The Disaster and Climate Change Artathon: Staging Art/Science Collaborations in Crisis Informatics

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ABSTRACT
Information systems increasingly shape our knowledge of crises such as disasters and climate change. While these tools improve our capacity to understand, prepare for, and mitigate such challenges, critical questions are being raised about how their design shapes public imagination of these problems and delimits potential solutions. Prior work in human-computer interaction (HCI) has pointed to art/science collaboration as one approach for helping to explore such questions. As an attempt to draw on this potential, our team designed and facilitated a 2-day "artathon" that brought together artists and scientists to create new works of art based on disaster and climate data. Reflecting on the artathon and its outcomes, we contribute two sets of findings. First, we articulate opportunities, suggested by the artwork, for expanding research and design in crisis informatics. Second, we offer suggestions for HCI researchers seeking to stage successful art/science collaborations or similar inter-disciplinary events.

Author Keywords
Crisis Informatics; Art/Science Collaboration; Critical Data Studies; Workshops

ACM Classification Keywords
• Human-centered computing~ Collaborative and social computing~ Empirical studies in collaborative and social computing

INTRODUCTION
For two days in April 2017, our research team gathered about 30 people in a small community center in downtown San Francisco to work together on art projects that engage with questions of climate change and disasters in the San Francisco Bay Area. A diverse group of academics, professionals, and working artists came together for this "artathon," an intensive two-day experimental and production-oriented workshop. We led participants through various team-building and brainstorming exercises for the majority of the first day, introducing them to data that they could use in their work, after which they worked in teams to develop and begin to execute their ideas. By the end of the second day, each team had designed a unique project that, in various ways, sat at the intersection of art and disaster or climate science. Some of the projects were polished works of art or design proposals, while others remained works in progress or concepts in various stages of development. The artworks created over the course of the weekend offer interesting, alternative perspectives to the information systems typically created and used in disaster and climate risk management and, in doing so, offer possibilities for future research and design in crisis informatics

Maps, models, and statistics are invaluable tools for informing expert and public understanding of crises like disasters and climate change. The understandings that these tools provide in turn shape and constrain the kinds of solutions that governments, humanitarian agencies, and the public can imagine and implement. It is therefore necessary to interrogate the design decisions that give specific form to crisis informatics systems, including data standards, visualization practices, and other tools [73]. Disaster and climate risk models, the information systems we worked with during the artathon, convey the potential impact of threats such as earthquakes, hurricanes, or sea-level rise on human populations and the build environment. Used in insurance, urban planning, and emergency management, these models most often express danger in terms of monetary values of disaster impacts. What does or does not get accounted for in these tools can become matters of life-safety and express preferences and biases, whether explicit or not, for which people and places to protect from which potential harms, and how. They provide powerful, but incomplete, understandings of the world around us.

Artwork about disasters and climate change can present different perspectives on these issues than risk models. The well-known project *HighWaterLine* [57] by artist Eve Mosher takes sea-level rise projections for several coastal areas around the United States and, using chalk-lines on sidewalks and pavement in each city, delineates areas predicted to be underwater. These works of public art seek to inspire activism by expressing the data into the local

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context it is meant to describe, powerfully indicating which communities will be affected and what is at risk. The San Francisco-based *Climate Music Project* [15] uses climate data—atmospheric CO2 concentrations, average temperatures—to adjust the volume, tempo, and pitch of original music scores over the course of a performance. Their live shows include string instruments, drums, and keyboards and original video projected on a large screen behind the musicians and take viewers through a timeline or human history that begins prior to agriculture and traverses through several potential climate futures, based on IPCC projections. As temperatures rise and climate impacts increase, melodies that began as soft and harmonious grow discordant and chaotic, stressing the urgency of the problem and the necessity to respond. Both *HighWaterLine* and the *Climate Music Project* reframe expert knowledge and data about disasters or climate change to challenge viewers to think differently about these phenomena.

Collaboration between artists and scientists has been put forward as an approach for helping reveal hidden assumptions in contemporary expertise, communicate complex ideas in compelling or novel ways, and suggest new questions or framings to pursue [8][20][31][40]. Our team was comprised of an interdisciplinary group of disaster experts with backgrounds in computer science, engineering, urban planning, and natural resources management. We sought, through the design and facilitation of the artathon, to learn more about this potential and how it might inform the design of crisis informatics systems. Specifically, this work asks:

- How did the artwork produced over the course of the event alter, challenge or influence technical (scientific and engineering) understandings of disaster and climate?
- What did we learn from this experiment about how to stage art/science collaborations in crisis informatics, and human-computer interaction (HCI) more generally?

This paper begins by reviewing relevant work in crisis informatics and HCI. We then describe the organization and design of the artathon and our research team's methods for studying it. The results of the artathon and our study are presented in two ways. First, we discuss the artworks produced by the interdisciplinary teams of artists and scientists. Second, we draw from participant interviews to highlight key aspects of their experience of the event. In the Discussion and Implications section, we reflect on how the work produced during the event exposed opportunities for designers to develop new forms of crisis informatics systems and what the artathon revealed about how HCI can support future art/science collaboration.

