that have the richest biodiversity on Earth that inhabited by humans thanks to mosquito's bite; FDA says no significant environmental impact, environmental assessment)
Concern of the experiment/trial design – related to the operation of the trial and the location, community selected for the trial (e.g., site near a senior center and a school, why they want to try there if no prior case; fear or mistrust as "guinea pigs" /lab rats
Other risk: Public fear, distrust, risk/concern without clear category

Supplemental Table 2. Interrater Reliability between two coders on sample of 20 articles

Article Number	Percent Agreement	Krippendorff's Alpha	Number Agreements	Number Disagreements	Number Cases	Number Decisions
1	100.00	1.00	12.00	0.00	12.00	24.00
2	91.67	0.81	11.00	1.00	12.00	24.00
3	83.33	0.72	10.00	2.00	12.00	24.00
4	100.00	1.00	12.00	0.00	12.00	24.00
5	100.00	1.00	12.00	0.00	12.00	24.00
6	91.67	0.85	11.00	1.00	12.00	24.00
7	100.00	1.00	12.00	0.00	12.00	24.00
8	100.00	1.00	12.00	0.00	12.00	24.00
9	91.67	0.83	11.00	1.00	12.00	24.00
10	100.00	1.00	12.00	0.00	12.00	24.00
11	100.00	1.00	12.00	0.00	12.00	24.00
12	100.00	1.00	12.00	0.00	12.00	24.00
13	100.00	1.00	12.00	0.00	12.00	24.00
14	100.00	1.00	12.00	0.00	12.00	24.00
15	83.33	0.54	10.00	2.00	12.00	24.00
16	91.67	0.85	11.00	1.00	12.00	24.00
17	100.00	1.00	12.00	0.00	12.00	24.00
18	91.67	0.76	11.00	1.00	12.00	24.00
19	91.67	0.84	11.00	1.00	12.00	24.00
20	100.00	1.00	12.00	0.00	12.00	24.00
Average	**95.83**	**0.91**				

CHAPTER 4

UNDERSTANDING ORGANIZED OPPOSITION TO FIELD TRIALS OF GENETICALLY MODIFIED MOSQUITOES THROUGH NARRATIVE: ACTIVISTS' SENSEMAKING WORK AND RATIONALES FOR RESISTANCE

In preparation for submission to Public Understanding of Science

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Keywords: *Sensemaking, Activism, Public engagement with science and technology*

ABSTRACT

Possible field trial releases of Oxitec's genetically modified mosquitoes in the Florida Keys have been discussed as early as 2010 but, to date, have not come to fruition (despite regulatory approval and endorsements by public health officials). Delays in releases have largely been due to intense public resistance, and the efforts of resident-activists in the region. The research presented here explores how local activists from one organized environmental group rationalized their resistance and made sense of the risks and benefits of the field trials. Through a close examination of data obtained through in-depth interviews, I attend to how intersubjective meanings arise from individual stories and narrated experiences. Rather than possessing anti-science, or anti-technology sentiments, activists' privileged the authority of ('good') science in their sensemaking work, and rationalized their resistance to the field trial plans by drawing from the traditional norms of science itself. Activist narratives indicate that the focus of collective resistance was not GM mosquitoes per se, but the hype surrounding their benefits and safety, perceived inconsistent and inaccurate representations of GM mosquitoes, and the institutional denial of inherent uncertainties. Finally, discourses of skepticism were commonly used as demonstrations of informed judgement and good citizenship. The fact that these expressions were explicitly labeled as anti-scientific and uniformed by proponents of GM mosquitoes contributed to the intractability of the controversy.

Introduction

"The opponents have very little information, and they are led by a few people who are non-science-based… We have tried to explain the real answers to them. They are not interested in the truth."

–Florida Keys Mosquito Control District Commissioner (quoted in Alvarez 2016)

Since their initial considerations nearly a decade ago, proposed field trial releases of Oxitec's genetically modified (GM) mosquitoes in the Florida Keys have been embroiled in controversy. Touted by proponents as a safe, more effective, and more ecologically-friendly approach to vector control and disease prevention, releases of genetically modified mosquitoes have, to date, been stalled by intense opposition from local residents. In contentious debates in the Florida Keys, opponents raised issues related to the possibilities of unintended consequences of GM mosquitoes, the capabilities of scientific and regulatory institutions in predicting and managing unforeseen risks, the necessity of the field trials in the region, and the legality and ethics of releasing GM mosquitoes without informed consent.

As is evidenced by the introductory quote—offered by a Commissioner for the Florida Keys Mosquito Control District in the New York Times—collective resistance to new technologies is frequently interpreted as irrational, misinformed, and misguided by the perspectives of a vocal minority (Melucci 1996; Fairhead and Leach 2012). Our Commissioner's reading of public opposition to GM mosquito field trials exemplifies Melucci's (1996: 42) notion of a hegemonic 'theory of bad faith' that "…..customarily interprets collective action as comprising a 'decent' majority which,

however unwittingly, becomes guided by deception or by suggestion—and in actuality against its own true interests—by a minority of agitators." In such interpretations, these 'agitators,' or activists, are frequently depicted as anti-science, and/or anti-technology, largely because of the explicit values they bring to discussions (Fairhead and Leach 2012; Ottinger 2015).

This paper challenges such assertions. Using data gleaned from in-depth interviews, I explore the sensemaking activities of four activists who were instrumental in leading the resistance to GM mosquito field trials in the Florida Keys. My analysis reveals that, rather than possessing anti-science, or anti-technology sentiments, activists' privileged the authority of ('good') science in their sensemaking work, and rationalized their resistance to the field trial plans by drawing from the traditional norms of science itself. Activist narratives indicate that the focus of collective resistance was not GM mosquitoes per se, but the hype surrounding their benefits and safety and the institutional denial of their inherent uncertainties. In addition to hyped-up communication efforts by proponents of the field trials, perceived inconsistent and inaccurate representations of GM mosquitoes served as major cues for triggering activists' sensemaking work in the first place. Moreover, discourses of skepticism were commonly used as demonstrations of informed judgement and good citizenship by the activists in my study. The fact that these expressions were explicitly labeled as anti-scientific and uniformed by proponents of GM mosquitoes helped create barriers to productive deliberations and conflict resolution. These findings hold significant implications for understanding public controversies surrounding technoscientific issues.

The Case

Following outbreaks of dengue fever in the Florida Keys in 2009 and 2010, the Florida Keys Mosquito Control District began considering the use of Oxitec's OX513A genetically modified *Aedes aegypti* mosquito as an alternative form of vector control. OX513A mosquitoes are modified to carry genes that affect cellular functioning, resulting in premature death during the insect's larval and pupal stages. In the laboratory, the lethal effects of these genes are suppressed through the administration of tetracycline in the diet, as OX513A mosquitoes are reared to adulthood. Following the removal of the majority of biting females from laboratory populations of OX513A, adult males are then released en masse into wild populations of *Aedes aegypti* mosquitoes. Modified males pass on copies of lethal genes to their offspring, through their matings with wild type females. Without access to the tetracycline antidote, most of these offspring die before reaching adulthood—resulting in decreasing numbers of *Aedes aegypti* mosquitoes over time (Oxitec 2017, 2). Based on data from open field trial releases in the Cayman Islands, Panama, and Brazil, Oxitec reports that OX513A is capable of reducing mosquito populations by over 90% (Oxitec 2016b). The Florida Keys Mosquito Control District (FKMCD) announced its partnership with Oxitec to the public in 2011, and field trial plans were submitted to the FDA for approval in 2012 (Herndl and Zarlengo 2018). Discussions on GM mosquitoes in the Florida Keys heightened in 2016 in response to the growing Zika virus outbreak in the Americas (Wang and Guo 2018).

Despite the Food and Drug Administration's (FDA) "findings of no significant impact" in its risk assessment of OX513A in March 2016, and its subsequent approval

of field trials in the Florida Keys in August 2016, opposition by Florida Keys residents has, so far, been successful in stalling release plans. Residents' suspicions of expert claims regarding the safety, effectiveness, necessity, and legality of GM mosquito releases were readily apparent during contentious town hall meetings held in the Florida Keys in 2012 and 2014 (Phillips 2017; Herndl and Zarlengo 2018; Taylor and Dewsbury 2019), and widely covered by both local and national media. Organized opposition to release plans was spearheaded by a local activist, who started a much publicized online petition in 2012 (that to date has garnered over 231,000 signatures of opposition), the Florida Keys Environmental Coalition (a grassroots, environmental protection and restoration group), and other local and national NGOs (Herndl and Zarlengo 2018). Between 2015 and 2016, performances of community dissent escalated, and were enacted through protests at mosquito board meetings, residents' posting of lawn signs reading "No Consent," Freedom of Information Act (FOIA) requests to obtain private emails between Oxitec and the FKMCD, and submissions of letters and comments of opposition to the FDA, following its initial assessment of field trial plans in March 2016 (Loyer 2017; Herndl and Zarlengo 2018; Bloss et al. 2017).

In response to the growing controversy, the Monroe County Board of Commissioners made the decision to bring field trial plans to vote, in a non-binding public referendum in November 2016 (Atkins 2016). Fifty-eight percent of voters in greater Monroe Country approved of releases of genetically modified mosquitoes. However, the majority of voters (65%) residing in Key Haven, the proposed site of the field trial releases, rejected the plans (Atkins 2016). Given the low levels of support

from Key Haven residents, the FKMCD decided not to move forward with the Key Haven releases, and instead begin looking for an alternative site. In December 2017, Oxitec applied for an experimental use permit with the Environmental Protection Agency for field trial releases of OX513A in an unspecified Florida Keys location, following transference of regulatory oversight from the FDA to the Environmental Protection Agency (EPA) under revisions to the US Coordinated Framework for Regulation of Biotechnology. Though media coverage and general public interest in GM mosquito discussions had much declined by this point, the Florida Keys Environmental Coalition and other activist groups remained vigilant in efforts to prevent field trial releases in the Keys. Oxitec subsequently withdrew its application with the EPA in November 2018, stating that the company would be replacing OX513A technology with 2nd generation genetically modified mosquitoes and applying for a new permit in the coming months. Oxitec submitted its new application to the EPA in September 2019.

A brief overview of activism in the Florida Keys

Much has already been written about the Florida Keys controversy, and the reasons for public resistance to GM mosquito field trials (Herndl and Zarlengo 2018; Taylor and Dewsbury 2019; Bloss et al. 2017). Some scholars (myself included), have observed that public resistance to Oxitec's initial field trial plans was, at least in part, a response to dominant, technocratic framings of field trials in science communication and public engagement efforts (Herndl and Zarlengo 2018; Taylor and Dewsbury 2019), which left little room for citizens "to actively engage with and discuss the meaning of the risks involved" (Engdahl and Lidskog 2014, 706). However, public

opinions were not shaped *solely* by institutional science communication efforts. They were also influenced by the communicative efforts of local activists, who played an instrumental role in reframing discussions of GM mosquitoes, and problematizing the field trials. Central to these efforts was the "positioning [of] the trial as a scientific or medical experiment" (Loyer 2017, 38), which involved human subjects. The slogan "No Consent," widely circulated through online campaigns and on public signs of protest (Figure 1), was leveraged as a collective action frame to highlight the injustice (Snow and Benford 1992, 137) of the field trials, and thus legitimate and mobilize social action.

Figure 1. Photo by Greg Allen (2016)

Activists in the Florida Keys, many of whom were members of local grassroots groups such as the Florida Keys Environmental Coalition, also took it upon themselves to educate the community about the potential risks of GM mosquito releases. Acting as "alternative science communicators" (Maeseele 2009), these

activists publicly contested the objectivity, transparency and neutrality of expert risk assessments, and disseminated oppositional information through blogs, local and national media, and through social media websites created for the purpose of organizing opposition to the field trials (Loyer 2017). As is often seen in public protests surrounding technoscientific issues, oppositional materials frequently combined research with rumor (Fairhead and Leach 2012).

In addition to the notion that GM mosquitoes could potentially be used to administer mass inoculations of vaccines (Figure 2), rumors that GM mosquitoes might be responsible for Zika outbreaks in Brazil gained traction in 2016, at the height of public discussion about the field trials (Specter 2016). While it is tempting to brush these speculations off as baseless conspiracy theories, it is important to note here that activists in the Florida Keys often drew from science-related materials to support these claims.

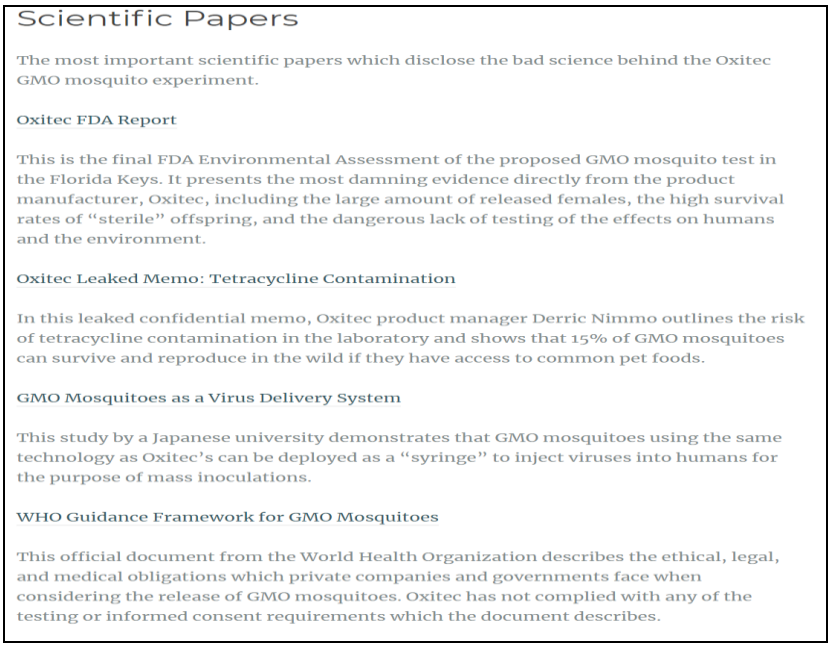


Figure 2. Screenshot of oppositional information disseminated through the activist-created blog Never Again, LLC (2016)

The unsubstantiated link between releases of Oxitec mosquitoes in Brazil and subsequent Zika outbreaks in the region, originally suggested in a Reddit post (u/redditsucksatbanning 2016), was in fact, bolstered by a 2016 article in The Ecologist, an online environmental journal (Tickell 2016). This article has since been heavily criticized by several bioinformaticians and geneticists, and I am cautious of lending credence to the claim. I do, however, want to emphasize here that, rather than eschewing science in their efforts to prevent releases of GM mosquitoes, activists frequently aligned their arguments with those of various counter-experts, to make the case that "scientists know what is hazardous [in this case, GM mosquitoes], and that citizens need that knowledge too" (Tesh 2000, 95).

