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Mobilising Publics: Governing Biodesign Technologies

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Biodesign technologies enable us to design a living system and observe how that system and its environment transform over time by analysing, editing, and (re)constituting biological materials. This project creates a new mobile, tangible, and approachable design product to speculate and explore uncertain futures as well as ambiguous ethical issues related to biodesign technologies. To involve multiple and mobile publics, we selected two art festivals held at Sado Island, Japan, and recorded the feelings, thoughts, and views of various audiences through visual thinking strategies (VTS). Our project mobilised both human participants and biomaterials, (social) media services, exhibition spaces, and the culture and environment of Sado Island. Considering the future governance of biodesign technologies allowed us to blur and transgress the boundaries between nature and artefact and between designers and the designed.

Keywords: biodesign, mobile publics, visual thinking strategies, mobility, public engagement

1   Introduction

1.1   Project outline

While the typical acronym used to understand the implications of emerging technologies is ELSI (ethical, legal, and social implications), we turned this on its head, naming our project 'Innovation for Society, Life and Ethics' (ISLE). While ELSI research often leaves scientists, decision-makers and citizens with negative impressions of scientific development (Balmer et al., 2015), our project aims to foster proactionary approaches to emerging biomedical research by portraying both its positive and negative societal aspects. Under the Japanese government funding initiative for evidence-based policy making, this project also intends to serve part of the policymaking by collaborating with wider stakeholders and providing available evidence for biodesign technology policy. From a design perspective, a good entry point for a diverse range of people to engage in our project would be a tangible, mobile, approachable product paired with visual images. However, conventional speculative bioart works are somewhat critical of the commercial development of technologies and convey a rather straightforward, unambiguous message. Therefore, it is important to articulate the kinds of visual images that can be used to speculate on and explore uncertain futures and vague ethical issues.

This paper first introduces biodesign technologies and examines the role of publics in design as the key concept of our project. Chapter 2 presents how we applied visual thinking strategies in meta-design and introduces the product design of a pop-up book on biodesign technology. Chapter 3 shows how we designed and organised public events including citizen science, pop-up talks, and workshops for the designed product at two art festivals held on an island. Chapter 4 summarises the main findings and limitations of our project, along with prospective ideas for further investigation.

1.2 Biodesign technologies

The recent development of genomic research has led to the convergence of chemistry, engineering, nanotechnology, and informatics. Genome analysis, editing, and synthesis technologies have been used to develop increasingly complex artificial computation devices using engineered biological motifs (Manzoni, Urrios, Valazquez-Garcia, de Nadal & Posas, 2016), in addition to digital tools for acquiring, storing, distributing, and analysing genomic big data (Stephens et al., 2015). These techniques apply rational design rules to the use of living organisms in structures, objects, and tools that is often conceptualised as 'biodesign' (Myers 2012). Unlike other emerging technologies, such biodesign technologies have two specific features: (1) anthropogenic (designing nature) and (2) heritable (designing the future). Hence, biodesign technologies enable researchers to design a living system, as well as to observe how this system and its environment transform over time by analysing, editing, and (re)constituting biological materials. The results are widely applicable to medicine, industry, agriculture, and environmental science, including genetic engineering, genome editing, synthetic biology, biomimetic chemistry, and molecular robotics. As biodesign technologies blur the boundaries between the natural and artificial and cause long-term effects on entire living systems, the autonomy and irreversibility of these systems has become vital (Schmidt, 2016).

1.3 Designing (with) publics

Public engagement is a necessary part of opening up future directions of emerging technologies; however, little is known about who are the publics to be engaged (Stilgoe, Lock & Wilsdon, 2014). Designing with publics does not mean consuming pre-existing publics but rather connecting to multiple and mobile publics that temporarily emerge and assemble around shared concerns (Birkbak, Petersen & Jørgensen, 2018; Galloway, 2010). Continuous, active engagement is key to improving public understanding (and appreciation) of science and reaching an audience that may otherwise not dare to enter scientific venues. This dilemma can be solved by fostering public engagement in science outside of formal learning environments (Falk & Dierking, 2010). One possible answer is to turn to the social science understanding of mobility, which focuses on how people physically and socially shape the world through how they move and mobilise people, objects, information, and ideas (Büscher & Urry, 2009). In such an approach, human and nonhuman actors as the participants are placed on equal footing. Mobilising publics in relation to the governance of biodesign technologies can further breach the boundaries between nature and artefact and between designers and the designed. The following two chapters demonstrate how we co-created a product and project on biodesign technologies using a novel approach that applies visual thinking strategies to real-world issues via design and places them in unusual locations to attract multiple and mobile publics.