RELATED WORK

Crisis Informatics & the Consequences of Datafication

Crisis informatics is a field of study linked to HCI that explores the role of information and communication technologies within the problem space of crises and disasters [62][73]. Though it has gained the most recognition for early research into the use of social media in moments of crisis [61][75][79], crisis informatics researchers have also studied diverse topics such as the design of 911 systems [76], the role of journalists in communicating disaster information [17], and the technologies that enable civilian communications during wartime [68]. Here, we engage with information products called risk models, which are used in the fields of disaster and climate change mitigation and preparedness. Practitioners construct them using mapping and statistical software that brings together information about natural hazards, the built environment, and human population in order to quantify the potential impacts of these events on society. Risk models are designed to inform numerous societal decisions, including setting insurance premiums, building codes, long-term planning, infrastructure siting and design, disaster mitigation, and emergency response planning. In the San Francisco Bay Area, numerous such models, e.g., [2][60], have been conducted in relation to earthquakes, sea-level rise, and other hazards.

Research in HCI and related fields, including science and technology studies (STS) and critical data studies, have examined the social and political effects of data and algorithms that shape public understanding of issues. The issues are wide-ranging, but for the sake of this research we can identify three broad areas of concern. First, this research notes that information systems, by shaping our understanding of complex issues, serve to articulate the contours of the debate, including what is at stake, who might be affected, and the terrain of potential responses [43][55]. Second, and as a consequence of the first, these issues are often portrayed in a de-politicized manner [10][21][22]. That is, expert, supposedly neutral interventions limit public voice and participation in important decisions that affect their lives [24][44]. Third, studies have shown that despite their supposed neutrality, such systems inevitably contain biases that can exacerbate or reinforce existing inequalities [10][16][70]. In the area of disasters and climate changes, these issues have serious consequences, determining who is exposed to danger, and who receives assistance in disasters [46][73].

Broadly speaking, research suggests that there are two categories of approaches for understanding the implications of information systems used in crisis management and intervening in their social impacts. First, we can evaluate the technical aspects of the tools– we can interrogate the data standards used to enframe environmental phenomena [72], ask questions about what data is collected and what isn't [28][16][70], analyze the design of the tools and algorithms used to manipulate this data [10], or examine the technologies to communicate information about crises to its audience [32]. Second, we might instead focus on the social life surrounding these systems and consider tactics such as participatory approaches to data collection or modeling [81], augmenting the so-called "data literacy" of target

audiences [64], or intervening in the decision-making processes that where the evidence produced by these tools is compared to other factors [83]. In this work we explore the potential of art/science collaboration as a way to inform a wide range of opportunities to change the way crisis informatics systems are designed and implemented. To do so, we adopt a socio-technical approach that understands that the social and technical are interrelated and co-constitutive.

Art/Science & HCI

Art/science collaborations are drawing increasing interest in the fields of disaster and climate risk management [11][31]. In one approach, advocates of "post-normal" science [67]. "mode -2" society [59], or those who frame climate change and disasters as wicked problems [36], emphasize the high degrees of uncertainty and interconnectedness between multiple dynamic and high-stakes stressors that characterize such issues. Here, art is recruited as corrective to science that offers ways to communicate complex ideas to the public in novel or compelling ways. In particular, it does so by addressing the affective elements of crisis that are rarely put forward explicitly in the maps, statistics, and charts produced by experts [73]. In other approaches, art is seen to offer a way of thinking differently about these challenges, such as raising new questions or provoking deeper contemplation, as opposed to solving technical problems [13]. Still other research has focused on the social practices surrounding art/science collaboration, and the situated context in which it occurs [8][38].

Sustainable HCI, a research area that shares concerns with crisis informatics, has paid considerable attention to art/science collaboration. We drew upon three themes from this literature to frame this study. First, we avoided limiting the role of art to transmitting scientific knowledge in evocative fashion. Instead, inspired by several studies in sustainable HCI and art [13][39], we sought to "open up questions around technology design and use rather than offer technological solutions [13]". The ability of art to critique the information technologies used to understand crises was thus as important as its ability to convey their findings. Second, we focused on how the results of the artistic collaboration could inspire the design of new crisis informatics systems. While we anticipated that that works produced during the artathon would be interesting in their own right, following Jacobs et al [39], we also wanted to draw on them to inspire different approaches to climate and risk modeling. Third, by attending to art/science collaboration as practice [31][41], we sought to learn what the experience of the artathon could teach us about how to stage future collaborations of this sort.