Further evidence for this assertion comes from several other observations as well. For example, a widely circulated document on "GM mosquito Talking Points" (Bethune 2016). relied heavily on the arguments of Dr. Helen Wallace (Wallace 2012), an environmental scientist and director of the activist organization GeneWatch UK, to challenge the safety, efficacy, and ethics of field trials. Additionally, activist groups in the Florida Keys formed alliances with other types of experts, including a local Florida Keys physician. Concerned with the possibility that tetracycline-reared genetically modified mosquitoes might spread antibiotic resistant bacteria in the region, this physician filed a petition with the FKMCD and Oxitec to have bacterial cultures performed on OX513A before any releases took place (O'Hara 2016). He quickly became what Eyerman and Jamison (1991) refer to as a "movement intellectual" in the campaign to prevent GM mosquito releases. Interestingly, amidst protests against the use of Oxitec's mosquitoes in the Florida Keys, one of the more

vocal anti-GM mosquito activist groups, the Florida Keys Environmental Coalition (FKEC), also began researching and publically endorsing other experimental techniques for mosquito control such as Mosquito Mate's EPA-approved Wolbachia-infected mosquitoes. Working much like OX513A to suppress mosquito populations by affecting reproduction, Wolbachia mosquitoes were promoted by many GM-mosquito opponents as a more benign, effective, and evidence-based alternative (Klingener 2016; Global Justice Ecology 2016).

Missing from the scholarly literature on the Florida Keys controversy is an in-depth exploration of the rationales of organized activists in their efforts to prevent the field trials, and how they made sense of the science and uncertainties involved in GM mosquito releases. This article attempts to fill this gap by examining the narratives of four of the most vocal and engaged activists in resistance efforts. The conceptual framework used in my analysis of these narratives draws heavily from the notion of sense-making, and is outlined in the following section.

Conceptual Framework

Rather than a unified, coherent theory, sensemaking is better viewed as a conceptual perspective, or framework (Faehnrich 2018; Weick, Sutcliffe, and Obstfeld 2005), that attends to the processes through which people "produce, negotiate, and sustain a shared sense of meaning" (Gephart, Topal, and Zhang 2010, 285). Sense-making is an inherently social and collaborative process (Weick, Sutcliffe, and Obstfeld 2005) whereby the production of individual accounts—or discursive constructions of reality (Antaki 1994; Maitlis 2005)—contribute to the creation of shared understandings of information, events, and experiences. Collective

understandings, then, serve as the basis for collective action (Meyer 2019). Sensemaking, in both individuals and collectivities, is a response to uncertainties surrounding novel, unexpected, and unfamiliar situations (Weick 1985). As such, the sensemaking framework is particularly well-suited for my examination of the rationales and motivations of activists in the Florida Keys, given that field trial releases of genetically modified are marred by numerous 'unknowns' surrounding the long term effects of Oxitec's novel technology on ecosystems, social relations, and human health. Moreover, because it has roots in symbolic interactionism and organizational studies, the sensemaking framework allows for analytical movement between meaning-making at both the individual and collective levels. The ability of this framework to span multiple levels of analysis is valuable to an understanding of activist rationales in the Florida Keys, as most of these actors were members of, or affiliated with the Florida Keys Environmental Coalition.

In his now classic work, Weick (1995, 3) identifies seven interconnected properties of sensemaking: "identity, retrospection, enactment, social contact, ongoing events, cues, and plausibility." I provide a brief overview of each of these elements below. My conceptualization of the interconnected nature of these properties is depicted in Figure 3.

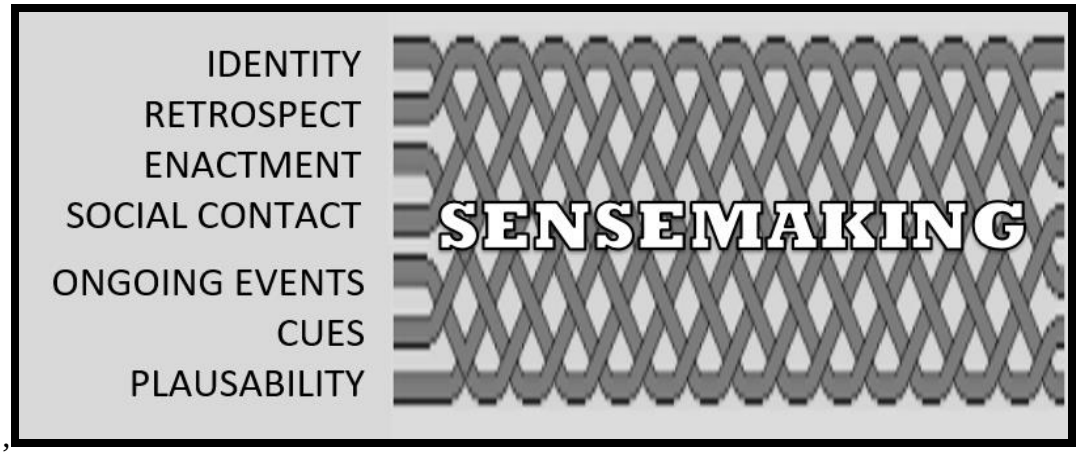


Figure 3. Author's conceptualization of Weick's (1995) sensemaking properties

Identity

According to Weick (1995), sensemaking is grounded in the construction of identity. Moreover, perceived threats to identity, on the individual and/or organizational level, commonly initiate engagement with sensemaking work. In the words of Weick (1995, 23):

> *"Individuals construct their identity in ways that meet human needs for self-enhancement, self-efficacy, and self-consistency. When one or more of these comes under threat, people are triggered to engage in sensemaking around the sources of threat, acting so as to restore their identity."*

Perceptions of self, combined with various constituents of identity such as values, experiences and abilities, mediate differences in how people respond in sensemaking situations (Cajander 2010).

Retrospection

Sensemaking, according to the literature, is always a retrospective process (Weick 1995; Maitlis 2005). As Kramer (2016, 1) explains, "although individuals may

consider possible interpretations of anticipated events, it is not until the event occurs that individuals collectively make sense or commit to a particular interpretation of the event." Retrospection involves pattern recognition, and the attachment of meaning to past experiences. It is through this process of retrospection that individuals and organizations continually construct and negotiate their identities (Gioia, Corley, and Fabbri 2002). Thus, the meaning of past events is always subject to revision, according to the demands of the context and the effects of alternative interpretations on the perceived identities of individuals and groups (Gioia, Corley, and Fabbri 2002). At the same time, retrospection often operates in tandem with prospective thinking (Weick 1995; Sonenshein 2010). This prospective, or future-oriented, thinking, works both to anticipate the outcomes of actions and events and, in a somewhat paradoxical manner, to reify or revise the past. Gioia et al. (2002, 623) explore the temporal complexity of sensemaking in their observations that:

> *"…people envision a desired or expected future event and then act as if that event had already transpired, thus enabling a `retrospective' interpretation of the imagined event. As quirky and convoluted as this process might sound, it is difficult to imagine a process for discerning the meaning of future events or states that might operate much differently. We are stuck with the future as yet another variation on the past – a past that, curiously, is continuously undergoing revision."*

Enactment

Weick's (1988) principle of enactment focus attention to the relationship between cognition, action, and context (Maitlis and Christianson 2014). For Weick,

acting *is* thinking, and actions alter the environments in which sensemaking occurs. In other words, people "enact their ideas about the situation in which they finding themselves in" (Meyer 2019, 134), and in-turn enact new structures in their environments that facilitate the on-going process of sensemaking (Maitlis and Christianson 2014). Meyer (2019, 134) speaks to the recursive nature of enactment by explaining that:

> *"This relationship between sensemaking and action can have iterative effects. Actors may stabilize their world and worldview by enacting their own perspective of the world and how it works. Of course, they can and do also fail dramatically, but often, sensemaking reinforces the situation, and vice versa, triggering dynamics very similar to self-fulfilling prophecies."*

In short, the principle of enactment recognizes that, through discourse, narratives, other actions, individuals simultaneously reify both their experiences and environments (Nicholson 2015).

Social contact

While sensemaking, on the surface, may appear to occur in the minds and actions of individuals, sensemaking always emerges within a given social context. Social context, and *contact*, are important here as people interpret their environment "in and through interactions with each other, constructing accounts that allow them to comprehend the world and act collectively" (Maitlis and Christianson 2014, 66). Sensemaking emerges through social practices, including conversations, narratives, and other exchanges. Gossip, rumor, and speculation are central to sensemaking, with

"shifts in language and conversation" serving as powerful catalysts for change (Balogun and Johnson 2005, 4).

Ongoing

In alignment with social constructionism, the sensemaking perspective premises that reality is a continuous achievement, "that emerges from efforts to create order and make retrospective sense of what occurs" (Weick 1993, 635). Acknowledging reality as a social construct does not necessitate denying that objective facts can and do exist. Rather, to say that reality is socially constructed is to recognize that what comes to be *accepted* as 'reality' is contingent on social relationships and shared knowledge. Sensemaking is both ongoing and transient, as individuals enact and react to changing environments, events, and cues (Maitlis and Christianson 2014).

Cues

Cues are instrumental to the sensemaking process, as sensemaking is "focused on and by extracted cues" (Weick 1995, 49). When people experience situations that are unfamiliar, or confusing, they direct their attention to various contextual cues, and attempt to interpret them. Cues can be thought of "activating stimuli" (George 2015, 194), originating from both external events and internal motivations, that help people determine the relevance and acceptability of information, explanations and decisions (Morlidge 2019). Cajander (2010, 54) explains:

> *"In the constant flux of events, something is extracted, and reacted on, and these are the cues that a sensemaker builds her sensemaking on. The cues are deeply set in the context of the enacted world as well as linked to the identity of*

the sensemaker. Different people will extract different cues, depending on how they enact their world, or depending on how they perceive themselves."

During the sensemaking process, small cues are enlarged as people try to understand situations and events. Extracted cues serve as orientating phenomena, which connect individual "ideas to broader networks of meaning" (Ramírez and Abad-Quintanal 2018, 88). Because they can be, and often are, interpreted in different ways by different actors, cues are somewhat analogous to the notion of boundary objects in the science and technology studies literatures (Cajander 2010; Star and Griesemer 2016).

Plausibility

Finally, the sensemaking perspective holds that people optate plausibility over accuracy in their interpretations of objects, events, and situations (Weick 1995). In other words, "sensemaking is more about what is plausible, than about the rational truth or the full complex problem"(Cajander 2010, 92). This idea that plausibility supersedes accuracy in sensemaking decisions, parallels the concept of 'satisficing' (Simon 1956) in the behavioral economics and risk perception literatures.

Data and Methods

This study draws on narrative data obtained through in-depth interviews with four Florida Keys activists to address three interrelated questions: 1) what motivated individuals to become involved in debates surrounding field trials? 2) how did these individuals make sense of the science and risks involved in GM mosquito releases? And, 3) how do individual narratives work together to create a shared rationale for resistance? Keeping in mind that sensemaking is "a collaborative process of creating shared awareness and understanding out of different individuals' perspectives and varied

interests" (Weick 2000 cited in Guilherme, Glaser, and Méndez-García 2010, 111), I attend to the intersubjective meanings that emerge from individual narratives. Approval for this study was granted by the Institutional Review Board (IRB) at the University of Rhode Island (#931214-7).

Participants were purposively selected based on their level of involvement in field trial discussions, and their familiarity with its issues. Prior to recruitment, I identified seven individuals who consistently acted as leaders in the opposition against field trial plans in the Keys through journalistic reports, social media groups related to the field trial, and conversations with local residents. I attempted to recruit all seven of these individuals for this study, however only four consented. Of the remaining three individuals, one was unable to be reached, one was unable to participate due to scheduling conflicts, and another unfortunately passed away during the study period. All participants in my study were members of, or at least affiliated with, the Florida Keys Environmental Coalition (FKEC). The FKEC is a grassroots organization that was established in 2010 in response to the BP Deepwater Horizon gulf oil spill earlier that year. The stated mission of this organization is to "coordinate and support organizations, businesses and individuals, who work to protect the coral reefs and ecosystems of the Florida Keys and to provide a unified voice for our community. within our island environment, and do everything we can to protect it" (Florida Keys Environmental Coalition 2013).

All interviews took place in the Florida Keys, at various locations determined by the study participants, between February 2018 and January 2019. Interviews were semi-structured in that they were based on a pre-determined set of questions that

encouraged individuals to reflect on the ways in which personal experiences, events, and social relationships shaped their evaluations of GM mosquitoes. There was considerable variation in the structure of the interviews, as I approached them more as a conversation that allowed participants to guide the trajectory of topics and themes. Interviews lasted between 1.5 and 2.5 hours and were digitally recorded with permission from my participants. Intelligent verbatim transcription was used to transform the audio recordings into text, meaning that I attempted to transcribe participant statements word for word, but removed unnecessary fillers, repetitions, etc. to enhance clarity and readability. At times, I inserted additional information in my own words (indicated with brackets), to provide clarifications on what or who statements were referring to, for the reader.

Following the transcription processes, interviews were coded in Nvivo software. I first applied a thematic analysis to the data to identify the issues and events that participants considered relevant to their evaluations of GM mosquitoes, and to their participation in activism. Once these themes were isolated, I revisited the transcripts and utilized in-vivo coding to highlight statements and passages that captured the "various points of convergence and divergence" (Little 2010, 192) in participant narratives. As a result, this process of in-vivo coding served a dual purpose: to both triangulate the data, and attend to intersubjectivity. An overview of these themes and the positions taken by participants are presented in Table 1.

Themes	Interpretations of participant positions
1: Views on GMOs in general	Participants were largely ambivalent about GM products, and showed considerations of both the benefits and risks in interviews.
2: Problems with Oxitec's Representations of GMMs	Participants reported being supportive or curious about GM mosquitoes at first. Perceived inaccurate/inconsistent representations of GM mosquitoes, (by Oxitec and FKMCD) largely contributed to participants' feelings of mistrust towards the company and the field trials.
3: Political and Corporate Interests	Participants believed that financial and political motives compromised the rigor, transparency, and credibility of risk assessment.
4: Fundamental Problems with the Trial	Participants largely perceived the trial as one that involved human subjects (thus requiring consent to participate), and noted various scientific, ethical and regulatory issues with it that compromised their confidence in the trial.
5: Lack of Competence in Scientific and Regulatory institutions	Participants noted that the problems they saw with the field trials were symptomatic of larger, institutional problems in science and regulation. Resistance to field trials could only be understood in the context of systemic problems with institutional standards of technology regulation and governance.
6: Hype and alternatives	Participants took issue with hype surrounding GM mosquitoes, noting that alternative forms of effective vector control existed. Participants felt that the risk of mosquito borne diseases had been overstated, in attempts to scare people and garner public support for Oxitec's mosquito.
7: Social relationships	Participant felt that it was their obligation as Keys citizens to be skeptical of the trial, but recognized that their views were not shared by the majority of Keys community. Participants expressed that at time they had to distance their views from those of other opponents to maintain credibility. They also reported feeling that they had been treated as "uniformed" and "uneducated" by Oxitec/FKMCD staff.

Table 1. Themes and Interpretations

For the purpose of validity, I utilized synthesized member checking (Birt et al. 2016), and sent all participants a document that summarized the major themes identified in my analysis, accompanied by supporting statements (from all participants) that I based my analytical interpretations on. Participants were asked to review the document and provide feedback on any interpretations that they felt were inaccurate or incomplete. While the coding process was instrumental in identifying

what themes were relevant across participant narratives, its value is limited in efforts to understanding the sensemaking work of the activists in my study. The themes I identified in the interview data can be viewed as the major nodes around which sensemaking occurs but, on their own, they offer little insight in to *how* sensemaking unfolds. As narratives and stories are "the primary form[s] by which human experience is made meaningful" (Polkinghorne 1988, 1), I expand my analysis in the following section through narrative sketches (Little 2010) of the four activists in the study. These sketches condense and restory the interview data according the themes identified in the coding process, and aim to provide deeper insight into the lived experiences, standpoints, and intentions (Little 2010) involved in sensemaking work, on both the individual and collective levels.

