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Geoengineering at the 'Edge of the World': Exploring Perceptions of Ocean Fertilization through the Haida Salmon Restoration Corporation.

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Abstract

This paper describes an opportunistic case study of the 2012 Haida Salmon Restoration Corporation's ocean fertilization project. Anchored in notions of place and identity, the Haida Salmon Restoration Corporation marks a novel entry point into social research on geoengineering, which enables a more situated engagement with ocean fertilization, in keeping with geographical traditions. The paper adopts an innovative design that combines ethnography with Q-Methodology, to identify clusters of shared meaning around the way in which contestation surrounding the geoengineering ambitions of the Haida Salmon Restoration Corporation invoked different interpretations about the role and nature of 'nature' and human agency. This case study suggests that 'geoengineering' will always be performed and interpreted through contextually specific meanings and such local particularities as geography, people, practices and place. Nevertheless, interpretative resources that have been described in relation to a range of geoengineering technologies, (including solar radiation management proposals), through earlier, and less situated, social science literatures, are also traced from this place-based experience of geoengineering. Furthermore, we suggest that our Q-Methodology factors have some interpretative overlap with ideal-typical 'worldview' heuristics, used to describe contemporary Western cultural currents in earlier literatures. This connects ocean fertilization in Haida Gwaii with debates about other geoengineering technologies and with wider cultural meanings and literatures that consider the human relationship with nature. We suggest that the Q-factors may serve as useful mnemonics for helping to conceptualise some of the deeper contested values and assumptions that drive public contestation about geoengineering.

Introduction

New turns in the geoengineering debate

The desire for human control over climate and weather has a long history, emerging and re-emerging in different places, in different cultures, at different times and with different goals (Fleming, 2010). Paul Crutzen's (2006) seminal essay in the journal *Climatic Change,* 'Albedo Enhancement by Stratospheric Sulphur Injections: A Contribution to Resolve a Policy Dilemma?', is widely credited with giving renewed credibility to ambitions for *global* control over *global* climate (Hulme, 2014) and to contributing to a new academic, policy and public discourse on geoengineering (Buck, 2012; Nerlich and Jaspal, 2012; Porter and Hulme, 2013; Hulme, 2014; Boettcher and Schäfer, 2017).

A stagnant global response to mitigating greenhouse gas emissions, coupled with emergence of the climate tipping point metaphor (Russill and Nyssa, 2009) and concerns that significant climate change has become 'locked-in', have added urgency to Crutzen's narrative. And now, a decade later (Boettcher and Schäfer, 2017), geoengineering has transitioned from fringe to more mainstream policy discussions, positioned as a third policy response alongside mitigation and adaptation (Stilgoe, 2013; IPCC, 2014).

In a world where shifts towards far-right populism in Western governance regimes make the likelihood of a meaningful global response to climate change mitigation appear even more challenging (Milman et al., 2017), geoengineering research is today taking new strides. Scientists at Harvard University are about to begin spraying aerosol particles into the Earth's stratosphere in the world's first open-air field trials to test the viability of solar geoengineering (Ramachandran, 2017). And a new non-profit group, the Oceaneos Marine Research Foundation, has emerged in Vancouver, around a proposal to fertilise Chilean waters in the Pacific Ocean with iron, in efforts to stimulate the growth of phytoplankton (Tollefson, 2017).

As interest in geoengineering gathers, debate is spreading wider and deeper, drawing together an ever-greater range of stakeholders, political actors and interests, with multiple, and often competing, perceptions and understandings of why geoengineering may, or may not, be desirable and feasible (Hulme, 2014).