As conveners of the artathon, we thus approached the intersection of art and science as a question of design. Drawing from prior studies of hackathons and participatory design workshops, we planned a two-day event where small teams of artists and scientists would work together to investigate how art might help us think differently about risk information. Previous work in HCI suggests that workshops such as these can act as boundary objects, serving to bring people from different social worlds into meaningful collaboration [63]. Fox et al argue that such events can act as infrastructural inversions, or as material-semiotic breaching experiments, that can unsettle dominant modes of understanding social and political issues [27]. Here the workshop itself is an "inventive method [52][66]" a mode of research capable of creating sophisticated knowledge about how sociality is enacted and suggesting opportunities for change. This paper thus contributes to a growing body of literature that is re-examining the role of events in HCI research and practice and attending carefully to the details of their design [3][27] [37] [63][66].

STUDY SITE & METHODS

Bay Area Climate Change & Disaster Setting

The San Francisco Bay Area is rich site of study for the intersection of art and science around issues of disaster and climate change. The region faces numerous hazards including the well-known threat of earthquake but also wildfire, sea-level rise, flooding, and mudslides. It hosts several top-ranked universities with leading experts who research these topics, local governments operated by staff with significant experience in the area, as well as a number of architecture and design firms, and nonprofit organizations working on these issues. The region also has a vibrant cultural life and plays home to numerous artists producing world-class material that engage with social and environmental questions. Efforts to plan for, and address, climate and disaster impacts on communities in the Bay Area are challenged by factors including rising inequality and one of the nation's most severe housing crises, a history of racial discrimination, and fragmented jurisdictional boundaries across over 100 city and regional government agencies [51].

The artathon was hosted at an event space in downtown San Francisco called Epicenter, a site that the city government uses to conduct seminars and trainings for educating the public about earthquake safety. Pictures of earthquake-damaged buildings along with building retrofit plans on the walls, maps of local seismic faults, small scale testing equipment in the corner, all created a setting that reinforced the theme of disaster risk, while also providing evidence of how experts typically construct our understanding of disaster (e.g. photographs and technical plans, maps, engineering studies). The space otherwise contained only moveable tables and chairs as needed for the various activities throughout the two days and a projector for A/V. A collection of basic art supplies were also made accessible for use by participants at any time, including drafting paper, paint, clay, plaster, cloth, LEDs, various glues, and miscellaneous materials from a local upcycle store.

Participants

Figure 1: Participants gathered in small teams around tables for the weekend.

We advertised the artathon through university and professional arts and sciences email lists and social media platforms. The website and flyer described the event as "a playful collaboration between the arts and sciences to explore new visions for the future of the region." Materials highlighted the collaborative and experimental nature of the event as reasons for participating. Though the emphasis was on process and exploration over finished product, it was also stated that works produced during the weekend would be exhibited at venues around the region. Over 70 people responded to the call for participation. We selected 24 participants based on short essays they submitted describing their motivation, experience in their own field, and prior work in the area of arts/science collaboration. Attendees were roughly half working artists and half scientists or students in fields of science and engineering, though many had experience working in both areas. Each of these very general categories of participant, "artist" and "scientist", contained significant variety of subfield, job function, and level of experience.

Event Structure

We began the artathon at 9:00am on a Saturday morning with introductions and a short welcome and overview of the goals and agenda for the weekend. Next, participants heard three short presentations from guest speakers. These talks included an urban planning expert with significant experience in the Bay Area, an entrepreneur and investor working in climate change and clean energy, and an arts curator who had previously organized exhibitions on the topics of disaster and climate resilience. Time was set aside at the end of the three talks for questions and general discussion. These activities were intended to set the scene and highlight the interdisciplinary nature of the event. Finally, all participants were given an introduction to a selection of geospatial or statistical datasets about climate and disaster risk in the region that organizers had collected, resources that were available for the rest of the workshop.

Following the opening session, we divided the group into seven teams of three to four participants each. The selection process was mostly random, only constrained by the need to have a mix of self-described artists and scientists in each team. The next session consisted of a series of activities designed to support team cohesion and build bridges across the different disciplinary perspectives. The teams were guided through a series of exercises including 5-minute "teaching talks," where each participant was able to establish expertise in their own field by teaching the rest of their team something about their area of work. Another exercise had each participant describe an artifact that they had brought from home (these ranged from thick engineering textbooks to other pieces of art) to convey to their team something about their background and/or what they hoped to gain through their participation in the event. A third activity aimed at building empathy and teamwork through collaborative sketching and clay modeling.

Figure 2: Preparing for peer feedback session on artathon project proposals

In the afternoon, teams began working on their projects. The guidance provided at this stage was purposefully open-ended. The only prompt participants were given was to work together to develop projects that creatively engaged with climate and disaster risk information. We began with several brainstorming exercises, modeled after rapid iteration practices incorporated used in design-thinking workshops. These were meant to encourage teams to think expansively about possible mediums, hazards (e.g., sea-level rise or wildfire), and themes they might incorporate into their projects, rather than focusing too early on a single idea. The goal was to help participants move beyond preconceived understandings of disaster and climate and bring their backgrounds and perspectives together in novel, co-constructed ways. Teams were then given time to choose a few of the project ideas they had developed during the brainstorming stage and work together to develop them further. At the end of the first day, each team presented these concepts to the whole group for feedback and further discussion. The second day was mostly unstructured, giving

teams freedom to take one of the concepts they had developed on the first day as far as they could. At the conclusion of the event, the entire group reconvened for each team to present their projects and reflect on the experience. The works produced during the artathon were exhibited at an art gallery in San Francisco and Stanford University campus, with opening events at each site that many of the participants attended.