In efforts to protect my informants' privacy and maintain confidentiality, I use pseudonyms[1] to refer to the participants in my study. However, there are two interconnected issues that complicate these efforts. First, the Florida Keys controversy has attracted significant local and national media attention, and some of the views and experiences of participants in my study have been reported elsewhere (and under conditions where there was no expectation of confidentiality). Second, at the time of my study, most of my participants held prominent, public positions in the greater Florida Keys community, which they deemed extremely relevant to their understandings of the issues at stake, and their motivations for participating in activism.

[1] All pseudonyms were created by me with the exception of one, which was specifically requested by a participant.

While participants were onboard with my obligation to use pseudonyms, it was also important to them that I include information about the positions they held, so as not to diminish their credibility and expertise. Thus, I found myself in an ethical conundrum: Including details about their professional lives and experiences might provide the reader with potentially identifying information about participants. *Not* including these details, would largely misrepresent the standpoints and positions that my participants were speaking from. In the end, I made the decision to honor my participants' wishes, and include this information in my construction of the narrative sketches. Once complete, I sent each participant their individual sketch and asked that they carefully read their sketch in its entirety and provide feedback on whether or not they felt it accurately reflected their views and experiences. They were also asked to mark any passages that they felt misrepresented them or their views, or any details that they didn't feel comfortable with me including in my report. Three participants responded to this request, all with positive feedback, and gave their approval on the final sketches, which are presented below.

These sketches follow the tradition of Interpretive Phenomenological Analysis, as my analysis engages in a sort of 'double hermeneutic'—"whereby participants are seen to make sense of x while researchers make sense of the participants' sensemaking" (Finlay 2014, 127). Crucial to this task was an explication of the personal values, experiences, and interests that I bring to my readings of participant stories and narratives. My combined training in biology, anthropology, science communication, and public engagement with science has invariably impacted my interpretations. My training in biology has largely shaped my respect for science as a

way of understanding the world, and I am inclined to privilege the authority of science in matters of risk evaluation and policy. At the same time, as an anthropologist, I view science as a particular epistemic culture, embedded with its own unique norms and subjectivities. As a scholar in science communication and public engagement with science, I am highly critical of deficit-based understandings, which reduce public resistance to science and technology to a lack of scientific literacy. While I acknowledge that public misunderstandings and misinformation can, and do, contribute to the intractability of public scientific controversies, I am also wary of interventions that attempt to get publics on board with technoscientific interventions by providing *more* information, or replacing misinformation with 'proper facts.' This perspective is rooted in my standpoint that what are often interpreted as displays of 'public ignorance,' are better understood as efforts to reframe the issues at stake, as reactions to the behaviors and postures of expert institutions, and as expressions of different forms of knowledge and expertise (Fairhead and Leach 2012).

As my conceptual framework is grounded in a social constructionist paradigm, I am interested in illuminating processes of *meaning-making*, rather than determining the factual accuracy of participant stories and narratives. I am well aware that many of the statements made by participants in my study might be best characterized as rumor, and I caution against taking all of them at face value. At the same time, I am of the view that rumors (and related phenomena such as gossip, and conspiracy theories) are not simple reflections of public ignorance, or proxies for some other issue. Rather, I take the position outlined by Fairhead and Leach (2012:35) that rumors, in the context of public engagement with science, are active expressions of "anxieties around the

content, methods and goals of specific scientific practices and their wider social and political implications." And, as Thomas and Thomas (1928, 572) observed nearly a century ago, when people "…define situations as real, they are real in their consequences."

The narrative sketches below explore how various elements of sensemaking manifest in individual stories. The discussion section then explores how collective meanings of field trials of GM mosquitoes extend from a multiplicity of stories. I return to the issue of intersubjectivity in this final section of the paper.

Narrative Sketches

Raquel's story: picking up on the red flags

Raquel was the first activist I interviewed, back in February 2018. We both attended a public workshop on GM mosquitoes at the Florida Keys Mosquito Control District's Marathon headquarters, in which various experts discussed the risks and benefits of both GM and non-GM options for reducing mosquito populations. We met at the Cracked Conch Cafe on the Overseas Highway following the event. I asked Raquel to tell me a bit about how she first heard about GM mosquitoes, and her initial impressions. She explained:

> *"My best friend was a science teacher in a third grade classroom at Key Largo School in the very Upper Keys. And this probably goes back to 2010 maybe, and she was telling me about how the mosquito control came in and they were talking to the kids about all these, you know, novel ideas. And she brought up the genetically modified mosquitoes, and I'm like 'Wow', that's sounds*

awesome, and I just started doing my own independent research. And immediately there were red flags."

Throughout our meeting she talked at length about these 'red flags' and how they served as cues for how she made sense of the uncertainties involved in GM mosquito releases, as well as the trustworthiness of Oxitec. Many of these cues were extracted from science communication efforts. Early on in their public engagement activities, Oxitec frequently referred to their technology as a new iteration of the Sterile Insect Technique (SIT), a process first developed in the 1950s in which insects are made sterile through radiation in the laboratory, and then released en masse to control the mating efficacy of wild populations (Reis-Castro and Hendrickx 2013; Taylor and Dewsbury in press). She spoke of her observations at the first town hall meeting on GM mosquitoes in 2012:

"There were so many lies, just in that first presentation, based on what I read off the Oxitec website itself. . .The first thing off the bat was, he referred to it as a sterile insect technique. Which as you may have learned today, there's a huge difference between SIT and an Oxitec genetically modified mosquito. . . Previous field trials that [Oxitec] did were for mating efficacy. They were trying to make them mate better. That is the opposite of sterile. They do produce larva, afterwards. They have such bad birth defects due to all the genetic modification, that they never grow up to be an adult. They die. Big difference between the two. I'm a huge fan of SIT [but] they're complete polar opposite on the ends of the spectrum."

Raquel explained that she had read Oxitec's initial application to the FDA for field trial approval and noticed other problems as well in how the company's science and technique were represented in public engagement events.

> *"They said they only release males. Complete bullshit. In the application [to the FDA], per 10,000 mosquitoes released, approximately 62 would be females, which are biting. So they go through the same process. They're hand selected. Human error definitely accounts for something, and when you're talking 22 million mosquitoes, there's gonna be a percentage of biting females that were genetically modified with herpes, and E. coli, and red coral and other things like that. That's a huge red flag."*

I was impressed with Raquel's knowledge of GM mosquitoes, and the science behind them. She was spot on here in her understanding of some of the types of organisms that were used to construct GM mosquito transgenes (though she estimated a higher number of released females than Oxitec reported to the FDA).[2] She emphasized that these details, which were often oversimplified in science communication efforts, mattered greatly in predicting the risks involved in field trial releases, as well as creating a well-informed public.

> *"So they applied for up to 22 million mosquitoes[3] to be released. So, in a neighborhood of about 400 and some odd houses, lots of families, kids and what not—just basic—how would you like to have that many mosquitoes? Just the actual inconvenience of having them all over you. I can't honestly say what would be the long term effects. As someone who cares about my environment, I*

[2] Oxitec estimates that <.2% of GM mosquitoes released are females, or <20 per 10,000.
[3] In an interview with Florida Keys News, Oxitec clarified that the company applied for releases of 14.3 million mosquitoes over a 2 year period (Atkins 2016).

was surprised that they only took the endangered tree snail [into consideration in their risk assessment], because we have 23 endangered species down here in the Florida Keys. That's the only thing [the tree snail] they had on their FDA application. However, we have a salt marsh rabbit, only found down here, a skink, only found down here, nearly extinct, that were within the field trial area, and they didn't take either one of those into consideration. I mean, my husband's a fisherman, you know? Fish eat bugs. What's gonna happen to the birds? We're delicate down here."

Raquel often combined scientific and ecological knowledge with well-known tropes surrounding GMO's to emphasize these uncertainties:

"To add something that never actually existed on before, it's…who knows. Who knows what's in Pandora's Box? Maybe nothing will happen. Do you want to take a risk?"

She said she was much more in favor of using Wolbachia as an alternative vector control strategy because the technology was more natural and, hence, easier to make sense of and understand. Unsurprisingly, based on my knowledge of activist discourse surrounding the field trials, Raquel often spoke of the field trial as an experiment involving human subjects:

"It's just fascinating and it's happening in our back yard. And it's the first ever, on the face of the earth, where a genetically modified animal, that uses human blood meal, is gonna be biting people and they don't need our consent. I'm not ok with that. If you walked into a hospital and you said 'hey, I wanna sign up for a clinical drug trial, you sign your paperwork, you have consent,

you have informed consent. They sit down and talk to you. And this thing, they were originally planning to deploy on us without any consent whatsoever."

She stated that she was 'particularly suspicious' because the field trial design in many ways triggered associations with experimental disasters (Figure 4). She explained that Key Haven, the site of the proposed releases:

"…was isolated. There was lots of water all around it. There were buffer areas. So that in my mind, if something happened to go wrong, it could be quarantined off and killed in that one area."

Figure 4. Oxitec's (2016a) image "Proposed site for investigational release of OX513A mosquitoes. Areas identified are Treated (TA), Buffer, and Untreated Control Areas (UCA), respectively"

I asked her what she envisioned might be the consequences of GM mosquito releases on her community and local environment. She took this question as an opportunity to retrospectively reflect on a recent experience:

"I just got back from camping with my ten year old [child] last night. And I drove through a farm. And I grew up in farmland. And I grew up in cornland.

Back before all seeds were provided to us from Monsanto. And corn used to be 6-8 feet tall, and you might get one or two cobs off of it. I drove through an entire farm. Miles of 4-foot tall corn plants. That were all new. They didn't have any brown yet. I mean they're brand spankin' new. . . all of them identical corn, in the identical placement . . .which doesn't even make sense to me because they need sunlight too. But it's like, that's America. . . that's earth right now basically."

Later on in the interview she clarified her positions on GM products in general:

"I'm not a GMO hater. There's been so many good advances on earth. But when they…back to corn…It just made me feel uncomfortable. Like it's just not the natural way."

At many points in our conversation, Raquel spoke to both the external triggers that motivated her activism against the field trials, as well as the internal 'uncomfortable,' 'gut' feelings that stemmed from her identity as a mother, a well-informed citizen, and a self-proclaimed NIMBY. She stated that this was her first time involved in activism and explained:

"I've never done this before, but I wanted to be a part of this. I know, just in my heart as a mother there's something wrong. Just the reality of everything I've read scientifically, they've just…they're black and white. So I had a baby at the time and at that point it was: 'I'm protecting my kid from this!' I don't know how, but, I know it's wrong."

She described herself as 'probably in the top 3 percentile of educated people' in the Keys and a lover of science, but reflected:

"I don't like low numbers or 'not significant. And I know science is not definitive. So that's why I'm not a scientist. But I would feel much more comfortable if I had definitive answers to questions and we haven't."

She also told me that:

"I'm a NIMBY. Proud. I'll admit. They [proponents of GM mosquitoes] called me NIMBY one day. I was like Yea! It's not a bad thing!"

Throughout my interview with her, Raquel was also quite vocal about her belief that financial and political interests behind the field trials compromised the rigor, transparency and credibility of risk assessments. She told me she believed: "There's a much bigger picture which I'll never be privy to. But's it's not about mosquito reduction or health concerns." Tapping into the issue of plausibility vs. accuracy, she acknowledged that many of her views might be read as conspiracies or motivated by personal interests. She described how the hype surrounding not only GM mosquitoes, but also the severity of the Zika outbreak in 2016 had affected her personally:

"As a hairstylist [her profession] …wedding after wedding cancelled. Or the bridesmaids were pregnant and didn't want to come down. We have no locally transmitted Zika down here. But yea, the press just took off and ran with it. There's Zika in the Florida Keys! It hurt business. Unwarranted. I'm gonna say it out loud. I really felt that that whole Zika scare was promoted by these companies. Look, we're the solution! Cause they swept in."

Tom's story: the importance of accountability

It was nearly a year after I met with Raquel that I returned to the Florida Keys, this time to interview three other activists who were heavily involved in leading the opposition to Oxitec's field trials. I met first with Tom, a local entrepreneur, environmental consultant, and high-ranking member of the Florida Keys Environmental Coalition, in January 2019 at a wellness center in Key West. Tom explained that he had retired in the Florida Keys several years prior He explained to me a bit about the formation of the Florida Keys Environmental Coalition following the BP oil spill:

> *"Everybody, over the next couple of days [after the spill], realized this is serious. So [we] had a number of meetings and then it ended up with the realization that in the Florida Keys we have an enormous number of environmental problems. The reefs. The sharks. The turtles. Everything. And we're all going in different directions, and so [we] wanted to speak with a single voice."*

Tom told me that after the work he did helping to monitor the effects of the oil spill, he was not interested in taking on any more fights. He said he was contacted by a few members of the FKEC asking him to get the coalition involved in activism against the field trials. He was initially unconcerned with the field trial plans because he didn't really see any difference between "modifying mosquitoes through genetics" versus "modifying them through breeding." He spoke about his plans to appease members of the FKEC and ameliorate concerns:

"I know how to do this. And the way to do this is to get a low threshold of questions. That mosquito control board can answer, but would make it appear that they were tough questions. So my people would be satisfied that our president protected us by asking these questions, and mosquito control board would go—'these are easy questions'—and everybody wins."

He explained that he asked three questions at a Florida Keys Mosquito Control board meeting in 2011: Who is the regulatory authority overseeing the field trials? What are their regulatory standards? And, what are the criteria for the field trial's success or failure?

"And I thought they were gonna laugh me out of the building. I mean that's like, Hello. You wanna put a pool in the back yard? You wanna put a stop sign in? You have to show your authority to do that, the standards in which you're gonna do it, and the criteria for success or failure. How many feet this way. How deep the pool is. And all my people are going, Yea! And everybody in mosquito control board just didn't know what to do. And let me tell what were after in those questions. Were they loaded? Yea. Slightly. But they could've answered them, if not that night, then the next day. Send me an email. It's all over. Release the mosquitoes. That was April 14, 2011. It's now January 14, 2019. And they haven't answered any of them."