2   A mobile product

2.1   VTS as meta-design

We began our design process with meta-design. While participatory design involves users in shaping a project and ends when the product is taken into use, meta-design allows users to act as designers by anticipating or envisioning potential design to take place in use after project design. It empowers all stakeholders (including end users) to actively engage in the ongoing development of personally meaningful sociotechnical systems (Fischer & Herrmann, 2011; Ehn, 2008). In order to collaborate with general citizens as potential product users, we applied visual thinking strategies (VTS). VTS is an approach that uses discussion of artwork or visual images to encourage creative and critical thinking as well as communication and visual literacy skills (Yenawine, 2013; Moeller, Cutler, Fiedler & Weier, 2013). It invites viewers to freely share their multiple perspectives about artwork or visual images by asking three deceptively simple questions:

- What's going on in this picture?
- What do you see that makes you say that?
- What more can you find?

Although VTS has been used in the sciences (The Wild Center), it has not been previously used in bioart, which requires integration of ethical and moral discussions in bioethics and aesthetics (Vaage, 2016). Bioethics is always at risk of focusing on future ethical matters by reflecting on possible and speculative technological developments, with consequences that demand immediate attention (Nordmann & Rip, 2009). Aesthetics also has difficulty in addressing and recognising authentic issues, for which VTS requires viewers not only to provide their views on the artwork, but also to reflect and reframe their values within the social context (i.e. meta-cognitive thinking). As these interdisciplinary discussions require a certain level of critical thinking and literacy skills, it is vital not only to have a good facilitator, but also to focus VTS on an accessible, ethically ambiguous work. Moreover, viewers may find it difficult to objectivise an artwork containing overly multi-layered concepts that generate spatiotemporal transformations, presuppose specific contextual knowledge or reflect the whole project process as a piece of work (Kitano & Hara, 2017).

The bottom line is that most existing bioart works remain conceptual, ethically unambiguous and/or technology-oriented; none of them address gene drive technology and its ethical and social ramifications. This led us to produce a new mobile, tangible, and approachable piece in collaboration with designers and artists. While often used as an art education method, we applied VTS to ask viewers to consider more open-ended, value-laden, ambiguous questions such as: 'What does this image tell you about the societal implications of emerging technologies and desirable futures'?

2.2   *Gene Drives Elastic Future*

We named our final design product *Gene Drives Elastic Future* (2018). It consists of a lift-the-flap book on the governance of 'gene drive' technology with a mixture of photos, illustrations, manga stories, pop-ups, and layered pages. Gene drives is a biodesign technology to alter or suppress wild populations by adding, disrupting, or editing genes and propagating traits that reduce reproductive capacity (Esvelt et al., 2014).

The book is divided into three sections. The first comprises two facing pages expressing the dual nature of gene drives using intertwined and layered images of socio-biomaterial

assemblies in our daily lives: vaccinations, a doctor visiting a school, eggs, the flu virus, sneezing, a pedestrian crossing, a chicken, traveling to a tropical region, insect bites, and a mosquito. In this section, viewers are asked to contemplate the following question: 'Are daily life and biotechnology related'? (Figure 1)

Figure 1. Section 1 of Gene Drives Elastic Future

The second section refers to the current governance of biodesign technologies in order to discuss the consequences of gene drives for future societies. This section includes a small, manga-style book that describes how gene drives propagate a specific suite of genes throughout a population and how this technology could potentially wipe out mosquitoes that transmit malaria, dengue or zika to improve public health. As the leading question—'What are the light and dark sides of biotechnology'?—suggests, the manga story suddenly stops by inferring the negative aspects of this technology. The manga book is followed by drawings of two possible future worlds: what may happen if gene drives are used and not used, and the resulting vivid interactions between humans, machines, plants, and animals. Again, both positive and negative consequences are suggested in the drawings (Figure 2).