Figure 3: Exhibition opening at art gallery in San Francisco

Research Methods

In addition to the first author's observations of the event, we used several approaches to assess the results of the artathon in relation to our goals to support collaboration between artists and scientists working in the field of climate and disaster risk reduction. First, we asked attendees to fill out paper response surveys during the afternoon of the second day in order to gauge how well the event met their expectations, which components of the event worked well or did not, and what they felt they gained from their participation. Second, we facilitated a group discussion at the end of the second day of the artathon in order to capture immediate reflections on their experience. Finally, the first author conducted in-depth one-on-one interviews with 14 of the attendees between six and eight weeks after the artathon. The interviews lasted, on average 45 minutes and allowed for in-depth discussion of the participant's experience, their collaboration with their teams, and how, if at all, the artathon changed their perspectives on the issues of disaster and climate change.

We present the results in two sections. First, we offer brief descriptions of all seven of the teams' projects below, as a way of understanding the outcomes of the artathon and drawing contrast between the artwork produced and standard disaster or climate risk models. In some cases, these descriptions are supplemented by photographs and quotes from members of the project team. Second, we draw on interview and survey data to describe participants' experience of the artathon and their reflections on the event.

The first author used a process of open, iterative coding of the qualitative data collected to develop four thematic memos, relating to motivations, learning, roles, and outputs. These memos provided the basis for the second results section. Further information on the research instruments, the artathon schedule, and other information can be found in the supplementary materials.

RESULTS

Works Produced

The understandings of disaster and climate change produced by the artathon teams are, unsurprisingly, quite different than the technologies used by experts to define and circulate formal knowledge about disaster. Through these differences, they challenge preconceived notions about disaster and climate risk models and suggest alternative approaches that the field might pursue. We provide brief descriptions of all of the projects below.

Ironic Advertising Posters

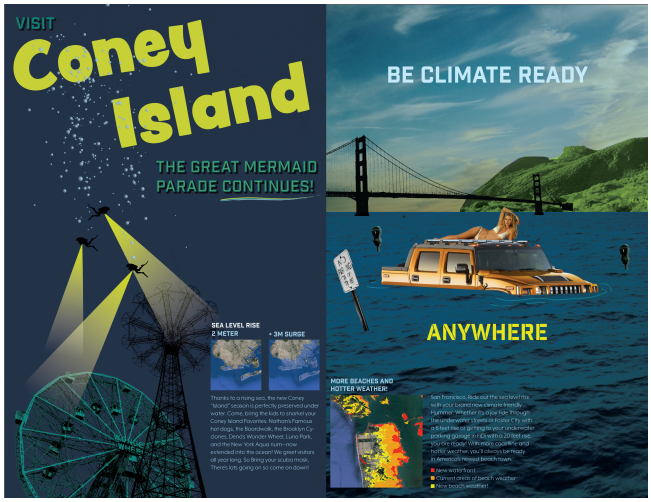

Figure 4: Ironic Advertising Posters

This team created a pair of ironic advertisements for a future world of sea-level rise that show, in their words, that "the effects of climate change can be commodified like anything else, from the need for more rugged transportation to the pleasures of exploring submerged cities." The aim of this work was to take sea-level rise forecasts for iconic areas and use irony and humor to inspire the public to action. The first is for a new kind of Hummer, an all terrain vehicle, that would be able to drive underwater. The headline of the poster is "Be Climate Ready" in military-inspired font. The ad shows a hummer half-submerged in the middle of the SF Bay. Maps in the corner show the extent of land projected to be inundated by sea-level rise in the Bay Area in the future. The second is a travel poster for Coney Island, which in the future described in the piece is completely underwater, and now must be visited with diving gear. Playing off of the annual event at Coney Island, the poster advises viewers that "The Great Mermaid Parade Continues" and exhorts them to bring the kids and

scuba equipment in order to experience iconic locations like Nathan's Famous Hotdogs, the Boardwalk, and Deno's Wonder Wheel, all of which are underwater in the sea-level rise scenario used by the team.

The Bellwether Tree

The Bellwether Tree is a proposal for a large-format sculpture, featuring a cross-section of a redwood tree that, in the scenario presented by the piece, lived from 1417 to 2117. The biography of the 700-year old tree, which "died" a century in the future, tells the story of human's entanglements with the environment through the width and shape of its rings. Small pins placed along the rings of the tree mark particular events and time-periods. The artist statement places the location of the tree in what is currently a State Park in the East Bay, close to northern California's two major fault lines. As a bellwether, the tree records the history of "both climate change and earthquakes" in the region, and "its rings record the story of the relationship between humans and their environment in California's more recent history. The increasing migration of people into California correlates with increased levels of carbon in the atmosphere due to both regional events, such as gold mining in the 19th century, and also events occurring on a global scale, such as industrialization." Recorded through the size and shape of its rings, the tree shows a future escalation of carbon emissions until its death, from submersion in saltwater as a result of sea-level rise in 2117.