Tom clarified that he didn't really care about the specific answers to these questions, he was just asking them to see if the mosquito control board *cared*. Like Raquel, he also used the 'red flag' metaphor to refer to the concerns that were raised by the perceived inability of the FKMCD to answer his questions. Also like Raquel, he

was critical of the way Oxitec had presented information to the public and held concerns over how releases might affect food web dynamics:

> *" . . . we started finding out number, one, well they started with 'female mosquitoes de minimus.' That's the number. What do you guys call de minimus? And then all of a sudden the numbers ranged. From 3% to 18% out of 22 million mosquitoes in the initial release. Now I'm getting mad. Then you factor in…I don't care if they're just male mosquitoes… What [about] the circle of life? Something's gonna eat the male mosquitoes. Frogs. Birds. Other insects. Dragonflies. What's gonna eat them? All of a sudden now they're in the food chain. . .Why aren't they telling us the truth? They could've done this so easily, but…"*

I asked Tom if he thought that his views and concerns were representative of the larger Florida Keys community. He expressed that most people were clueless, and "didn't understand the fundamentals of policy, or public health, or experiment." He provided an example:

> *"Back in the day, they did a lot of experiments in prisons. But they changed those laws and now if you want to conduct an experiment in prisons, you have to get informed consent. They have to actually know what's about to happen to them and you better get it in writing. Now, you're not gonna just tell them. You'd better make sure they understand. So these lunatics are gonna be sending out genetically modified mosquitoes? Without informed consent? What are you guys nuts?"*

He further clarified that most people didn't see a problem with Oxitec's field trials because they heard their studies were peer reviewed. He said that his experience, and expertise, in public policy surrounding environmental issues had shed light on the problems with peer review. In his words:

> *"Peer reviewed. I mean peer review. What a joke all that crap is. I don't mean to burst your bubble but they really are concerned more with format than substance. Right? They never get involved in the science. They get involved in how it's conducted. Or the format of it. And then, they're so easy to fool. You know? It's like, so, when somebody says 'peer review' I go: does anybody realize what peer review is and what they're looking for? They're all ready to get on the bandwagon without being critical. Peer review is not a critical analysis of what you're reading? My two cents."*

His personal and professional experiences had also led him to conclusion that:

> *"Environmental laws are not made or enforced to promote environmental protection. They are made to give someone an advantage. Now that is a very cynical way of looking at the world, but I just know better. Environmental laws aren't there to clean up the environment, they're there to give some company, or country, or individual, an advantage over somebody else. I don't care if it's coal mining, acetone crap…I don't care what it is. When it gets to the state legislature, money talks."*

While he criticized the peer review process and the importance of getting the public on board before releases were carried out, Tom also privileged the authority of science in many of his statements. He argued that decisions over the field trial "should

never have gone one way or another, because of public opinion. This is science. The science should have ruled." He explained that "science is questioning", and that "science is not accepting someone's word." At one point he paraphrased a now famous quote by the philosopher George Santayana (1955, 50):

> *"So my point is this. Skepticism is the chastity of intellect, in that it should not be given up very quickly. Be skeptical of everything and everybody because nobody in this country is. Check out everybody."*

He went on explain that:

> *"I'm not a conspiracy theorist. But I know too many people in government who are hiding shit. And how they hide shit. I know how they do it. Should we be fearful of own health administration? Dial 1-800-Flint Michigan."*

Tom often times switched back and forth between evaluating the field trials based on a public health and environmental perspective, and from the standpoint of public relations. While emphasizing that Oxitec's profit motives, lack of transparency, and hype all contributed to his negative evaluations of GM mosquitoes he also told me, when I asked him what Oxitec could have done differently in their public engagement efforts:

> *"The CEO of Oxitec should have gotten some blue jeans, and a t-shirt. And came down here in flip flops. And invited us over. And he should have sat there. Not on the stage. Sat at our level."*

He added:

> *"If you wanna sell something, don't try to do anything in public policy unless you're willing to get involved with people and develop relationships. Not with*

the elected officials. Not with the appointed officials. But you know, come in, and start going to the coffee shops and the bars. Do that months before. If you have a big investment, you better talk to the people. You better look at how they talk. What clothes they wear. Right? You have to [know] what their prejudices are. You better learn everything about them before you come up with something this major. And they came in and danced around and thought they had the mosquito control board. Oh we got this. They ran into a buzz saw in the city commission. We kicked them out. Right? And we won. We won the whole thing."

I was struck by how closely Tom's sentiments aligned Wynne's (1993) observations on public uptake of knowledge in the arena of science and technology. Wynne argues, that central to lay evaluations of new technologies, are considerations of the behaviors and postures of the scientists and institutions involved in risk communication efforts. In both my interviews with Tom and Raquel (and in the interviews that follow), violated expectations—surrounding Oxitec and the FKMCD's engagement efforts, the FDA's conduct, and perceived norms of science—served as major cues in activists efforts to make sense of the possible risks involved in GM mosquito releases. Near the end of my interview with Tom, I asked him what I might be missing, as an outsider studying the controversy. He responded by talking about what he perceived to be a lack of accountability and government oversight:

"What you're missing is, where is the governmental responsibility? Where does corporate responsibility and governmental public policy connect? And we have it right here. There shouldn't have needed to be a Florida Keys

Environmental Coalition. Because Oxitec should have been responsible to make sure their product was right. And to be honest about it either way. And they weren't. Our elected officials should have stepped in and looked at this critically and honestly. And they did not. Our local and county and state board of health should've gotten involved in this, and they did not. Not once."

Ethan's story: becoming a movement intellectual

A year before I met him, I saw Dr. Ethan Charles give a presentation at a public workshop hosted by the Florida Keys Mosquito Control District. Following presentations by representatives of Oxitec, Mosquito Mate, and other stakeholders, Ethan took the podium to express his concerns surrounding Oxitec's GM mosquitoes, drawing from to his expertise as a medical doctor. Given that tetracycline antibiotics are used to inactivate lethal genes in laboratory-reared mosquitoes, Ethan was especially concerned that once released, these mosquitoes might spread antibiotic resistant bacteria to the organisms and objects they came into contact with. At the start of our interview at his office in the Keys, Ethan spoke to me about his professional interests in antibiotic resistance. Pointing to a framed New York Times article on the lobby wall, he explained:

"Bottom line is, the newspaper clipping over your head, you can see the date—it's October something 1996. That [article] is on TB Resistant bacteria. I'm working with the American Lung Association at the time. I'm chief medical resident. Next thing you know, I'm sitting with a New York Times reporter asking me questions. And then I'm on the front page opening of the New York Times. I had no idea I was going to be the front page opener. I literally was

working with people with resistant bacteria way back in the 90's when I finished medical school. And I ended up running ambulatory care for Rutgers New Jersey medical school. So for one of the med schools I ran the practice that the school opened—you know for quality improvement and so forth. What I will tell you is that antibiotic resistance was always a huge issue. I had no clue whatsoever that this [GM mosquitoes] had tetracycline or antibiotic involvement at first. I heard they had a genetically modified mosquito and that it was sterile and that it would go ahead and wipe out mosquitoes, basically by making females not have babies. I had no idea."

Ethan went on to tell me that when he first heard about the field trial plans he thought: "Cool. I loved it." Like Raquel and Tom, Ethan was adamant that his motivations for opposing the field trials were not due to anti-GM sentiments. He recognized the place of GMO's in society and his professional work:

"So when it comes down to genetically modified, I use genetically modified products everyday—have never had anything to do with that [anti-GM activism]. But because activists were out there with their picketing signs, and these people were all over, and then, the people in Key Haven were like: 'what are you releasing on us that's genetically modified? We've seen way too many sci-fi movies about this going bad.' It was out of control."

In addition to positioning himself as ambivalent about, if not pro, GMO, Ethan undermined the credibility of other activists who were motivated by anti-GM stances. I also saw this play out at several times in my interviews with Raquel and Tom. At one point in my interview with Raquel, she informed me some activists had been

ostracized from organized resistance efforts for using terms like "frankenskeeters" in public discussions. Tom told me a similar story about how the core group of opponents to the field trials were often frustrated with other activists for using various sci-fi references to articulate their concerns (i.e. references to Jurassic Park, Frankenstein, etc.).

Ethan's concerns over the potential for GM mosquitoes to spread antibiotic resistant bacteria were triggered by a discussion he had with his wife. He told me that she had asked him if he knew what a TTA protein was, since it was referenced in Oxitec's promotional materials. Ethan explained:

> *"I'm still not caring [about GM mosquitoes] at this point. Until my wife comes to me [and says]: 'What is TTA protein?' I don't know what TTA protein is, I said. Where do you have the reference? And I'm like, half thinking about my patients and she goes: 'Tetracycline Trans Active.' Tetracycline? I just wrote that four times I said to myself. What are [they] using it for? And then I read what was going on."*

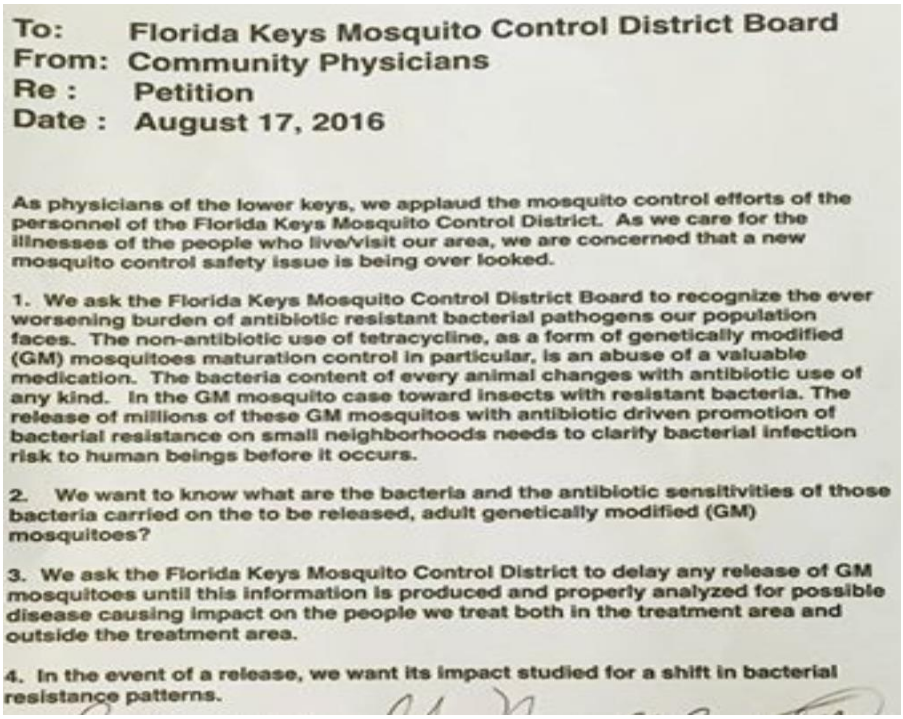
He went on to tell me that he subsequently went to the next mosquito control board meeting to express his apprehensions, and obtain clarification on how, exactly, Oxitec could be sure that their mosquito laboratories weren't a "superbug factory." Drawing on his expertise in medical science and his understanding of evolutionary processes, Ethan detailed how and why his concerns were heightened following the FDA's findings on Oxitec's risk assessment.

> *"Suddenly the FDA puts down that there's low risk. Negligible risks in their FONSI [findings of no significant impact]. It states that there's negligible risk.*

I say how the hell can that be? That makes no sense in life. I mean, I can't—if you came in here with a sore throat and you told me that you wanted antibiotics, I would tell you no. I've actually, on the news, NBC nightly news, had me on as an expert. Literally I'm explaining, no, why a person with a sore throat? . . . Everything becomes resistant. I'm explaining this to the mosquito control board, that no matter what you use, the organism, if it's not completely annihilated, is going to evolve, related to this being part of its environment. And the [offspring] that survive are going to be the ones that take over. And that's what they're telling me they've had to do this for, because the bugs are getting resistant. The mosquitoes are becoming resistant to pesticides. Well, I said, if you start using the antibiotic, it's already developing resistance to antibiotics that us physicians, we physicians are dependent on. You're literally trying to make it so our antibiotics don't work anymore."

Ethan's worries that the use of tetracycline in Oxitec's laboratory reared mosquito might have unintended consequences led him to request that the company swab a sample of mosquitoes before releasing them to check for antibiotic resistant bacteria. He told me that he specifically the asked Florida Keys Mosquito Control District and Oxitec to have a third party vendor test for resistance changes using an antibiogram test. When his request was denied by the company he circulated a petition amongst local physicians in the Keys, garnering over two dozen signatures (Figure 5). In this petition, Ethan concisely articulated his view, that the benefits of using GM mosquitoes needed to be weighed carefully against their potential risks, by posing a

question in its closing line: “Are we pouring gas on one public health crisis [antibiotic resistance], hoping to treat another [vector borne disease]?”



To: Florida Keys Mosquito Control District Board
From: Community Physicians
Re : Petition
Date : August 17, 2016

As physicians of the lower keys, we applaud the mosquito control efforts of the personnel of the Florida Keys Mosquito Control District. As we care for the illnesses of the people who live/visit our area, we are concerned that a new mosquito control safety issue is being over looked.

1. We ask the Florida Keys Mosquito Control District Board to recognize the ever worsening burden of antibiotic resistant bacterial pathogens our population faces. The non-antibiotic use of tetracycline, as a form of genetically modified (GM) mosquitoes maturation control in particular, is an abuse of a valuable medication. The bacteria content of every animal changes with antibiotic use of any kind. In the GM mosquito case toward insects with resistant bacteria. The release of millions of these GM mosquitos with antibiotic driven promotion of bacterial resistance on small neighborhoods needs to clarify bacterial infection risk to human beings before it occurs.

2. We want to know what are the bacteria and the antibiotic sensitivities of those bacteria carried on the to be released, adult genetically modified (GM) mosquitoes?

3. We ask the Florida Keys Mosquito Control District to delay any release of GM mosquitoes until this information is produced and properly analyzed for possible disease causing impact on the people we treat both in the treatment area and outside the treatment area.

4. In the event of a release, we want its impact studied for a shift in bacterial resistance patterns.

Figure 5. Community physicians’ petition to have Oxitec test for antibiotic resistance

According to Ethan, Oxitec responded to the petition by telling him that these issues were addressed with the FDA and that there was no risk of GM mosquitoes transmitting antibiotic resistant bacteria. Feeling that his concerns were being dismissed, it was at this point that he jumped on the activist bandwagon. He was quickly elevated to the status of a movement intellectual (Eyerman and Jamison 1991). As Leung et al. (1992, 5) explain, movement intellectuals are those activists who “draw on national or cultural traditions to articulate new identities and ideals.” Ethan’s experience as a medical doctor and his expertise in antibiotic resistance lent scientific

credibility to the resistance movement, and helped activists reframe their articulations of concerns through a scientific lens.

Like Tom, Ethan's sensemaking work seemed to simultaneously privilege the cultural authority of science, *and* critique contemporary scientific practices. Similar to other activists in my study (and as is often seen in public discussions of environmental issues), Ethan's criticisms drew heavily on the precautionary principle

> *"…one of the biggest things with research is, most research is nonsense. If you don't publish you perish right? Lady who's doing a paper. So when it comes down to it, my issue really was, let's go ahead and let's address this. And let's just do it simple. If Oxitec is clean, it's clean. Let's say they have a resistant germ. This chair probably has a resistant germ. Then let's just plan for it. You know? Let's look at that."*

To be clear, Ethan was not advocating for zero risk. Similar to other participants in my study, Ethan took issue with the marketing hype surrounding GM mosquitoes, and 'unrealistic' claims that releases carried no significant risks. He articulated this sentiment concisely with:

> *"The number one thing likely to kill either you or me today is our cars. The way you got here. And I'm not laying in front of cars saying don't drive. I'm saying that, guys, don't tell me you have a perfect technology. Because you saw how they billed it. They billed it as near perfect."*

Craig's story: the importance of trust

Craig was the last activist I interviewed in January 2019. We met at Lorelai's Restaurant and Cabana in Islamorada during my final day in the Florida Keys. Like

Tom, Craig is also a high-ranking member of the Florida Keys Environmental Coalition. In line with the three other activists I interviewed, Craig told me that had not intended to get involved in GM mosquito activism, and initially 'loved' the idea. He started our interview by talking about his expertise as an engineer, and the importance of trust in science communication.