Figure 2. Two possible future worlds shown in Section 2

The book ends with two pages, separated by tracing paper, which show two different research spaces: (1) academic researchers in an advanced lab and (2) amateur citizen scientists in a domestic kitchen (Figure 3). The amateur citizen scientists with biodesign technologies, called do-it-yourself (DIY) biologists or biohackers, mostly take interdisciplinary, open, and not-for-profit approaches whilst developing cost-effective tools and equipment and working for democratisation of self-empowerment. Their activities also raise a wide variety of issues concerning research and product safety, public health and environment, biosecurity, and ethical and social implications of emerging technologies

(Seyfried, Pei & Schmidt, 2014). Inspired by transhumanism, which advocates the enhancement of human body and intelligence by technology, the motivations of biohackers include cybernetic exploration, personal data acquisition, and advocating for privacy rights and open-source medicine (Yetisen, 2018).

Figure 3. Biohackers in a kitchen in Section 2

The third section also contains two facing pages but includes pop-ups that appear when opening the pages. This section focuses on two questions: 'Are gene drives my business?' and 'How are gene drives related to me?' Readers are asked to make this issue their own and behave as active actors, rather than passive viewers in the current context of sociotechnical governance. The pop-ups three-dimensionally arrange different images of humans and their associations: experts on an advisory committee, neighbours gossiping, academic researchers, biohackers, a mother caring for her child, a rough-and-tumble boy, a bemused girl, a worried couch potato, a chronically ill patient, and a disappointed traveller (Figure 4). In the governance of biodesign technologies, neighbours, and biohackers may become more of political actors, corresponding to experts and academic researchers in conventional governance. Mothers and patients who prevent infectious diseases would also be affected by the development of gene drives. Even bystanders could be empowered by changing their awareness, understanding, and behaviour.

Figure 4. Pop-ups in Section 3

An illustrator worked under the direction of a product designer, who added photos and paper pop-ups and compiled them into a book. From the very beginning, they closely collaborated with different researchers in art education, epidemiology, biosecurity, bioethics, and science policy. The design was modified several times during production. An epidemiologist pointed out that adult anopheles mosquitos always rest with their abdomens sticking up in the air, causing us to redraw a mosquito in the second section's manga book. We also updated the portrayals of stereotypical, obsolete laboratory equipment, supplies, and instruments after receiving suggestions from a university researcher and visiting his lab.

After the product was finalised, we organised a six-hour VTS workshop at the Kyoto University of Art and Design (KUAD) in June 2018, during which we invited five citizens to participate (Figure 5). As part of the meta-design and project design steps, we then reflected on the workshop's outcome and developed additional ideas on how to use this design product. Two months later, we visited Sado Island in Niigata Prefecture, Japan to test the product.

Figure 5. VTS workshop at KUAD

3   A mobile project

3.1   Art festivals and islands

The Earth Celebration (EC) is a summer festival that has been produced by the Kodō Taiko Performing Arts Ensemble since 1988. Internationally renowned for its performances of a broad range of Japanese percussion instruments, the festival showcases outdoor concerts, workshops, and the Harbour Market at Ogi Harbour. It is held at the southern part of Sado Island—the sixth largest island of Japan just off the city of Niigata on the Japan Sea Coast. In 2018, the Sado Island Galaxy Art Festival (SIGAF) grew out of artistic sensitivity and cultural tourism on the island that developed following the EC. At these art festivals, we saw an ideal public space to attract those not necessarily interested in science and technology (cf. Bultitude & Sardo, 2012). Therefore, via site visits and remote exchanges, we built rapport with both the SIGAF executive committee and the EC general producer, eventually securing workshop space at the Harbour Market during the EC and an event venue at the i-Port Sado Complex during the SIGAF.

These art festivals were especially appropriate venues for our project because of their location on Sado Island. Our project name, ISLE, is not only a backwards version of ELSI,

but also reflects the vital role of islands as spaces for public engagement and mobility. Islands exist in a state of tension between openness (migration and mobility) and closure (insularity and isolation), which is reflected in islanders' identity and way of life (Baldacchino, 2004). In addition, discussions regarding colonialism and sustainability are necessary to improve islanders' lives, as well as to safeguard their cultures and environments (Grydehøj, 2017). Such tensions are apparent on Sado Island. For example, the Sado Gold Mine was Japan's largest gold mine and operated from 1601 until 1989. Another instance is the Kitazawa Flotation Plant, a gigantic industrial heritage site that was once the largest ore beneficiation plant in East Asia. Now serving as tourist attractions, these places commemorate how workers suffered under poor working conditions due to government and industry pressures. Although the art festivals do not explicitly focus on this dark legacy, most festival participants (tourists as well as local residents) were well-aware of these locations. Both the art festivals and Sado island thus sharpened a 'sense of place' in the dynamics of human-environment interactions among participants (Haywood, 2014).