Coastal Resiliency in a Changing Climate

This project focused on the tradeoffs inherent in making decisions about coastal resilience and sought to develop a game that engaged participants in thinking, in a tactile fashion, about them. The design of the game centered around a hanging mobile with several tiers, each of which represented certain decisions and tradeoffs such as potential tension between developing new housing in the region and preserving land for biodiversity. To "win" the game, players would work together to place investments in each area while achieving a balance at each of these levels. As the game progressed, "shocks" such as floods, economic downturns, or political conflicts could affect the game and threaten to upset the balance.

Lights on Climate Change

Lights on Climate Change is an audio-video project that raises the question of voice in the discourse surrounding climate change. In a reflexive move, the team conducted brief interviews with other participants in the Artathon, asking them to talk about their own background, work, and relationship to climate change and place pins into a map of the world in locations where they were from or had worked. Selections from the interviews were woven together into a polyphonic audio track that is at times abrasive and at others beautiful. The track is played to a visual of the world map that lights up with different speakers voices, closing with all lights coming on at once. The work asks viewers to think carefully about whose voice matters, whose perspectives are reflected in the discourse surrounding climate change and potential solutions, and encourages us to resist collapsing different perspectives into simplistic narratives of the issue.

Process Reflections

One team chose to focus on their process over the course of the artathon, sharing their design notebooks, sketches, paintings, and handwritten text containing personal reflections on risk and resilience – including participants lived experience of disasters in their own lives. When viewed together, the materials tell a story of collective memory. The team writes that, "further curating could examine how places/objects become living records, how healing properties surface involuntarily when walking down a street or holding a broken cup for example. Collective memories can help communities become more connected and resilient to respond/prevent disasters." The project suggests that art can bring out the personal and emotional qualities of such stories and raises the importance of biography and personal experience in shaping how disaster data is created and interpreted.

Submerge: Emerge

Figure 5: Visual Renderings of *Submerge: Emerge* Project

This team, inspired in part by Maya Lin's Vietnam War Memorial, produced several mockups and a clay model of a rammed-earth constructed maze with blue plastic water bottles forming the interior walls. The descent into the maze indicates the steadily rising seas, with the plastic waste materials designating humanity as bearing the responsibility. As visitors descend further into the maze, the walls arch over their heads, an experience intended to be

both beautiful and claustrophobic. At the end of the maze, they are taken back up into daylight where they can explore a small park atop the grass-covered roof of the maze. Here they can rest on benches, contemplate their experience, or read various signage that provides information on sustainability practices and climate change adaptation.

Invisible Dialogues

The work puts the three-member team into conversation with each other and with more traditional technologies of inscribing threat to "develop a greater understanding of ourselves, a better sense of how our innate personalities respond to different stresses and situations so that, when disaster strikes we can navigate them (hopefully) more gracefully." The piece was composed of three parts – a seismograph, humanograph, and a desirograph. The installation places one existing tool for earthquake measurement, a seismograph, alongside two speculative technologies that measure things such as our impact on the world around us, and how our desires draw us through the world, helping us gauge which types of desires have the strongest pull. In the words of the team, this piece "explores the tension between our agency as individuals to create and control the parameters of our own desires and the unpredictable forces of our changing climate that animate and affect them."

Participant Response

We organize our findings related to participant reactions to the event around four themes drawn from the interview data. First, we sought to understand the participants' motivations for devoting the weekend to the activity. Second, we asked about their experience collaborating with their team members and what, if anything, they learned from the weekend. Third, how did the teams divide work and what roles did individuals from different backgrounds act in? Finally, what were the participant's reflections on the outputs of the event, the artwork that they produced?

Motivations

The majority of attendees told us that their motivations for participating in the artathon were the opportunity to broaden their social networks and expand their thinking through collaborating with individuals from different backgrounds on the topics of disasters and climate change. They reported in the closing survey that they found their experience satisfactory in this regard, and most said they would participate again in future artathons or similar events. The perceived novelty of the event also attracted attendees. All of the participants had at least some prior work on disasters or climate change, and the opportunity to explore new ways to approach these problems was a draw. Several of the respondents were interested in creating their own art/science collaborations and attended in order to learn how the facilitators would approach this challenge.