> *"So, communication, for us, really falls into a world of trust, alright? And it should for anybody that's scientific as well. If you don't trust the person giving the information, you ask more questions. I'm a master's degree electrical engineer. I pretty much have done science. I did research and development for GE [General Electric] for 6 years. Alright? So it's not a remote concept to me, or practice, But you know, when the first, you know, marketing push that you hear, that it's coming from Oxitec being fed to your mosquito control board, and to the radio personalities—well, they don't have any science. I'm going, I have a master's of science degree. I work with a senior technical advisor that has a PhD. We are able to analyze good science, and we're able to ask good, pertinent questions. That you should be able to answer clearly without obfuscation and without, you know, a side step."*

Like Raquel, he felt that the "details mattered" but that these details were often glossed over in science communication efforts. He commented on the ways in which activist concerns were discredited and misrepresented by Oxitec and the FKMCD:

> *"All these people that you [Oxitec and FKMCD] consider so simple have taken the time to learn. And just because they may not have some credential,*

doesn't mean their ignorant or inept. And you owe them respect, and recognize that they have worked and are asking questions."

For Craig, Oxitec's 'market-speak' was a major cue that triggered his sensemaking activities surrounding GM mosquitoes. In line with stories and statements provided by other participants in my study, Craig spoke at length on the problem of hype in science communication:

"I learned a long time ago, when I was young in engineering, that you if you wanna get a hold of someone? You call them. You wanna convince them that you're telling the truth? You put it on paper and print it. And they'll believe it. So that's exactly what happens with modern science today. They want to market. They don't do it by putting an ad out there. They don't do it by going door to door, necessarily, though that actually happened here. They do it by getting some independent, objective, source, to corroborate what they're saying. Just because they repeat it. Not because they understand it. Because they repeat it. And that, to me, is one of the biggest problems of science."

At several points in the interview, Craig mentioned that he felt that Oxitec and the FKMCD had presented the public with both oversimplified and idealized details about GM mosquitoes. In his words:

"I don't have a problem with saying this is, in general how it [GM mosquitoes] work. In general…but the characterizations of what you're describing to people matter. Oxitec comes in and says: this is how it works. And it's not, like: let me tell you in theory how this works perfectly. This is the

perfect design. Hey, if you had come in and said this is it but nothing's perfect, and this is how it actually performs….Isn't that simple enough?"

Craig informed me that, in his years as an environmental activist, he had noticed some alarming patterns in how profit-driven companies (like Oxitec) promote their products. He shared his observation that, when companies that think they have a "cash cow," they will tell consumers that "it's the only thing that does the job." At the time of our meeting, Craig was involved in an initiative to inform people about the negative impacts of oxybenzone and oxynoxate-based sunscreens on the health of reef ecosystems. He told me that he saw many similarities across issues, explaining that there is:

"…a correlation between the patterns of profit driven companies that think they have a cash cow. And that's what Johnson & Johnson [one of the leading manufacturers of Oxybenzone-sunscreens] believes. Oxybenzol and Oxynoxates are the cheapest things they can do."

He went on to say that this is the "exact same thing that Oxitec did to us." A few moments later he added:

"We cannot allow science to offer convenience and for it to put us at risk. Especially when we don't know the level of risk. I don't mean to misrepresent, or combine both subjects, but they are pertinent. And when you look at oxybezone, look, it basically gets inside of your body, alright?"

Similar to other participants in my study, Craig seemed to largely make sense of Oxitec's technologies through the lens of other environmental and public health issues. Craig's worries over the ability of both sunscreens *and* GM mosquitoes to 'get

inside the body' was especially interesting. His concerns over the ability of GM mosquitoes to penetrate corporeal boundaries were a common element in Craig's narrative which he often articulated, like other participants, through the language of consent. He reasoned that:

> "*You're looking at a technology that really should fall under what's called the common rule with health and human services. Which means that when you have an invasive test on your body, you should be informed about what that means, in detail. Whatever detail you need. And you have to either consent or deny."*

He continued:

> *"The Nuremburg trials basically outlawed that type of behavior [human experimentation sans consent]. And, of course, the conversation is, 'well, it's not the same thing.' Why isn't it? People are gonna get bit."*

I was reminded here of the work of Douglas (1966, 69) and her argument that there is always a "continual exchange of meanings" between corporeal and social concerns. I was curious to learn more about Craig's thoughts on GM products in general, and asked him what role he thought the GM issue played in public resistance to the field trials. He explained:

> *"You see all this black ink that come out, it just tells how wonderful genetically modified mosquitoes are gonna be, and that, you know, there are these people that are afraid of genetic modification. It's not fair, and it's not correct. I don't think anyone was afraid of genetic modification down here. There are some. Sure. Look, I've been invited to many things. GMO-Free Florida. GMO-Free*

USA is one of our [FKEC] supporters. But that doesn't mean, you know, I believe in being abstinent from genetic modification research. I don't. I think it's a technology that if you use it appropriately, it's going to have a place."

He went on to clarify that, personally, he abstains from GM products, and elaborated on his views:

"Now, do people have an inherent fear of genetic modification? Yep. Why shouldn't they? I don't think that's wrong. People aren't stupid, you know? There's a risk there. They understand that. They want that risk characterized. They want you to be clear and honest."

For Craig, Oxitec's "years and years of misrepresentations" on the risks and benefits of their GM mosquitoes had resulted in a lack of trust and confidence in the company and their products. He also recognized that distrust is "pervasive in our society and it should be." He implicated the FDA in this widespread public distrust, stating that:

"You know, one of the problems that comes with this whole credibility of communication is the fact that people start relying on, 'Oh, the FDA this. The FDA that.' But then, it always comes to---well, thirty something percent of the things the FDA approves end up being recalled. You know and people become aware of these things, and so there's a subjectivity of whether or not they trust regulatory process."

In addition to regulatory failures, Craig also noted that companies' failure to deliver on their promises surrounding GM products, also contributed to his feelings of distrust.

"I look at the whole picture, you know? I'd prefer not to have genetic modification in my food either. And it's kind of an indentured servant program sponsored by Monsanto and Baer. You know, there are absurdities everywhere. And that's one of them. You haven't done anything for world food production other than you make products available on a finance program that people can't get out of it once they get into it."

As an alternative to Oxitec's GM mosquitoes, Craig was a leading figure in promoting Mosquito Mate's Wolbachia mosquitoes. Although Mosquito Mate's technology works similarly to Oxitec's, it does not have the nomenclature of 'GM' attached to it. I was curious as to why some of the most vocal opponents to Oxitec's field trials, would endorse another product that carried many of the same uncertainties regarding its effects on ecosystems and human health. Craig outlined several reasons why he supported Wolbachia mosquitoes:

"All the things were done the right way. Go look at the WHO guidelines for even gene drive mosquitoes. Which are the newest version of genetically modified mosquitoes…They [the WHO] put right there at the top: Public communication. Public outreach. You know, getting their buy-in. That's exactly what they did with Wolbachia…They went through a process."

He continued to explain that, in contrast to Oxitec's mosquitoes, he believed that the risks involved in Wolbachia releases were well characterized:

"Now let me put the technologies a lit bit in perspective of each other. You've got a technology using genetically modified mosquitoes, with a host of really cloudy answers and poorly answered questions, and uncertainties. And then

you have Wolbachia. A bacterium that's already on the vast majority of insects in the world. Approximately 65%. So now there's a lot of other things that can happen. You know, science is finite, it's not all-knowing. It's just what it is, what we know today. And we rely on that as our best knowledge, and we make mistakes. All because we have unknowns basically. So could something bad happen? Yes. But right now we haven't been able to characterize anything, so [Mosquito Mate] did a great job of coming in and spending the time with the people. But the concerns were low, because of the ethics."

Here, Craig touches upon the role of identity, values and, social relations in sensemaking about both GM *and* Wolbachia mosquitoes. I interpreted his statement that 'concerns were low because of the ethics' to mean that perceived value similarities between himself and the Mosquito Mate corporation had fostered a sense of trust in the company. This trust, in turn mediated Craig's perception of risk surrounding Wolbachia mosquitoes. In fact, all of the participants in my study touched on this reciprocal relationship between risk and trust (or distrust), in one way or another.

Interestingly, despite Craig's distrust of Oxitec, he told me that he thought the original intentions surrounding the development of genetically modified mosquitoes were good. However, he felt that the science and methods behind them were lacking:

"I think it's bad form and bad methodology. Alright? It's a shame. And they just, brute force. No! Industry. Ya ya ya! Science. You know? NO! Bad science! Bad technique! Bad quality control! Lots of bad things. Can they do a good job? I hope they can. I don't have any malice for them other than you have

> *performed badly there. You need to show you can perform well. You need to correct these bad things. Your intent, when [Oxitec] came up with this concept and developed this? Brilliant. Wonderful. Altruistic. You know? Save the planet. I love it. Save people on the planet. But that's not what it ended up being. You know, you need to be honest about where the weaknesses are and go correct those. That's all [we] want them to do.*

As indicated in the quote above, as well as in interviews with the other participants in my study, it became especially clear that sensemaking about GM mosquitoes often took the shape of boundary work (Gieryn 1995)—or efforts to demarcate science from non-science. I elaborate on this notion in the ensuing discussion.

Discussion

Wyndham-West et al. (2017, 2) argue that, to research sensemaking "is to come to an understanding of what events and information mean, how they become significant and how they are acted upon." Through the restorying of individual narratives above, I have attempted to do just that, as well as to showcase the various points of convergence and divergence in activists' sensemaking activities surrounding GM mosquito releases in the Florida Keys. My examination of individual narratives reveals that activist motivations to resist the field trials were rooted in very different personal and professional interests and experiences. At the same time, individuals' narrated accounts tap into a "basic shared storyline" (Brown, Stacey, and Nandhakumar 2008, 1052) around which intersubjective meanings, and a collective rationale for resistance, emerge. This storyline centered on the notion that Oxitec's for profit motives had compromised the rigor of their risk assessments, as well as the

transparency and credibility of their communication efforts, and that regulatory institutions such as the FDA were incapable of protecting the public from potential unintended consequences of Oxitec's hubris.

In and of itself, this finding offers little to the literature on the Florida Keys controversy, as these observations have been noted elsewhere (Herndl and Zarlengo 2018; Taylor and Dewsbury 2019; Taylor and Dewsbury In press). Yet, my examination of activist narratives through the lens of sensemaking offers more nuanced insights into the various cues, events, social interactions, and identities that link individual understandings of GM mosquito field trials to collective meanings. While all of Weick's elements of sensemaking were present in activist narratives, some were more salient than others. Perhaps most strikingly are the role of cues and identity in triggering sensemaking work in the first place.

Weick (1985) argues that people's expectations in any given scenario largely determine what cues they focus in on and attach meaning to. In many cases, cues take the shape of *violated* expectations (Maitlis and Christianson 2014). For the activists in my study, perceived hype and inaccurate/inconsistent representations of GM mosquitoes embedded in communication efforts, not only by Oxitec but also by FKMD and mainstream media outlets, were cause for concern, and compromised participants' willingness to trust in the motives and competence of scientists promoting GM mosquito releases. As far as expectations go, leading activists in protests against GM mosquitoes were not demanding zero risk, but rather that regulatory institutions and GM mosquito proponents offer more realistic assessments of how risks measured up against benefits. Similar to findings by Marris (2001, 547),

the participants in my study "were perfectly aware that their lives are full of risks that need to be counter-balanced against each other and against the potential benefits." In other words, activist narratives reveal that it was neither GM mosquitoes, nor the uncertainties surrounding their impacts, that were the prime targets of activists' resistance. Instead, it was the 'institutional denial' of inherent uncertainties in the proposed releases that motivated collective resistance efforts (Marris et al. 2001).

This is not to say the GM-issue was irrelevant to participants' sensemaking work. In fact, various features of GM mosquitoes and the field trial plans appear to have guided the arc of activists' sensemaking in a particular way. While all the participants in my study positioned themselves as either pro-GM or ambivalent about GM products, and viewed GM technologies as both necessary and inevitable, it was clear to me that the perceived unnaturalness and novelty of GM mosquitoes mattered to activists' expectations regarding institutional risk assessments. I got the sense that, while not opposed to GM products, all of the activists in my study perceived GM mosquitoes to be riskier than their non-GM alternatives (such as Wolbachia), despite carrying similar uncertainties, and believed they should be assessed more rigorously.

Part of this discrepancy in expectations invariably stems not just from the perceived unnaturalness of GM mosquitoes, but also from participants' sharp awareness of institutionally sanctioned habits (and their problems), as they pertain to GM communication and regulation in general. Elsewhere, it has been noted that, in their original engagement efforts, Oxitec frequently engaged in a process of associative argument and switching, whereby the company strategically positioned their GM mosquitoes as either novel *or* conventional depending on the context (Reis-

Castro and Hendrickx 2013; Taylor and Dewsbury In press). For example, when discussing their benefits, Oxitec emphasized the uniqueness, and superiority, of their product as a vector control strategy. At the same time, the company downplayed the novelty of GM mosquitoes in discussions of their risks, by rhetorically positioning their technology as an improved variation of the Sterile Insect Technique. This tendency to switch between novelty and convention was not lost on the participants' in my study, and this communicative tactic appears to have triggered suspicions surrounding company motives. In fact, all of the activists I talked to retrospectively made sense of their mistrust of Oxitec by reflecting on instances where they felt they had been presented with inconsistent, inaccurate or oversimplified explanations by the company. Participant narratives further confirmed Wynne's arguments (1992; 1993; 2008), that assessments of the trustworthiness and institutional behaviors of scientists and regulatory are critical to public evaluations of new technologies, such as GM mosquitoes.

Reiterating previous observations on public reactions to the field trials (Taylor and Dewsbury 2019), my participants' concerns over the FDA's ability to juggle its dual priorities—to facilitate biotech innovation while at the same time ensuring public safety—paralleled scholarly critiques on the agency's neoliberalized mode of risk governance and corporate bias (Meghani and Kuzma 2018; Meghani 2014; Hogarth 2015). Knowledge of past failures of science and regulation was invoked by the activists in my study to both anticipate the potential risks of GM mosquito releases *and* to challenge pervasive narratives of progress surrounding technoscientific innovations. In many ways, participants' sensemaking around GM mosquitoes

followed the logic of Beck's (1992) much discussed risk society, a finding also noted by Herndl and Zarlengo (2018) in an unrelated study on the Florida Keys controversy. Positioning themselves as reflexive citizens, the activists I interviewed rationalized their resistance to the field trials by highlighting the contradictions and limitations of experts and regulatory bodies in managing and predicting the risks of GM mosquito releases. Instead of blindly trusting expert assessments, my participants demonstrated that they were proactive in educating themselves, and others in their community, about the risks and benefits of using GM mosquitoes as an alternative vector control strategy. In the process of doing so, they developed various forms of counterexpertise about diverse subject matter—including knowledge of GM and other techniques for vector control, of potential ecological and public health risks of GM mosquito releases, and of policies and laws surrounding experimental practices.