Geoengineering: Opening up a debate about the human relationship with 'nature'

A small, but emerging, body of empirical (Nerlich and Jaspal, 2012; Corner et al., 2013; Macnaghten and Szerszynski, 2013; Porter and Hulme, 2013) and theoretical (Galarraga and Szerszynski, 2012; Preston, 2012; Clingerman, 2014; Hulme, 2014), social science literature, has argued that debates about geoengineering are in a sense debates about human identity, about the nature of reality, about the knowledge we acquire and about the futures we desire. 'Nature', Olwig (1996: 87) argues is 'a ghost that is rarely visible under its own name' and narratives of geoengineering have been found to embody diverse beliefs about nature and human agency. Human self-interpretation lies at the heart of the ways in which people conceive of and relate to the concept of 'nature' (Soper, 1995; Castree, 2005). Thus the geoengineering debate invokes not only different conceptions of nature, but also discordant interpretations of human identity and place within the world (Galarraga and Szerszynski, 2012; Clingerman, 2014). Culturally and cognitively fabricated, specific and variable, different understandings of nature, and the human place within it, have been particularly convincing at different times and in different contexts (Simmons, 1993; Cronin, 1995; Castree, 2005). Prevailing constructions of nature, have similarly tempered narratives of weather and climate (Boia, 2005; Donner, 2007, 2011)

Geoengineering is only one of the latest in a long line of technological developments – including genetic modification, nanotechnology, nuclear power and carbon capture and storage – that has provoked debate about the desirability and feasibility of humans attempting to control, shape or manage natural systems (Macnaghten and Urry, 1998; Corner et al., 2013; Hastrup, 2013). Through its dual identity as a technological endeavour of both 'global' and 'intentional' (Clingerman, 2014; Galarraga and Szerszynski, 2012) remit, geoengineering has, nevertheless, been argued to have unprecedented potential to recalibrate the parameters through which notions of nature and human agency are constructed, to widen the meaning of what it is to live within the 'Anthropocene' and thus to draw humanity into a new relationship with nature (Galarraga and Szerszynski, 2012; Preston, 2012; Hamilton, 2013; Macnaghten and Szerszynski, 2013).

If then, as Clingerman (2014: 7) claims, geoengineering "challenges us to rethink our sense of being human", it is surely prudent to self-consciously and collectively define the terms of this new relationship. Yet, a small number of actors are disproportionately being given authority to frame debates on geoengineering (Kintisch, 2010; Hamilton, 2011b; Buck, 2013; Porter and Hulme, 2013) and to date social science literatures on geoengineering have largely brought forth a limited range of voices. Existing debate on geoengineering has therefore been gendered, as well as ethnically, culturally and geographically biased (Whyte, 2012; Bellamy et al., 2013; Belter and Seidel, 2013).

A situated engagement with perceptions of 'geoengineering' through the case of the Haida Salmon Restoration Corporation

Social science literature has typically explored perceptions of geoengineering in controlled, survey or focus-group-type settings. Deliberative methods, usually executed in focus groups with notable sophistication in their design, have become the gold standard of research on public perceptions of geoengineering (Bellamy et al., 2016; Bellamy et al., 2017; Macnaghten and Szerszynski, 2013). However, participants in these deliberative processes typically don't have much advance understanding of geoengineering, which means that these research designs still, in some senses, have to create the views that they seek to elicit (Buck, 2010; Stirling, 2008). In a move away from research on public perceptions of geoengineering that has previously been dependent on more abstract rationality, this paper focuses on a 'real world' case of geoengineering, diversely experienced and interpreted by a varied range of 'public' and 'expert' actors and commentators.

The Haida Salmon Restoration Corporation (HSRC) was an ocean fertilization (OF) project that preceded the Oceaneos Marine Research Foundation, with notable continuity among some members of the project management teams. Originally led by US entrepreneur Russ George, known for his controversial history in carbon credit ventures (CBC, 2013), in the summer of 2012, the Haida Salmon Restoration Corporation (HSRC) tipped 120 tonnes of iron sulphate and iron oxide into an ocean eddy in international waters, off the west coast of Haida Gwaii. Branded the world's 'largest geoengineering experiment' by media outlets (Lukacs, 2012; McKnight, 2013), the HSRC was funded by the First Nations Haida village of Old Massett, on the promise that the project would revive depleted local salmon runs, while providing a meaningful response to the threat of anthropogenic climate change and generating millions of dollars for the village from the sale of carbon credits

(White, 2013).