3.2 Mobile citizen science

However attractive our product may seem, it is quite hard to engage people who otherwise may not think and talk about science and ethics in unusual locations, such as art festivals and islands. Our project thus needed a priming event and agent to connect keen public interest in the arts and tourism to people's active engagement with our product. The agent is the Science Communication Research Institute (SCRI), based in the city of Yokohama. Together, we shared a tented booth at the Harbour Market (17–18 August 2018). There, the SCRI sold the 'L-eye', a mobile microscope that attaches to smartphone cameras and can take photos and movies of minerals and micro-organisms. To promote the L-eye, the SCRI created a 50 × 50 cm^2 exhibition space called 'Go-Go-Museums', where visitors could experience micro-worlds in an easy and enjoyable way. Volunteering high school students were able to combine the L-eye with a citizen science app called 'iNaturalist'. This app was launched in 2008 to serve a global community, and to aid in the observation and identification of natural phenomena, allowing users to explore, observe, and discover the natural world by taking pictures of naturally occurring organisms, and uploading the images to a global community of naturalists who crowdsource to identify them (Nugent, 2018).
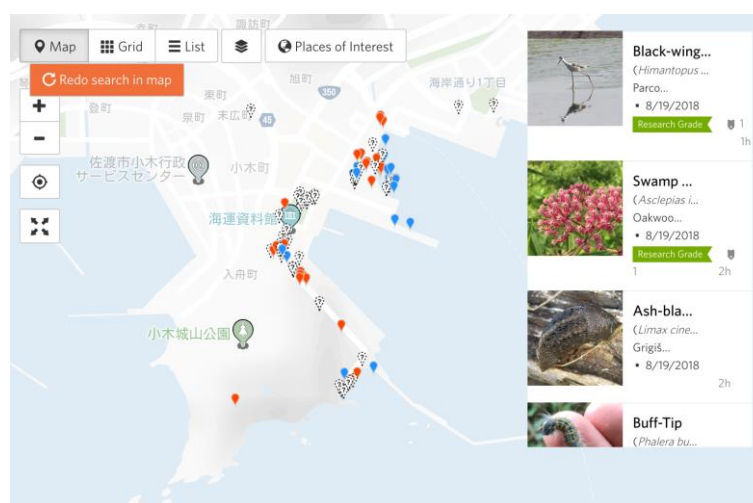

Figure 6. iNaturalist location mapping during the EC festival

These mobile tools take science out of the laboratory, opening the field to the public and galvanising people and things as mobile publics. The high school participants took pictures of organisms around Ogi Harbour and uploaded them to iNaturalist (Figure 6). Thus, they had some opportunities to reconstruct the meaning of nature and science around them.

3.3 Pop-up talks
Through the SCRI's priming event with their mobile tools, our project members chatted with visitors and showed them how to use the pop-up book. Although a few people showed some interest and gave us useful comments, more intensive discussion was needed. As a prototype for a later public workshop, we then organised a casual, brief open-air interactive session of VTS on *Gene Drives Elastic Future* at a park in the Harbour Market close to the EC venue.

The participants were seven local volunteer high school students who helped to manage the EC festival and joined in the iNaturalist location mapping. Four took part in two 30-minute sessions in the morning, and three in the afternoon on 18 August. Informed consent was obtained from all respondents to collect their data. First, we asked them to flip through the book individually for several minutes; we initially provided them with no information or instruction about our identity, project or product. We then facilitated a group discussion where they guessed what the product was saying, why we made it, and their impressions. General impressions focused on socioecological vulnerability to emerging biotechnologies, but one participant took away a message regarding the relationships between humans, animals, and artefacts. Going beyond contrasting technology as the subject with society/environment as the object, she seemed to achieve a sense of the sociomaterial assemblies as publics. Participants' final comments showed their willingness to realise and commit to the worlds they did not know, to critically and reflexively examine their daily lives and social change, and to clarify and share a desirable future. Because they had little knowledge of the development and governance of genetic technologies and identified potential issues on their own, this participatory exercise can be considered as having a new type of participatory design that is not technology-driven or issue-oriented but rather involves the co-designing—or at least the co-wondering—of sociotechnical worlds. In this case, gene drive technologies, sustainability, and public health concerns triggered public debate on a desirable future.