Indeed, much of the knowledge deployed by activists seemed to be filtered through the teachings of the environmental movement and the precautionary principle (Tesh 2000), and I was struck by the wide range of other issues (for example, GM foods, environmental pollution, antibiotic resistance, historical examples of unethical human experimentation, etc.) that participants deemed relevant to their evaluations of GM mosquitoes. Exhibiting a type of sensemaking that Marcu et al. (2015) term 'pragmatic reasoning,' participants anchored their understandings of GM mosquitoes in more "familiar objects, notions, and technologies" (12). Instead of eschewing science in resistance efforts, activists often situated their protests within a scientific framework (Tesh 2000). This is not to say, as Tesh (2000) also observes, that the activists in my study always used science rigorously or limited their understandings to

scientific evidence. Rather, I am arguing here that the activists in my study did not rely on any 'special form of reasoning' (Tesh 2000, 93), but rather located their arguments within environmental and public health frameworks. Exhibiting what Eden et al. (2006) call 'epistemic flexibility,' activists both relied on science and critiqued science in their arguments.

Along the same lines, participants in my study drew heavily on their knowledge of traditional norms of science itself to judge the actions of Oxitec, the FKMD and the FDA in field trial matters. As sociologist Robert Merton observed in 1942, the ethos of modern science has traditionally been characterized (by scientists themselves) as adhering to four norms: Communalism (openness and transparency), Universalism (objectivity and standardized criteria), Disinterestedness (free from bias and self-interest), and Organized Skepticism (constant scrutiny of knowledge and evidence) (Merton 1942). Historically, these norms have served both as a set of agreed upon principles to guide scientific research, and as mechanisms for demarcating science from non-science. While these norms continue to perform prescriptive functions by providing guidelines for what scientists *ought* to do, they are often transgressed in actual practices of scientific research and application. Nowhere is this more apparent than in the realm of biotechnology, where proprietary patents, intellectual property rights, and commercial incentives are seemingly in direct antagonism with basic Mertonian principles.

In all of my interviews with activists, scientific norms were leveraged to problematize GM mosquitoes (and the science behind them) and to rationalize resistance. In fact, in many instances, sensemaking was indistinguishable from

boundary work. Boundary work, according to Gieryn (1983, 782) involves the "attribution of selected characteristics to the institution of science (i.e., to its practitioners, methods, stock of knowledge, values and work organization) for purposes of constructing a social boundary that distinguishes some intellectual activities 'as non-science.'" While this concept of boundary work has traditionally been used to explore the ways in which scientists maintain credibility and cultural authority by demarcating science from other forms of knowledge, it was also integral to the sensemaking narratives of the participants in my study. Sensemaking, for activists, was as much about demarcating good science from bad science using traditional norms of science, as it was about anticipating the risks of field trial releases.

It is important to note here that implicit *and* explicit references to Mertonian norms in participant narratives served multiple other rhetorical functions as well. Throughout my interviews, I was acutely aware that activists were attempting to convince me of the rationality of their positions, and the credibility of their claims. As Gauchat (2011, 4), observes participant accounts are always "subject to the performances of 'Publics-in-Particular'—or those publics (such as activist groups) who are committed, in one way or another, to "engaging with science'" (Michael 2009, 622). Inevitably, these performances include the strategic construction of "collective identities for various audiences" (Gauchat 2011, 4), including researchers. While on first glance this acknowledgement may appear to undermine the trustworthiness of my findings as they pertain to activists' sensemaking, I would argue that the rhetorical nature of participant narratives is especially revealing in that

sensemaking always occurs in the context of identity construction and maintenance (Brown et al. 2008). Paraphrasing Weick et al. (2005), Debergue and Harrison (2015, 155) write:

> *"Who people think they are (self-awareness) in their context shapes how they interpret events and choose to act. Their general orientation projects self into their environment. People notice and extract cues from the environment and interpret those cues in light of values, beliefs, experiences, narratives and mental models."*

In their interviews with me, Raquel, Tom, Ethan and Craig all positioned themselves as accountable, self-informed citizens. Similar to findings by O'Key and Hugh-Jones (2010) and Hobson-West (2003) in their studies on vaccination resistance, skepticism was deployed by activists in my study as an expression of good judgement, and of good scientific citizenship. Participants often justified their resistance efforts through their desire to protect the people and the places that they loved, and they devoted considerable attention to attempting to convince me that they possessed the qualifications and knowledge to do so. With the exception of Raquel, who often emphasized that she was speaking from a lay perspective, participants saw their individual forms of professional expertise (in business, medicine, and environmental policy) as relevant and valuable to field trial deliberations.

Disinterestedness was also implicated in the construction of identity, at both the individual and group level, as all of my participants positioned themselves as 'accidental' activists—who were initially reluctant to get involved in GM mosquito protests, and ambivalent about GM products in general. Undoubtedly, expressions of

disinterestedness were crucial to establishing and maintaining credibility, and were closely linked to both identity, as well as boundary, work. As (Gauchat 2011, 756) explains:

> *"From the boundary work perspective, science is the cultural domain where credible 'truth claims' can be made. Research on boundary work has shown that "credibility contests" often boil down to which groups can successfully claim disinterestedness, unbiased methods, and objective knowledge."*

Moreover, in efforts to protect their identities as informed and disinterested citizens the participants in my study often drew boundaries between themselves and other publics, including other activists who they perceived as being motivated more by values than facts. I noticed in my interviews that participants attempted to distance themselves from, and often discredited, the views of other opponents with extreme anti-GM stances, likely in efforts to maintain their own credibility.

The fact that activists' expressions of (what they perceived to be) informed judgment and good scientific citizenship were explicitly labeled as anti-scientific and uniformed by proponents of GM mosquitoes helped create an impasse for productive deliberations and conflict resolution in the Florida Keys. I am reminded here of Wynne's (2007) argument on invited vs. uninvited participation in efforts to engage publics in science and technology decisions. He explains:

> *"Uninvited public engagements usually arise in response to expert-led, expert-justified interventions and misrepresentations, exacerbated by further expert-led impositions of provocative and alienating definitions of what the issues and*

concerns are; thus also, by misrepresentation and lack of recognition of those publics themselves."

Scientists' delegitimization of activists concerns, and the discrediting of the individual forms of expertise that activists brought to discussions, contributed not only to participants' feelings of alienation and mistrust, but also motivations to resist the field trials. It appears that proponents' representations of activists as anti-GM, misinformed, and non-scientific in their reasoning, was especially threatening to the groups' collective identity as science enthusiasts, environmental and public health stewards, and good citizens. This final finding in particular, reiterates one of Wynne's (2001, 445) most crucial insights on how publics make sense of science and technology—"namely, that sceptical public reactions are not reactions to (supposedly misperceived) risks as such . . . but rather are public judgements of dominant scientific and policy institutions and their behaviours, including their representations of the public."

Some readers will undoubtedly question how my study contributes to the public engagement with science literature and science communication literature—and to our understanding of public scientific controversies in general—on the grounds that my findings have been generated from an extremely small sample size. To be sure, I am not arguing that these findings are representative of larger publics, or even the average citizen who may encounter information on GM mosquitoes. Rather, my study provides insights into how a small, organized group of activists made sense of the science and risks surrounding field trial releases. Yet, herein lies its contribution. In her now classic work on environmental activism, Tesh (2000) suggests that, rather

than asking how individual, unaffiliated citizens make sense of new technologies, we should instead be asking the question: what reasoning do organized groups use? This suggestion is rooted in an acknowledgement of the fact that policy decisions are influenced primarily by organized groups, rather than by individual, unaffiliated citizens. Moreover, as was the case in the Florida Keys these organized groups are instrumental in translating and disseminating knowledge to larger publics.

Conclusions

Sensemaking has proven to be a valuable framework for capturing how Florida Keys activists construct retrospective and plausible meanings to rationalize their ongoing resistance to field trial releases of genetically modified mosquitoes (Weick, Sutcliffe, and Obstfeld 2005). Through the restoring of interview data, I have attempted to offer a thick description of activists' sensemaking work, and map the intersubjective meanings that arise from individual narratives. To this end, it was my intent to privilege participant voices and perspectives in their own words, and on their own terms. Still, the meanings of these stories I have presented were co-constructed, as I have inserted my own subjectivity through my interpretations of participant statements, my determinations of what stories to include in narrative sketches in the first place, and my choices surrounding how to best present these stories to the reader. Through the process of restorying interview data, I have—unavoidably—produced *new* stories (Byrne 2017). Thus, the stories presented and examined here are as much a product of my own sensemaking work as they are of my participants.

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Supplemental Materials

For the purpose of illustrating how participants were recruited, the types of interview questions asked, and the methodological process for Chapter 4, I have included the following items here:

1. IRB Materials
    a. Study advertisement letter
    b. Consent forms
2. The interview script
3. The synthesized version of my interpretations which was sent to all participants for member checking.

1. ADVERTISEMENT LETTER

Dear_____,

I am writing to let you know about an opportunity to participate in a study exploring perceptions of science communication surrounding the use of genetically modified mosquitoes in the Florida Keys. The study is being conducted by myself, Cynthia Taylor, a PhD student in the Science Education and Society Program at the University of Rhode Island under the guidance of my dissertation advisor, Dr. Bryan Dewsbury. This research intends to better understand a) how scientists have communicated and interacted with residents in the Florida Keys b) how scientists and residents perceive the effectiveness of these interactions, and c) how communication and public-scientist interactions related to the release of genetically modified mosquitoes have influenced individuals' opinions regarding possible benefits and risks. This research has been approved by the University of Rhode Island (URI) Institutional Review Board (IRB).

I am hoping to recruit both Florida Keys residents and scientists to participate in a short, in-person interview with me sometime between September 2018 and September 2019. Interviews are expected to last approximately 45 minutes, but may be terminated at any time by the participant. I am specifically looking for participants who are aged 18 or older, who have 1) either attended OR presented at a science communication event/meeting during which genetically modified mosquitoes were discussed, or 2) who have followed communication surrounding the proposed release of genetically modified mosquitoes (through media, internet, etc.) at any point during the past 12 months. My study offers no direct benefits to participants, however you may view the potential contributions of this project to the advancement of research in science communication and public understanding of science as incentive to participate.

I kindly ask that you distribute this letter to anyone you think might be interested in learning more about/participating in my study. Interested individuals may contact me directly at (401)-439-3902 or at cynthia_taylor@uri.edu.

Thank you for your time and consideration!

Cynthia Taylor
PhD Student, Science Education and Society
The University of Rhode Island

2. CONSENT FORM

Consent Form for Research

Greetings! You are invited to participate in a preliminary study on perceptions of, and experiences with, science communication. I, Cynthia Taylor, am a student in the Science Education and Society program at the University of Rhode Island, and will explain the project to you in further detail. Please do not hesitate to ask any questions. If you have additional questions at a later date, you may contact me directly at 401-439-3902, or my doctoral advisor, Bryan Dewsbury at 401-874-2248. You must be age 18 or older to participate in this project. This research has been approved by the University of Rhode Island (URI) Institutional Review Board (IRB).

Description of the Project

This preliminary investigation will help inform my doctoral research, which aims to explore how the Oxitec field trial plans were communicated to the public, and how these communication efforts impacted public opinion surrounding the use of genetically modified mosquitoes in response to vector-borne disease threat. During this phase of the research, I am looking to document experiences, opinions, and perceptions of science communication and outreach initiatives related to the release of genetically modified mosquitoes in the Florida Keys.

If you decide to participate in this study, you will be asked a series of questions related to perceptions of communication surrounding Oxitec's proposed plan to release genetically modified mosquitoes. My questions will be open-ended, in hopes that this experience feels more like a conversation, than an interview. Participation in this study will require approximately 45 minutes of your time.

Participation Eligibility

For this study, participant eligibility will be determined by the following criteria:

1. Participants must be over the age of 18.
2. Participants must be permanent or part-time Florida Keys residents, or visitors, OR they must be a scientist working on mosquito control solutions in the Florida Keys.
3. Participants must have attended at least one science communication/outreach event or meeting related to the release of genetically modified mosquitoes, OR they must have regularly followed science communication related to the release during the past year.

Risks or Discomfort

The risks of this study are minimal, although you may at times feel uncomfortable providing your opinion or sharing your experiences. Please keep in mind that your participation is completely voluntary, and you may refuse to answer any questions, or end the interview at any time should you feel uncomfortable.

Benefits of the study
The results of this study will be used to improve science communication and outreach efforts, as well as public participation in decision-making as it pertains to biotechnology.

Confidentiality
With your permission, I will audio record this interview. If you object to being recorded, I will take hand-written notes throughout. Interviews will be kept private, meaning that only myself and my supervisor will have access to the data collected. All of your responses will be kept confidential, and no one will know that you participated in this study, or what your responses to my questions were. I will take great care to not to include any information that could be used to identify you personally, and ask that you refrain from saying your name or providing any identifiable information during the interview. Please keep in mind, however, that while your responses will not be attached to any personally identifying information, the data obtained through these interviews will be made publically available. I may choose to quote some of your words directly in my final report, but will not include your name or any details that could link your words to your identity. In such cases, it will be necessary to use a pseudonym, so I will ask you if there is a pseudonym you prefer. At your request, any part of your interview can be removed from the study at any time before September 1, 2019. At the end of the interview, I may ask if you would like to be contacted again for a follow-up study in the future. If so, I will need to collect contact information from you, but will keep this information in a location separate from your interview recordings/transcripts to maintain privacy and confidentiality.

Decision to quit/withdraw from the study
Again, your participation is completely voluntary and you may choose to end the interview at any time. If you would like to have any/all of your responses to my questions removed from the study, please contact me at 401-439-3902 or my doctoral advisor Bryan Dewsbury 401-874-2248 by September 1, 2019.

Rights and Complaints
If you are unhappy with any aspect of the research process, you may discuss your complaints, anonymously with my doctoral advisor, Bryan Dewsbury at 401-874-4328. If you have any additional questions about your rights as a research participant, you may contact the University of Rhode Island's office of the Vice President for Research and Economic Development at 70 Lower College Rd., Suite 2, Kingston, RI 02881 (telephone: 401-874-4328_ the Institutional Review Board at the University of Rhode Island.

Consent to participate can be given by signing below. Your signature confirms that you have read the consent form, understand the information provided, and have agreed to participate in the study.

_____
_____
Signature of Participant
(Indicates your Consent to Participate)

Signature of Researcher

_____
_____
Signature of Participant
(Indicates your Consent to be Recorded)

Signature of Researcher

_____
_____
Typed/Printed Name

Typed/Printed Name

_____
_____
Date

Date

Please sign both forms and keep one copy for yourself. If you would like to be re-contacted for future interviews/correspondence, please check the box below and indicate your preferred mode of communication.

Consent to be re-contacted? ☐ YES ☐ NO

If yes, please indicate the best way to contact you:
Email: _____
Phone:_____
Other:_____

3. FINAL SYNTHESIZED MEMBER CHECK DOCUMENT (sent to all participants)

Summary: After transcription and careful readings (and re-readings) of interview transcripts, several major themes and findings emerged. These themes and findings are summarized below and accompanied by selected examples of participants' quotes. If you have any feedback, concerns or changes you would like me to make to these interpretations, please provide comments in the spaces below each theme section. Thank you!!!