The HSRC case study invoked a rare site of live, and often very sophisticated, debate about the desirability and feasibility of OF as a form of geoengineering and embroiled a diverse set of actors, who made sense of the geoengineering ambitions of the HSRC through a diverse range of cultural, political and educational experiences. Through the Haida Nation, these actors include Indigenous people, who have been largely excluded from previous public consultation on geoengineering. The HSRC case study therefore offers the opportunity to 'open up' (c.f. Stirling, 2008) the existing social science literature to a wider range of empirical perspectives.

The HSRC becomes a 'controversy'

As is outlined in more detail in Gannon (2015), the HSRC was deeply divisive in Haida Gwaii (and elsewhere) and provoked strong, emotional reactions in resistance to, as well as in support of, the project. "*It has divided families*", an Old Massett resident explained (Gannon, 2015: 133). Critics on, and off, island challenged the scientific validity of the project and the potential for it to obtain meaningful data about the impacts of OF on the ocean ecosystem and to measure carbon sequestration (Hume, 2012; Suzuki, 2012; Pearson, 2013). Lack of transparency surrounding the project's design, implementation and data collection processes fuelled many of these concerns. As did the lack of traditional scientific credentials within the HSRC, as well as the belief among many, that the project bore significant, unreasonable and poorly understood risks to the marine environment: A position that broadly reflects statements expressing disapproval of OF from both the London Convention on Ocean Dumping and the Convention on Biological Diversity.

The legality of the project was also a source of significant controversy, particularly in light of the commercial intent of the project design, which constitutes a legal grey area. Further, with no market or mechanism for verifying carbon credits from OF currently in existence, it remains unlikely that the CAD$2.5 million dollars that Old Massett Village Council (OMVC) originally invested in financing the HSRC – let alone the 'guaranteed' profits from the project – will ever be returned to the village. For a community that experiences around 70% unemployment following resource depletion and structural exclusion from the remaining resource-based industry (Gill, 2009), as one community member explained, "*that was a lot of money*" (Gannon, 2015: 172).

Local tensions were also fuelled by a feeling of lack of ownership over the project by some members of the Old Massett community. Many believed that the Haida name and the proud and politically powerful (Dowie, 2017; May, 1990) Haida identity of environmental stewardship and cultural connection to the land and ocean – which was integral to the HSRC's public branding – was misappropriated and constituted a form of 'greenwashing'. The project's framing as 'salmon restoration' exacerbated this feeling among many. The significance of salmon as the "*life blood*" (Masset resident in Gannon, 2015: 142) of Haida people is age-old and the spiritual and nutritional value of local salmon runs has been extensively expressed through Haida art. In Haida Gwaii, salmon stocks, and sockeye salmon in particular, are considered to be in "dire straits compared to their historical abundance" (CHN, 2004: 14, see also Cohen, 2012). For many Haida people, protecting and securing access to salmon is fundamental to reclamation of the Haida cultural identity and autonomy, after deliberate and systematic colonial violation of the Haida way of life.

The business development rationale of the HSRC linked OF to salmon restoration through a conjecture discussed in an opinion piece written by Parsons & Whitney (2012). This paper hypothesised that plankton blooms in the subarctic North Pacific – linked to fertilization by volcanic ash plumes arising from the 2008 Kasatochi volcano in southwestern Alaska (Hamme et al., 2010; Langmann et al., 2010) – contributed to a 34 million strong 2010 sockeye salmon run in the Fraser River, through increased food availability ensuring greater survival of juvenile salmon. There is limited empirical evidence that OF could be advantageous for ocean food webs (Royal Society, 2009) and this hypothesis was highly contested (McKinnell, 2013). But when told by the HSRC that the problem needed to be fixed 'out at sea', Old Massett was surely ready to listen.

Moving forward through an interpretative lens

Reflecting what Clingerman (2014: 10) labels the implicit "theory of anthropology" of geoengineering discourse – an inherent interpretation of the nature of the human role and purpose – this paper is going to argue that, at

the heart of debate about the desirability and feasibility of the HSRCs OF project, lie diverse implicit philosophical assumptions about the nature of 'nature', of technology and of the appropriate relationship between 'human' and 'non-human' worlds. This paper therefore explores the way in which discourse surrounding the HSRC constructs different ideas about what it means to be human, about the way in which humans can attain knowledge of natural systems and about the 'natural' or 'artificial' quality of technological mediation of the environment.