One contrast between the scientists and many of the artists who attended was how participation in the event connected to their professional lives and livelihoods. Whereas the engineers and scientists interviewed for the most part seemed to approach the artathon as fun, interesting opportunity, many of the artists had significant practical concerns as well. In the words of one respondent:

> *(Many) artists struggle to pay shop rent, pay for materials and pay for our time. A lot of us aren't coming from a 9 to 5 job. I'm not getting a paycheck during the week from somebody and then just fooling around on the weekend with the artathon. If I'm spending time on this during the week then it's taking away from a furniture commission or something.*

In addition, other artists highlighted the value of being able to add participation in both the event and the gallery showings on their CV to help secure future work. In response to questions about how to improve future artathons, several also suggested that funding for their time and materials would have allowed them the opportunity to continue developing their projects beyond the end of the artathon. While each individual varied, the difference between how artists and scientists connected participation to their profession came across in many situations.

Experience and Learning

Participants reported their experience, as noted above, as positive overall, and reported a number of different factors that shaped what they were able to gain from the artathon. Several of the scientists reported that their participation helped them think about their research differently, and gain exposure to alternative ways of framing the problems that their work sought to address. One told us,

> *It was so interesting to hear how other members of our team approached these questions… their questions and insights made me think a lot about the ways engineers study disasters and what other options are out there.*

This engineer also reported feeling reaffirmed by her choice to work in the field of earthquake risk management. Another engineer mentioned feeling very challenged by the work, and that she was spurred to introspection on her role as a technical expert in such a challenging and difficult area. A number of the artists expressed appreciation at learning about new concepts or ideas related to disaster risk and resilience from their collaborators. Perhaps unsurprisingly, many participants noted that the short time-frame, fast pace of the event, and pressure to produce something for the gallery exhibits limited their ability to dive deeply into the issues that arose during collaboration with their teams. Finally, group chemistry within each team varied significantly. A number of the groups stood out for reporting working together extremely successfully, while several struggled to develop a shared vision or distribute project work effectively amongst the team.

Roles

The roles that participants played on each team varied significantly and extended beyond the simple artist/scientist binary the organizers set out in the design of the event. For

starters, many individual participants had, during their own lives and careers, transcended this distinction. A number of the artists had prior education or work-experience in environmental issues, and several of the scientists had, to varying extents, their own artistic practice. Some of the participants also commented on the ways that age and gender influenced team interactions. In teams where one of the members, and not always the artist, had significant experience in the tools being used to produce the work, for example Adobe Illustrator or CAD modeling software, this person took on the bulk of the production work while others helped with background research, refined ideas, or provided other kinds of support. One experienced artist reported that they found themselves taking on an activist or provocateur role, encouraging the team to think more critically about the data and the messaging of the piece, and didn't engage as much with the materials themselves or the final product. Finally, members of two of the teams reported having someone with significant background in teaching that ended up acting as mentors for other team-members and facilitators for their group. Not accounted for in the planning of the event, the diversity of roles that emerged during the artathon provides one indicator of the complexity of designing art/science collaborations.

Outputs

The stated goal of the artathon was to bring together artists and scientists to develop collaborative art projects. Centering art as the main output in the design of the event had a number of impacts, including for many teams, putting the pressure for delivering the final work on the artists. The organizers stressed in several ways that the focus of the event was on process and collaboration rather than product, and exhibition pieces could include everything from process pieces to proposals to polished work. In response, many participants reported feeling uncertainty about expectations or stress about delivering exhibition-quality work in the time constraints of the artathon. Despite this, many interviewees reported feeling satisfaction at the results of their work. Some even expressed surprise at the extent to which they were able to produce compelling or interesting projects in a short time. One artist, used to working alone and allowing longer time periods for ideas to develop, expressed initial skepticism about the design-thinking exercises aimed at ideation. However, by the end of the second day, when their team had completed their work, they felt they had been able to come to an interesting idea and produce a reasonable project for inclusion in the exhibits. During the follow up interview, they remarked, "it seems like your process worked."

DISCUSSION AND IMPLICATIONS

Based on our study of the artathon, we present two sets of insights and recommendations. First, we discuss opportunities that works produced during the artathon offer for the design of crises informatics models and tools. Second, we offer guidance for the design of future art/science collaborations.

Opportunities for Crisis Informatics

Prior work in HCI has looked at the role of art in communicating data to new audiences, or in novel or more compelling ways [39]. Here we consider how the art produced during the event suggests alternative design opportunities for crisis informatics. Though these findings focus specifically on disaster and climate information systems, we believe they may be applied, with some translation work, in sustainable HCI and other domains. Reflecting on the outcomes of the artathon, we found that works produced over the course of the weekend differed markedly from the quantitative models that disaster and climate risk experts are accustomed to. In comparison to the prevalent models of risk, e.g. [12], the art variously raises the limits of "informating" disasters [73] by pointing to silences or biases in current practices or suggesting new ways of drawing meaning from crisis data. In this section, we draw four themes from the artwork created during the artathon that offer opportunities for designers of crisis informatics systems to expand or alter their work.