Theme 1: Participant views on GMOs in general

My findings: Despite media depictions of opponents as "Anti-GM," participants were largely ambivalent about GM products, and showed nuanced considerations of both their benefits and risks in interviews. Participants viewed GM products as inevitable and necessary in some cases, but also noted that their benefits are often overstated and that they need to be regulated carefully with public input.

Examples of Supporting Quotes
They call us the anti-Gmo crowd. No no no no no. We wouldn't have insulin if we didn't have GMOs. It's fascinating the study of it. It really is.
We're not against genetically modified species. At all. But if you're gonna do it, you have to do it with real science, not this crap they gave us. And if you're gonna do something this risky, you know, then, you better bring the public along with you first. And make them a part of it. Instead of your adversaries.
You see all this black ink that comes out, it just tells how wonderful genetically modified mosquitoes are gonna be, and that you know, there are these people that are afraid of GM. It's not fair, and it's not correct. I don't think anyone was afraid of GM down here, there are some sure. Look, I've been invited to how many things, GMO free Florida. GMO free USA is one of our supporters. But that doesn't mean, you know, I believe in being abstinent from genetic modification research. I don't. I think it's a technology that if you use it appropriately it's going to have a place..
It's kind of an indentured servant program sponsored by Monsanto and Baer. You know there are absurdities everywhere. And that's one of them. You haven't done anything for world food production other than you made the products available on a finance program that people can't get out of it once they get into it. So yea, they produce more food, they have to produce food because now they have to pay you back. It's, it didn't solve the problem. It mitigated some food sources in the world. But there are some evils to it as well. And there's probably some better techniques we have out there. You know? Do a better job.

Theme 1 Comments? Are any of my interpretations incorrect? Is there anything that you would add/change?

Theme 2: Oxitec Representations of GMMs, Public Support and Field Trial Success

My Findings: Participants reported that they were somewhat supportive or curious about GM Mosquitoes when they first heard about them. However, Oxitec/FKMCD's inaccurate/inconsistent representations of GM mosquitoes, surveys, and field trial results, largely contributed to participants' feelings of mistrust and lack of confidence in the technology. Participants felt that communication by Oxitec and the FKCMD was oversimplified and lacked transparency.

Examples of Supporting Quotes
After you've gone through years and years of battle where you've found misrepresentation after misrepresentation, you get to the point where I don't necessarily trust you, you know? And it's not because I didn't respect the technology. I very much respected it. I'm still in awe that they're able to do such a thing. But they do it poorly.
And when the meeting was over, there were more questions than answers. You know, and that's not necessarily a bad thing. It's a complex subject. But, it was more the feeling that they had purposely not answered certain questions. They kind of, "oh, we're gonna answer it this way," and it was that summarizing, that glossing over, that I'm-gonna-give-you-the-answer-you-can- understand attitude that panicked people.
The first thing off the bat was, he referred to it as a sterile insect technique. Which as you may have learned today, there's a huge difference between a SIT and an Oxitec genetically modified mosquito, so at that point, another red flag goes up...Just admit, they're not sterile. Previous field trials that you did were for mating efficacy. Like it wasn't. You were trying to make them mate better. That is the opposite of sterile. They do produce larva, afterwards. They have such bad birth defects due to all the genetic modification, that they never grow up to be an adult. They die. Big difference between the two. I'm a huge fan of the S.I.T. They're complete polar opposite on the ends of the spectrum.
Well they started with female mosquitoes- de minimus. That's the number. What do you guys call de minimus? So there are gonna be. And then all of a sudden the numbers ranged; From like 3 to 18%. 18% out of 22 million mosquitoes in the initial release? Now I'm getting mad.
He is saying that the GM mosquito may have a 100% success compared to 30% that you get with uh pesticides. And I'm sitting down going, but I've given you the data, I've given you the FOIA emails showing that the scientists (in the Caymans) don't think it works in the Caymans. I went there and told you it was coming.

So, it's a buildup of different, you know, concerns and betrayals. I consider running a survey that's coercive, and repeatedly running a survey that's coercive, as being a real, a real problem. I mean it's hard for me to even characterize how loathsome I am of such a thing because you're taking people that are standing at their door and they're easily duped by a real smart, slick talking person. And you could get just the wrong answer. And that's not what they wanted. I don't know. We ran a very simple survey. And we did boots on the ground. We covered 63% of the population in Key Haven and we had a 75% rejection of doing the experiment there.

Theme 2 Comments? Are any of my interpretations incorrect? Is there anything that you would add/change?

Theme 3: Political and Corporate Interests

My Findings: Participants observed that financial and political motives compromised the rigor, objectivity, and credibility of risk assessments of Oxitec's mosquitoes. They noted how politics had influenced the regulatory processes and expressed concern that there were no independent, third party evaluations of Oxitec's mosquitoes. Participants questioned the motives of FKMCD in promoting the field trials, and lacked confidence in board members' competency in making responsible decisions regarding GM mosquitoes.

Examples of Supporting Quotes
But what my concern is, and I wasn't able to articulate it as well until I went to the FDA meeting, my concern is there's politics integrated into our regulatory process. Which makes them nonscientific…..So, I have a lot of contempt for things that can go wrong. That doesn't mean they always do. Alright? But you have to be aware that there are flaws in the process. One of them is the politics getting involved.
Environmental laws aren't there to clean up the environment, they're there to give some company or country, or individual an advantage over somebody else. I don't care if it's coal mining, acetone crap...I don't care what it is. When it gets to the congress, or it gets to the state legislature, money talks. And that's what people bought. Come on, like, we're protecting the.... Bullshit. Nobody's protecting anything.
I learned a long long time ago, that if you want to get a hold of someone... You call em. You want to convince em that you're telling the truth? You put in on paper and print it. And they'll believe it. So that's exactly what happens with modern science today. They want to market. They don't do it by putting an ad out there. They don't do it by going door to door necessarily though that actually did happen here. Um, they do it by getting some independent, objective, source, to

corroborate what they're saying. Just because they repeat it. Not because they understand it. Because they repeat it. And that is, to me, one of the biggest problems of science.
So here I am, and I'm faced with a technology that they want to release. A cutting edge, 21st century technology that no one really understands. That the only peer reviewed science is from the company. The for-profit.
But you know, the pinnacle of the, what I consider the breach of trust was when, what had happened was we were able to work with the community where we the experiment originally was (planned), Key Haven. And, we got to the point where the Florida Keys Mosquito Control District was so pressured that they decided to have the referendum. Alright, and then they played some shady games at the end of it. Right at the very end they decided that oh no it's not gonna be a Key Haven referendum. It's gonna be Keys wide. We have zero money, alright? We are grassroots. We are strictly people who love were we live and wanna protect what we love. And we're sitting there going, really?
The former director, that left, he was the worst one ever. He was so in the pockets of them. He thought he was going to make himself famous by being the first place to deploy them. He would not listen to anything. Anytime you would say anything he would just jump down your throat immediately on behalf of Oxitec without even stopping to listen.

Theme 3 Comments? Are any of my interpretations incorrect? Is there anything that you would add/change?

Theme 4: Fundamental Problems with the Trial and Public Engagement

My findings: Participants largely perceived the trial as one that involved human subjects, and noted various scientific, ethical and regulatory issues with it that compromised their trust and willingness to support the trial. That the field trials were promoted without informed consent by community members was perceived to go against participant values related to democracy, autonomy, and research ethics. Participants explained that opposition to the field trials was as much about the process, as it was about the product. Some participants believed the original intent behind the creation of GM mosquitoes was good, but the process was flawed and lacked quality control (and gave specific examples, including # of females released, failed trials in the Caymans, etc., to attest to this). All participants viewed tetracycline dependency of GM mosquitoes as a major flaw in the technology, and cited numerous concerns regarding antibiotic resistance. Moreover, they felt that their questions regarding regulatory standards, authority and accountability had not been answered, and that Oxitec/FKMCD failed to seek the public input necessary for the trials. There was little confidence amongst participants that Oxitec's new GM mosquito (announced in 2018) would be any better.

Examples of Supporting Quotes
I'm like, it's just fascinating and it's happening in our back yard. And it's the first ever. On the face of the earth, where a genetically engineered animal, that uses human blood meal, is gonna be biting people and they don't need our consent. I'm not ok with that. If you walked into a hospital and you said hey I want to sign up for a clinical drug trial, you sign your paperwork, you have consent, you have informed consent, and they sit down and talk to you. And this thing, they were originally planning to deploy on us without any consent whatsoever.
My deal is public policy. And that's all I've ever talked about. Don't talk about the science. Cuz it's never the product. Ever. It's the process. If you have the right process the product will always be there. This process failed.
And that is a systemic problem with Oxitec. Alright? So they sit there and act like, well you don't have any science, but I do project management for a living. ...This is part of what I do. I understand scientific process. I understand bad process. I understand good process. I understand good technical writing. And bad technical writing. And there's a pattern of lack of quality control in Oxitec. And that is demonstrated in the Cayman outcome.
Can they do a good job? I hope they can. I don't have any malice for them other than you have performed badly there. You need to show you can perform well. You need to correct these bad things. Your intent, when Oxitec came up with this concept and developed this, Brilliant. Wonderful. Altruistic. You know? Save the planet. I love it. Save people on the planet. But that's not what it ended up being.
I said to myself. What are you using it (tetracycline) for? And then I read what was going on. Went to the meeting. Listened to Oxitec talk. And I asked him. I said, there are 3 antibiotics that we have orally in order to control MRSA infections in soft tissues. One of those, was tetracycline. The other one is Bactrim asulfamed. You know, a lot of people are allergic to sulfa so you can't use that. And then clindamycin. So I'm sitting there saying, clinda is actually developing resistance, as we were talking at this point. And I said, how do you know that you're not a superbug factory?
So I'm up there, (and I say): "You can't do this unless you get them to answer 3 questions." One- What's the regulatory authority? What's their regulatory standards? And what's the criteria for success or failure? And I thought they were gonna laugh me out of the building. I mean that's like, hello. You want to put a pool in the backyard? You want to put in a stop sign? You have to show your authority to do that, the standards in which you're gonna do it, and the criteria for success or failure. How many feet this way. How deep the pool is. And all my people are going, Yea! And everybody in mosquito control board just didn't know what to do. And let me tell you what we were after in those 3 (questions). Were they loaded? Yea. Slightly. But they could've answered it, if

not that night, they would have the next day. Send me an email. It's all over with. Release the mosquitoes. That was April 14, 2011. It is now January 14, 2019. And they haven't answered any of them. Purpose of it was...what's your regulatory authority? This is mosquito control board. These people are clueless. And they're gonna release a new gene into our society? In a national sanctuary? With 34 endangered species? And they're gonna conduct an experiment, although they said none of the mosquitoes are gonna come in contact with humans because it's all males, there's not gonna be anything females. But what's your authority? World health organization? The county? The county board of health? The state board of health? The CDC? The UN? By what authority? Better not be mosquito control board.
The CEO of Oxitec, or Intrexon, should have got some blue jeans, and a t-shirt. And came down here with some flip flops. And invited us over. And he should have sat there. Not on the stage. Sat at our level. And said listen. We messed up. I know my product is good. I have to communicate the right...I don't know what to say. But I need your help. Because I know my product's worth. And I don't wanna be sitting around, and you don't wanna be sitting around, two years from now, when people are getting sick from Zika. And I can't sleep at night. Can we work together and come up with something….If you wanna sell, don't try to do anything in public policy, unless you're willing to get involved with people and develop relationships. Not to the elected officials. Not to the appointed officials. But you know come in and start going to the coffee shops and the bars. Do that months before. If you have a big investment, you better talk to the people. You better look at how they talk. What clothes they wear. Right? You have to....what their prejudices are. You better learn everything about them before you come up with something this major. And they came in and danced around and thought they had the mosquito control board. Oh we got this. They ran into a buzz saw in the city commission. We kicked them out. Right? And we won. We won the whole thing.
So basically, a for profit company put a lab into our tax paid building, without any consent from the general public. And then when we asked them, they spoke about a lease in one of the meetings. So we asked to see a copy of the lease. And then suddenly, Chairman GM turns, "there is no lease". Like ok, so, are you getting paid...or are you not. A lease to me means that somebody's paying you for a portion of our tax paid dollar building for a for profit company. The he says "it's just basically a closet". That happened.
Yea, they say they're going to submit an environmental use permit application. We're waiting to see that. Obviously, if it's based on the same antibiotic, you've got a hole in your technology that you can't really overcome.

Theme 4 Comments? Are any of my interpretations incorrect? Is there anything that you would add/change?

Theme 5: Fundamental problems with scientific and regulatory institutions

My findings: Participants noted that the problems they saw with the Oxitec field trial were symptomatic of larger, institutional problems in science and regulation. The participants did NOT express anti-science sentiments. Rather they evaluated science based on well-established norms of science itself (objectivity, transparency, etc.), and often commented on the difference between good vs. bad science. Their mistrust of Oxitec could only be understood in the context of what they perceived as systemic problems with current institutional standards of technology regulation and governance. Mistrust was as much about a lack of confidence in institutional standards of regulation, governance, and technical oversight as it was about the individual actions of scientists. They were aware of past regulatory failures, particularly by the FDA, and this contributed to their lack of confidence in risk assessments of GM mosquitoes. Participants expressed more confidence in EPA than FDA, given that EPA more willing to listen to their concerns.

Examples of Supporting Quotes
You can see I'm not, like, oh, I'm just worried about Oxitec. It's not that. They're a symptom. They're not the problem. They're actually trying to do well. And that's why I'm not sitting here, oh GM. Look. We're gonna have genetic modification. It's going to happen. You can sit here and fight all the technology you want. You're gonna have genetic modification. Let's make sure it's good. Let's make sure the standards that we have for them to test to are appropriate and that they assure quality is in that process.
We forced them. We forced the FDA, a group of 7 of us in the Florida keys, grassroots, completely, came from all different walks of life, but we actually made the FDA, admit that they were not the proper governing body. They did not have the proper scientists. It is brand new technology and they were originally trying to get it passed as an animal veterinary drug.
I wish we had a really strong regulatory body. Like we need a new division of the government that specifically deals with the top scientists in these fields and then the great minds get together and you have faith in them, and let them roll. We don't have it.
Last month, they actually changed the guidelines. Protocol for communication. Which was based on the 2001 what did they call it....When scientists, being deployed people, then yes, I believe our government should have something to be able to communicate what's going on. I would love that. Not that I have much faith in our government right now. But it would be a great thing to have somebody to trust.
Again, I wish there was that board of scientists that you could trust. Intelligent people that can listen to both sides of everything. That can judge whether or not and communicate responsible, clearly, so that the layman can understand. Which would be a beautiful thing. But we don't. We don't have that.