3.4 Public workshop
On 19 August 2018, we held a 1.5-hour public workshop on *Gene Drives Elastic Future* at the i-Port Sado Complex. An artist-scientist delivered a talk on the interactions between life science and art, and an ethicist gave a presentation on the ethical implications of gene drives. In between the two speakers, we organised group VTS discussions. Around half of the 15 participants were local Sado residents, including city councilors, an amateur artist, a schoolteacher, and a high school student. The others were project members and experts in science, ethics, policy, education and/or communication. Informed consent was obtained from all participants to gather the data.

We asked them three questions: (1) 'What is this book?' (2) 'Do you like the worlds illustrated in the second section?' and (3) 'What do you think the third section represents?' Responses to the first question include 'polemic', 'challenging', 'an apparent picture book', 'a sophisticated manga study book', 'suggesting invisible risks', 'connecting daily life and lab', 'different ideas on arts or life can be drawn by different viewers', and 'half of the book

addresses problems but the other half explores solutions via the two possible future worlds' (see Figure 2). The second question does not conform to the typical VTS framework, but was intended to examine viewers' own values. Most of the respondents were unable to judge which world they wish to live in because they found the negative, positive, and ambiguous aspects of both worlds. The discussions among one group then moved on to alternative precautions against mosquito-borne diseases. At the end of the workshop, we asked them to write down what they had learned during the talk, and then to share what they had written with others. Their final statements included the importance of talking about unknowns, increased curiosity regarding the term 'kitchen biology', and the value of such a fundamental discussion (Figure 7).
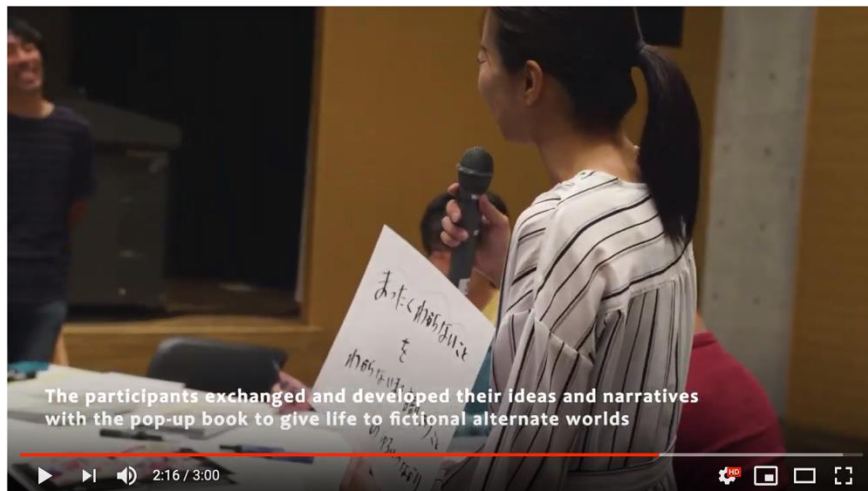

Figure 7. Public workshop at the i-Port Sado Complex. Source: https://youtu.be/TP7jIsarI-Q