Non-human perspectives on disasters and climate change

Several pieces raised the issue of non-human perspectives on disaster and climate change. *Bellwether Tree* tells the story of human settlement, disasters, and climate change through the biography of a 700-year old redwood. *Coastal Resiliency in a Changing Climate* put forth biodiversity as one of the considerations that planners in the Bay Area must take into account in preparations to cope with the impacts of climate change. Recent work in HCI has questioned anthropocentrism in design practices [13][26][47][49][53]. For crisis informatics, these reflections may point to the need for greater inclusion of non-humans in risk modeling techniques, which currently focus predominantly on human life and infrastructure. Research in environmental and ecological economics, for example, has attempted to incorporate the value of biodiversity and other "non-market" assets or services into traditional cost-benefit analysis, e.g. [18]. Yet this work has yet to achieve widespread adoption, challenged by lack of data, regulatory requirements, or accepted approaches to modeling [18][19][30][74]. Additionally, as illustrated by *Bellwether Tree,* incorporating non-human perspectives may also require attending more carefully to the temporalities around which crisis information systems are designed and the biases and implications therein, c.f.[58].

Agency, Entanglements, and Tradeoffs

Coastal Resiliency in a Changing Climate portrays planning for, mitigating, and responding to crises as a delicate balancing act — but one in which humans do have some agency. *Invisible Dialogues* argues that our relationship to disaster data is bound up with our desires, biographies, and the materiality of the tools we use to understand crisis. As such, these pieces highlight the social, political, and even personal processes underpinning both the creation of crisis as well as its potential mitigation. These questions of entanglement, balance, and tradeoffs

greatly complicate disaster risk data, often expressed as a single statistic or probability. Designers and researchers have a number of approaches that could be deployed to explore responses to these provocations. Speculative design practices or scenario-based planning, for example, may be deployed to help stakeholders engage more closely with disaster risk information through exploring the consequences of various mitigation options [23][84]. Systems modeling, sometimes used in emergency preparedness, may provide further insights into complex dynamics surrounding disaster risk mitigation, by revealing interdependencies between systems or the potential for cascading failures [33].

Affect

A number of the pieces produced during the artathon engaged directly with a wider range of the affective register than is typical of risk models. For example, *Ironic Advertising Posters* leverage humor in an effort to critique capitalism and inspire activism. *Submerge: Emerge* works with both claustrophobia and hope to encourage viewers to reflect on their role in environmental degradation and show the possibility of alternative futures. This theme is important, though perhaps unsurprising, and similar to other findings in HCI research about environmental data [20][38]. Disaster researchers have noted that official statistics describing disaster often fail to account for the psychological and affective aspects of disaster and disaster risk, which in turn limits official capacity to address them [4][46][72]. Drawing inspiration from these pieces, crisis informatics could leverage prior research in HCI in augmented or virtual reality [45][54] games [78], artistic data visualization, or persuasive technology [9][25] to incorporate the affective aspects of crisis and provide more compelling or engaging encounters with risk data.

Voice & Reflexivity

Several artworks sought to examine expert practice, and place attention on the engineers and scientists themselves. *Process Reflections* asks how individuals' biographies and lived experiences with disaster shape their interactions with expert scientific knowledge. *Lights on Climate* used the voices of artathon participants themselves to highlight the polyvocality of complex and pressing challenges facing today's world, and drawing attention to whose voices aren't heard in these debates. Risk, vulnerability, resilience, and other concepts that emerge in debates over disasters and climate change are complex, polysemous terms with long and contested histories [56][82]. By drawing attention to, and situating, different perspectives, we can better understand the terrain of these discourses. Whose voice is represented, and whose is not, in disaster and climate data is an issue of critical importance [10][16][70]. Participatory risk modeling approaches reveal different viewpoints and values and facilitate the creation of a shared conceptual model for risk management purposes [81], but actual efforts to accomplish this remain unfortunately few. In addition, crisis informatics may also draw from HCI work in reflective design [69], or critical technical practice [1][7], to support reflexivity on the part of experts who design and deploy information systems to interrogate the biases and assumptions embedded in these tools.

Designing Art/Science Collaboration

Vines et al. have argued that designers and facilitators of workshops should pay greater attention to how the features of these events shape participants' experience and their outcomes [80]. In response to this, we consider some of the successes and limitations of our attempt at staging art/science collaborations around crisis data through the artathon. We reflect on what was learned from this event about the design of these types of collaborations, and participatory design workshops more generally.

Crossing Boundaries

The central premise of the artathon was that facilitated collaboration between artists and scientists would yield novel or interesting insights about crisis informatics that would be more difficult to come to otherwise. Due to HCI's status as an interdisciplinary field of research and practice, and the frequent goal of participatory design of bringing groups from different social worlds together, research into how to support interdisciplinary collaboration is an important concern [38][63]. Although workshops and events like the artathon bring participants out of their daily routines and settings, participants do not leave their habitus or everyday lives fully behind [66]. In particular, Holmer et al. have pointed to the way that disciplinary frames constrain participants' experience of, and contribution to, workshops [34]. In the artathon, the teaching talks helped teams establish that each member brought their own forms of expertise and begin to develop a shared language, something crucial to orienting team collaboration during workshops [3]. In addition, the focus on concrete outputs gave direction and tangible purpose to the work.