Because one of the biggest things with research is, is most research is nonsense. If you don't publish you perish, right?
This question should never have been, should never have gone one way or another, because of public opinion. This is science. The Science should have ruled. Not convenient science. And that's all they did. In today's society what happens is you go look for the science that proves that supports your agenda, and you stop looking. That's not a scientist in my opinion. That's a fool. Because science, of course as you know, of proving the hypothesis, and then changing the inputs, and then prove it again. Changing the inputs, and prove it again. You prove it you prove it you prove it. It's not, Oh we found something that proves our product is good we just go to sleep after that. No. You question it. That's science. Science IS questioning. So when they say oh this has been tested all over the world. Say, well what was tested? That's science. Not accepting your word. Accepting somebody's word is not science.
I think it just points out the pitfalls that you have to be aware of so maybe you're a little more adept at being able to safeguard where the holes in those processes are. The holes start with an elected body, alright? That has this ultimate authority and has no technical oversight other than their own staff. Well your staff works for you technically! They're afraid of you! What you need is an appointed science body that once appointed you can't mess with.
What are they bothering us with this stuff for? And remember- They went to the FDA first. And that's when I knew that the press down here were brain dead. Because they went to the FDA and they're doing an IIS instead of an EIS. With an EIS you have to do a certain number of things. You have to do a previous conditions analysis, you have to have an alternatives analysis. You have to do an effect...how is it going to affect...the collateral impacts on other species. And with an IIS you have to do that shit. And that's what they did. What are they doing that for? Don't they realize that we're gonna demand it?
And you know, people start relying on, oh the FDA this, the FDA that. But then, it always comes to, well, thirty something percent of the things the FDA approves end up being recalled. You know? And people become aware of these things, and so there's subjectivity of whether or not they trust regulatory processes also. So distrust doesn't only start from here, from one incident. It's pervasive in our society. And it should be.
I will tell you that my experience so far with the EPA is a little more, confident, than with the FDA, but you know, that's just what I've experienced so far. We don't know outcomes. All I do know is that the EPA listened to us….I'm constantly communicating with the EPA team. It's not like we walked out of there and we're not gonna talk to you anymore. No. We had conversations that went back and forth. Not a lot. It wasn't like they were gonna give us a lot. But they would acknowledge what we sent them, or maybe ask us a question or something like that. I mean, very light. And they have to keep at arm's length. I want them to.

I want them to be independent. I don't want them to be my friend. But they did leave an open door for us.
And you know, now the EPA, when they came down here, they kept it independent. We aren't meeting with you. They aren't allowed in. You're not gonna meet with them. And you're not allowed to meet with them. I like that about them. The have to keep at arm's length. But, one of the things I asked the FDA before, right at the end of the meeting, last questions that was asked. I said, what scares you the most about this process and the outcome? Cause what we wanted was, we feel like technology right now is beyond what our regulatory bodies can responsibly handle. Alright?

Theme 5 Comments? Are any of my interpretations incorrect? Is there anything that you would add/change?

Theme 6. Hype and Alternatives to GM Mosquitoes

My Findings: Participants were critical of the hype surrounding GM mosquitoes as a silver bullet solution, noting that alternative forms of effective vector control existed (including Wolbachia and boots on the ground strategies), that met the WHO's vector control guidelines. Wolbachia, for example, was perceived as a safer, more natural, and potentially more effective technology. Moreover, Mosquito Mates' company ethos and strategies for public engagement aligned better with participants' values. The fact that alternatives to GM mosquitoes were not seriously considered contributed to mistrust of Oxitec/FKMCD. Additionally, participants felt that the risk of mosquito borne diseases had been overstated, in attempts to scare people and garner public support for Oxitec's mosquito.

Supporting quotes
They ran radio ads 10 times a day. In the Upper Keys, in the weeks leading up to the vote. And it was like, "Do you want less mosquitoes?" You know, "this is the solution." And they didn't mention anything about their technology. You know, it was just "Oxitec is here to save the day" kind of bullshit.
You've got one company saying look I've got this cash cow I'm protecting and I'm gonna tell you it's the only thing that does the job.
If you go back and realize that there was a dengue outbreak or incident, back around the cemetery, uh, 2009 I think it was, 34 cases or something like that but there were rumors that there were a lot more. But everybody covered it up. This is Key West, everybody covers up everything. But they were able to get rid of it. The Aedes aegypti infected dengue with boots on the ground. They hired special people that went, they go around, the undo all the stagnant water. You know they're very aggressive about it. But. If there ever is a Zika outbreak, boots on the ground. Because zika doesn't go everywhere. It's like, it starts here and goes there.

I mean, what was it 5% of people who were positive for dengue didn't even, out of everyone tested, 200 people tested, 5% were positive and none of them knew they were even sick. You're scaring the hell out of this old man using terror as a tactic. They hung up on me. The town hall. They hung up on me. Oxitec hung up.

Wedding after wedding cancelled. Or their bridesmaids were pregnant and didn't want to come down. We have no locally transmitted Zika down here. But yea, the press just took off and ran with it. There's Zika in the Florida Keys!! It hurt business. Unwarranted.

You know, they look at us and say you're non-scientific. Not only are we scientific, we're thorough. And we're making you expose your underbelly, because you guys have been anything but clear. You're supposed to be protecting us as people, and you betrayed that time and time and time and time again. And you defend a vendor, who is unproven, over the people in your community trying to tell you we have a problem with this. Don't we have an alternative? And low and behold, even when we got the alternative, go ask Mr. Goodman how he talks about Wolbachia. Go what do you think of Wolbachia? Try it. Try it. Before you write your stuff. Try it. Ok? Interview him. Alright? And you'll see for yourself. The attitude he has. He will talk down Wolbachia, even though the trial was like 90% successful.

It works great! What's the problem? Why are they so locked in (with Oxitec)? And it's a one-time application. You do it once. Maybe you need to come back the next year and do a little bit more again. Mop up. But that's it with Wolbachia. With the Oxitec science, every year forever. And they were estimating 1.2 a year. Million. Dollars. Wolbachia's like 34,000. Throw it out there, you're done. That's when we got into, show us all your stock options here. And when we would have big debates, I would challenge the people on mosquito control board to tell me that they or their family never had any stock in Intrexon. Because every time we spoke, Intrexon's stock tanked. And we knew that. So we kept on tanking them....

The Wolbachia trial. I understand that. Very easily. Dealing with something that has 10 different DNA splicings put into it, I can't comprehend. I know that if you get bit by one of these, mosquitoes they can't transfer DNA. DNA is only transferred when you mate and have a baby. You pass...you share, your DNA. But does that mean if you're eating them, and you're swallowing them, like in mosquito season. You do. We have a lot of mosquitoes. They get in your eyeballs. Back to the tetracycline.

Considering humans have lived with Wolbachia bacteria since we were evolved into humans. And nobody's ever said "Oh I got a Wolbachia transmission" ..."I'm sick from Wolbachia"...I do understand that there are some people that have written some interesting scientific papers on Wolbachia transferring...but they were really transparent in their information. And there was nothing that I could read...not one thing...that I got my hands on that I was like, ehhhh that doesn't smell right.

Because Wolbachia bacterium is naturally occurring. And they're basically taking it from an insect that it is already on and using it in that insect. So that insect knows how to...or is capable of handling whatever happens to it. What they're doing with herpes, E.coli, red coral, blah blah blah and putting it into an animal. A little suspicious. Why did you have to go that route?
We were big on Wolbachia. Nobody's gonna object to it. But we want the same criteria. You cannot be an organization like this that says well, we want informed consent but then say, well we just happened to like Wolbachia? That's not right. So our position was, that if you're gonna move forward with Wolbachia you should also have standards for success and informed consent. So that's how it went. There's been trials here. There've been trials in Australia. Now, we've never required informed consent but it's not something that's not found in the environment. It's more of the same bacteria.
Go look at the WHO guidelines for even gene drive mosquitoes. Which are the newest version of modified mosquitoes. And there's another group, I'm trying to remember, out of California that had a technical conference. And out of there they came out with very similar recommendations that the WHO carries. They all put right here at the top, public communication. Public outreach. You know, getting their buy in. This is exactly what they did with Wolbachia.
They heard it was natural. That's my humble opinion. That a lot of people bought into Wolbachia because it's quote on quote natural. I've never read about a human infection with Wolbachia and I actually did a pubmed search on it.

Theme 6 Comments? Are any of my interpretations incorrect? Is there anything that you would add/change?

Theme 7. Social Relationships

My Findings: Participant's motives for participating in opposition to the field trial plans were rooted in their desire to protect people and the place they loved. However, they recognized that their views were not shared by the majority of Keys community, who were often ill-informed of its problems. Participants also noted that, at times, they had to distance their views from those of other opponents (with anti-GM views) to maintain credibility. They also reported feeling that they had been misrepresented as "uniformed" and "uneducated" by Oxitec/FKMCD staff and the media.

Examples of Supporting Quotes
So you would think, with those fundamental questions, 75,000 people of the Florida Keys, would be all part of our army. But because they were able to say, and still to this day, they tested all over the world, and there's no problem. Whatever. Peer reviewed. I mean peer review. You've done a Master's now. What a joke all that crap is. I mean, I don't mean to blow your bubble but, they really are concerned more with format than substance. Right? They never get involved in the

science. They get involved in how it's conducted. Or, the format of it. And then they're so easy to fool. You know? It's like. So when somebody says “peer review", I go: does anybody realize what peer review is and what they're really looking for? They're all ready to get on the bandwagon without really being critical. So peer review should not be used in determining public health or public policy. They should’ve done clinical and biological tests. That's enough. And they should've had informed consent. So because they were able to bamboozle everybody, fools, including mosquito control board and key west citizens, and US 1 radio. Who I'm all friends with.
Most people are clueless. And they don't understand the fundamentals of policy. Or public health. Or experiment. Let me give you an example. Back in the day, they did a lot of experiments in prisons. But they changed those laws and now if you want to conduct an experiment in prisons, you have to get informed consent. They have to actually know what's about to happen to them and you better get it in writing. Now, you're not just gonna tell em. You better make sure they understand. So these lunatics are gonna be sending out genetically modified mosquitoes? Without informed consent? What are you guys nuts?
I'm probably in the 3 percentile of educated people. Lots of people just hear less mosquitoes. Hell Yea! We get bit by them all year round. So yea, extremely different than the general population in that area.
The pact ran radio and news ads, for a month leading up to the referendum. And the referendum was supposed to be specifically for Key Haven only. And at the very last second they said, Oh, we're going to do a Keys wide referendum. Like No. Nobody in the Upper Keys is educated. Like, that's not an informed vote.
But this is the first on earth. And I have a voice. I'm not afraid to use it. If I could say that historically, I potentially got some stronger regulations on this, I would be very proud of myself. But it's earth right now basically.
Science IS questioning. So when they say oh this has been test all over the world. Say, well what was tested? That’s science. Not accepting your word. Accepting somebody's word is not science.
If Oxitec is clean it's clean. Let's say they have a resistant germ. This chair probably has a resistant germ. Then let's just plan it. You know, let's look at that. But then you worry about the cystic fibrosis kids. When I sold my first hose down here, which is in key west, I sold it to a charity for cystic fibrosis kids. My first home in Key West, is now a respite for children with cystic fibrosis. Now they get pseudomonas, totally different germ from staph. But what happens is we have things like that go on down here. And I'm worried about my immunocompromised. My diabetics. My asthmatics. Cystic fibrosis, you know. Chemo patients. All these different things.
We have zero money, alright? We are grassroots. We are strictly people who love

were we live and wanna protect what we love.
One of them (activist friend) got kicked out of our group. Who was, in my mind, the most passionate, and eloquent, of our entire group. But sometime he was a little bit too flamboyant and too passionate. They're basically like look, you need to settle down. He's the one who was the frankenskeeter guy. That quote. That's him. None of us really liked that. No, you're gonna just go there with frankenskeeter? Like, no no no no no. Just speak facts.
You know, and the people took their time to get educated in Key Haven. And to say they were uninformed, and they just voted in fear of genetically modified mosquitoes is an insult to those people. It's not true. I mean, they were active in learning. And while they may not be able to understand all the science, they understand where the holes were.
So at the end, he decides he's gonna characterize everything and misrepresent it the other way. And I said oh no. You're not going to do that, misrepresent what I just got done telling you. He goes, well this window's closing. I said, not until I'm done. I just shut him right off and finished what I said and he goes, thank you. And then he signs off. But I was not gonna let him beat me up. And he tried to bully me, you know? He wanted to have his way. That I was afraid of technology and all this stuff. And I said, no, you're not going to do that. You're not going to recharacterize what I said and paraphrase it your way. It's this. And I don't know that he was upset over that, he probably kinda snickered, like, ok.

Theme 7 Comments? Are any of my interpretations incorrect? Is there anything that you would add/change?

Thank you for your participation in this study and your feedback on my analysis!!!

APPENDICES

A. Timeline of Significant Events in GM Mosquito Discussions

2009-2010	88 reported cases of Dengue Fever in Key West Florida
2011	Florida Keys Mosquito Control District (FKMCD) publicly announces collaboration with Oxitec, a British biotech company responsible for the development of OX513A genetically modified mosquitoes, on field trial release plans
	FKMCD conducts surveys with residents at proposed release site (Key Haven) and reports that 2/3 of residents are in favor of releases
2012	FKMCD invites Oxitec to present at informational town hall meeting in Key West
	Local Key West activist files online petition against the use of GM Mosquitoes on Change.org
	FKMCD and Oxitec seek approval for field trial releases with the US Food and Drug Administration, filing an Environmental Assessment report
2014	FKMCD and Oxitec hold 2nd town hall meeting in Key West
2015	Zika virus outbreak emerges in Brazil
	US biotech company Intrexon acquires Oxitec, Ltd. for $160 million
2016	WHO declares Zika virus a public health emergency in January
	First cases of Zika virus are reported in Florida in February
	FDA releases "Findings of No Significant Impact" in its review of Oxitec's Draft Environmental Assessment, and invites public comments on its website in March
	FDA extends comment period in April
	FDA and Center for Veterinary Medicine announce their "Finding of No Significant Impact" and approves Florida Keys field trials in August
	Local physicians in the Florida Keys submit a petition to have genetically modified mosquitoes cultured for antibacterial resistance prior to releases
	Field trials plans are supported by the majority of Monroe County voters in the November 2016 elections, however, the FKMCD halts field trial plans due to low levels of support from Key Haven (release site) voters
2017	FKMCD releases EPA approved Wolbachia-infected mosquitoes in the Florida Keys in April
	Oversight of all GM Mosquito products (including OX513A) is transferred from the FDA to the EPA under revisions to the US Coordinated Framework for the Regulation of Biotechnology

	Oxitec applies for an experimental use permit for field trials of OX513A in the Florida Keys with the EPA in March
2018	Oxitec withdraws its application with EPA in December
2019	Oxitec applies for experimental use permit for field trials of 2nd generation OX5034 mosquitoes in the Florida Keys with the EPA in September

B. Permission to reprint published articles

Cynthia Taylor <cynthia_taylor@uri.edu> Sun, Feb 9, 6:23 PM (20 hours ago)
to JCOM

Dear JCOMM Editorial Office,

I am completing my dissertation, "Making Sense of Public Scientific Controversy: A case study in science communication and public engagement surrounding genetically modified mosquitoes in the Florida Keys," at the University of Rhode Island this spring. I am writing to request permission to reprint an article I published with JCOMM in this dissertation, titled:

Barriers to inclusive deliberation and democratic governance of genetic technologies at the science-policy interface (Taylor and Dewsbury 2019).

The dissertation will be made public through the University of Rhode Island's library and published on ProQuest. The final dissertation will include a statement acknowledging that this article has been previously published in JCOMM.

If this meets your approval, please reply with a letter of permission to cynthia_taylor@uri.edu or kindly sign the attached letter.

Sincerely,

Cynthia Taylor

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Maria Teresa Leo