In addition to posters and flyers distributed at the art festivals, Ryōtsu Ferry Terminal and a café, several priming events were conducted for this workshop. At the same venue, there was a special exhibit featuring panels of drawings from *Watashi Wa Shingo* (My Name is Shingo), an internationally acclaimed manga series by author Kazuo Umezu, published between 1982 and 1986. This science fiction story centres around a hand-shaped robot with human emotions that believes an elementary school-aged boy and girl are its parents. Sado Island serves as one of the locales in the story (Figure 8).
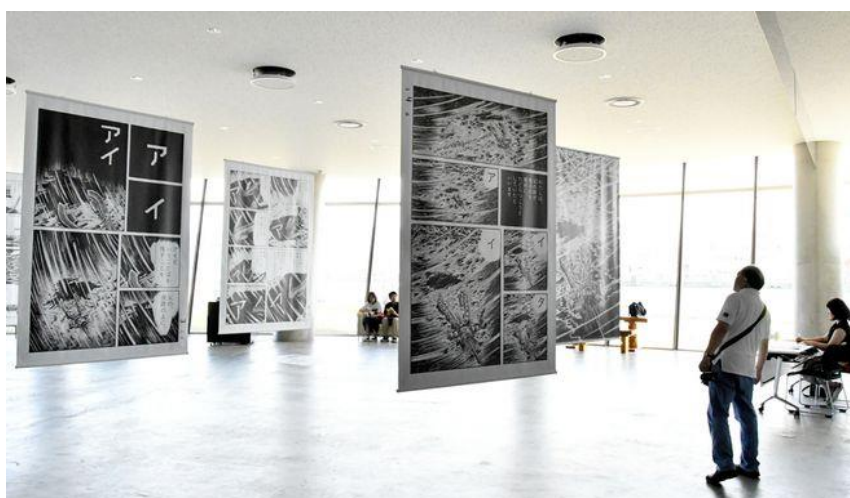

Figure 8. Panel exhibition of 'Watashi Wa Shingo'. Source: Hara (2018)

As the exhibit was organised as part of the SIGAF and we collaborated with this festival, the exhibit and our organised events resonated with the audience members. Our event was titled 'Animals in Sado, or a Super Lifeform'. Next to the exhibition space, the SCRI, in collaboration with the Sado Institute of Living Creatures (a civil society organisation for environmental education and communication), conducted another L-eye workshop through which participants jointly observed, photographed, and made a visual dictionary of microbes living in nearby paddy fields. The SIGAF and SCRI events were publicised together on 31 July through Dommune, a live streaming channel for broadcasting various cutting-edge aspects of culture. All of these events and materials served as publics as well as enablers for different people to participate in the workshop and project.

After the art festivals, we compiled both the project and product processes as open-access videos to promote our work (Figure 6). One of our members also presented public engagement activities on the project at the Biological Weapons Convention (BWC) Meeting of Experts in August 2018. These materials became independent actors for attracting those who may be interested in our work.

4   Conclusions and future work

As biodesign technologies transcend the boundaries between the natural and the artificial, and meta-design empowers all stakeholders to be actively engaged in the ongoing development of sociotechnical systems, designing the governance of biodesign technologies becomes anticipatory, reflexive, and analytic with multiple and mobile publics. Our designed product on the governance of gene drives was co-created by artists/designers and researchers from various disciplines. The product, with the help of VTS as meta-design, enables viewers to consider and discuss how socio-biomaterial assemblies around gene drive technology are disseminated in our daily lives, and how they are governed and related to each viewer. Our project selected two art festivals held on an island as unusual event venues for VTS, mobilising researchers, art festival organisers, science/environmental communication organisations, volunteer high school students and local residents, as well as our designed product, naturally occurring organisms, citizen science tools and data, events, exhibits and festivals, and the culture and environment of Sado Island. Considering the future governance of biodesign technologies, this heuristic mobilisation blurs the boundaries between nature and artefact and between designers and the designed.

We also faced some limitations. First, despite the help of festival organisers and science/environmental communicators, we attracted and involved a limited number of tourists and festival participants due to the short lead time. Second, both the pop-up talks and the public workshop were rather conventional, immobile settings in which participants were likely to try and give the 'right' and polite responses. Third, we have been struggling to find more effective channels through which key stakeholders can communicate, discuss, and decide with broader publics, as well as evaluate the effectiveness of public engagement.

As the next step, we will visit Teshima Island during Setouchi Triennale 2019, a contemporary art festival, and develop ways to identify participants' views on nature and the future based on our survey analysis of ambiguous public views toward synthetic biology and gene editing. To accomplish this, we will not only organise a VTS workshop, but also apply walking methods for tourists and local residents with audio transcription, photos, and location mapping tools (Macpherson, 2016). Participants will then be able to locate the product and

the project more naturally during the course of their visit to or living on the island, and during the art festival. Government policymakers and journalists are also invited to contribute to the development of a new policy framework for biodesign technologies. Considering that all of the sociomaterial assemblies presented on the island, the art festival, and the workshops are represented in the product, the (social) media tools, and the project are more likely to be mobilised to form publics beyond people.

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