Sustaining Collaboration

Given the potential complexity of the relationship between art and science, we viewed post-artathon collaboration amongst participants as equally or more important outcomes than the artworks which were produced. We therefore hoped, prior to the artathon, that participation in the event would lead to longer-term interactions amongst some of the attendees. Several of the exercises and activities, including the creation of a Facebook group ahead of the event, teaching talks, and post-artathon events such as the exhibitions, were intended to support the development of relationships that would persist past the event. Though several teams continued to develop their projects in preparation for the exhibitions, to our knowledge, this collaboration has for the most part ended. Prior work in HCI has noted that many participatory design events are isolated or one-off events and that achieving scale or sustainability has proved challenging [71]. In future art/science collaboration events, we would consider further options for supporting post-event collaboration, such as

identifying funding to support continued work by teams, as is common in hackathons, or other measures.

Rhythm and Temporality

Drawing inspiration from hackathons and similar workshops, the artathon was a fast-paced, production-oriented event that lasted for two days. HCI has begun to examine how the temporal and rhythmic aspects of workshops shape participants' experience. For example, Andersen and Wakkary find that high-tempo activities in group-centered workshops can help teams quickly make decisions without necessarily compromising the quality of the outputs [3]. Rosner et al. argue that allowing for flexibility in the timing of activities can help to enable meaningful engagement for a diversity of attendees [66]. Indeed, we speculate that other temporal structures for the event might have yielded alternative results. For example, some participants suggested breaking the event up into shorter 2-3 hour weekly meetings over a period of several months would allow more time between sessions for in-depth research or reflection. Alternatively, a shorter half-day or day-long event could have just focused on team-building and brainstorming, ending at the proposal phase, without teams having to attempt to pull together a piece for exhibition. Although the experience of the artathon suggests that fast-pace agenda was generally effective in supporting collaboration toward the production of interesting projects, more research on the effect of temporality is necessary to help workshop designers evaluate the potential consequences of these decisions.

Localization

While the framing of the event and all data provided to the teams was focused on the San Francisco Bay Area, in practice, the direct connection of the art-pieces to the region ended up being fairly limited. As recent work in HCI has asserted the situated and contextual manner of both the creation of data and its usage, this was perhaps a missed opportunity [50][77]. There are a number of ways that future efforts at supporting art/science collaboration in crisis informatics might consider strengthening the connection of the event to place. One way to do this might be to orient activities around a specific policy issue, hazard, or part of the city in order to make the activities more specific. In addition, Firoz and DiSalvo recommend that workshop designers invite participants for whom the data under discussion is a "matter of concern [63]." In future events of this type we would therefore explore opportunities for broadening participation beyond professional artists and scientists to include members of communities vulnerable to disaster, government representatives, or emergency responders as a means of more directly connecting the activity to local needs and context.

Outputs

Andersen and Wakkary point out that there are tensions between workshop activities that are goal-oriented and the values of open-endedness and participant control that participatory design emphasize [3]. In this case, the art-forward nature of the workshop suggested a number of new possibilities for crisis informatics research and design. However, we noticed that in many projects, the scientific aspects of the issues at stake were not given as much attention. This is probably due to the fact the event was oriented towards the production of artworks. Though we did not anticipate this, the "authenticity" of the science and engineering [39] was given less priority than the quality of artistic outputs. This suggests that art/science initiatives with alternate goals might aim at other kinds of outputs. For example, one attendee suggested that working toward developing research grant proposals might have shifted the balance from artistic expression toward scientific inquiry. Indeed, work in HCI has argued that speculative or fictional research abstracts or papers can help explore the potential of new directions of study or suggest new research questions that disaster risk experts might pursue [6][48]. Another model is to use art/science collaboration to help stakeholders and publics to engage in critique, debate, and reflection with regards to emerging scientific possibilities and their everyday applications. For example, design researchers at Goldsmiths have used design and art collaborations with scientists to explore ways of using design as a tool for debate and engagement [5][29][42]. Prior work in HCI on art/science collaboration has focused, like the artathon, on efforts aimed at producing art. Experimenting with other forms of output would enrich our understanding of the benefits that art/science collaboration.

CONCLUSION

The results of the climate and disaster risk artathon demonstrate significant opportunities for designers and artists to contribute to crisis informatics research and practice. This project also suggests that such contributions can extend beyond more effective communication of science to providing critical reframing of research questions and agendas. Through evaluation of the works produced over the two-day artathon, this paper has suggested several avenues for the design of future crisis informatics systems that our research community might explore. In addition, we have highlighted how findings from the design and facilitation of the artathon contribute to the growing body of research in HCI on how workshops and other participatory events can facilitate art/science and other types of interdisciplinary collaboration aimed at critical examination of computing technologies.

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