Human geography tells us that place matters as a centre of meaning in human life (e.g. Livingstone, 2003; Cresswell, 2004) and thus meanings of geoengineering will be anchored in, and shaped by, spatial forces, varying from place to place and understood differently in different locations. The HSRC, anchored in notions of place and identity, therefore marks a novel entry point into thinking about social research on geoengineering, that offers the opportunity to pursue a more situated engagement with geoengineering, in keeping with geographical traditions (Yusoff, 2013, see also Jasanoff, 2010).

Human geography has, nevertheless, actively advanced the theoretical and methodological dynamism necessary for meaningful exploration of the multiple, and often competing, social constructions of nature and human agency that lie at the heart of geoengineering discourse. Reflecting this tradition, this paper adopts an innovative design that combines ethnographic engagement with the HSRC case study, with Q-Methodology; a discourse analysis technique that enables interpretation of clusters of shared meaning within debates. The paper employs Q-Methodology to explore the ways in which diverse assumptions about the role and nature of 'nature' and human agency can be interpreted from discourse on the HSRC and to untangle diverse viewpoints in relation to OF.

Methods

Q-Methodology

Q-Methodology is a 'qualiquantological' (Stenner and Stainton Rogers, 2004) research method that structures the interpretation and comparison of key shared and contested 'points of view' that surround a given issue or topic (Coogan and Herrington, 2011). The technique has roots in correlation statistics and an inverted variant of factor analysis (Stephenson, 1936; Watts and Stenner, 2012). Q-Methodology is used across the social sciences and has been employed in the geoengineering literature to identify a 'framing gulf' among influential, or 'expert' geoengineering actors from diverse disciplinary backgrounds and sectors (Cairns and Stirling, 2014).

In Q-Methodology, data is gathered in the form of Q-sorts: Participants sort a diverse set of statements about a specified topic onto a fixed and approximately normally distributed, single dimension and face-valid grid (figure 1). They sort these statements according to what they deem to be meaningful and significant. The data is then considered in terms of the entire configuration of responses produced by participants, in a by-person factor analysis.

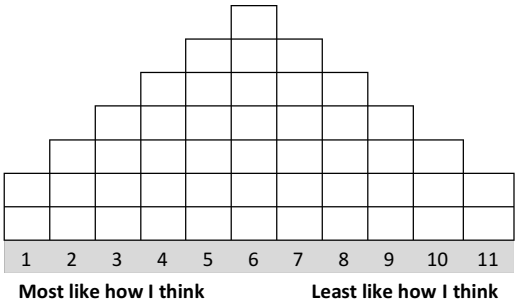

Figure 1: The Q-sort matrix used in the study
Q-sort grids are typically numbered from a negative value at one pole through to an equivalent positive number at the other pole (in an 11-point distribution these run from -5 to +5). However, to avoid forcing participants to allocate a positive ranking to an item they disagree with and *vice versa*, and in order to stress the relative, rather than absolute nature of rankings, in the grid used in this study, these were replaced by a positive continuous scale.

Q-Methodology aims to reveal patterns of association between the measured variables, and to generate a small number of factors that are used to help interpret shared meanings within the data (Stephenson, 1965; Watts and Stenner, 2012; Webler, er al., 2007, 2009). Yet despite its quantitative features, Q-Methodology can be perfectly at home in the interpretivist social sciences; seeking to engage with the multiple and messy, socially and culturally situated, subjective worlds in which people develop meanings of their experiences towards an object of study (Eden et al., 2005; Webler et al., 2009).

Its execution is a highly interpretative process. How the concourse is framed, which statements are used in the

Q-sort, which participants are chosen to conduct the sorts, and the way in which the analysis is conducted, all shape the research (Webler et al., 2007). Participants are typically selected along more purposive, qualitative rationales. Theoretical selection criteria "with due regard for any obvious contours in the data" (Brown, 1993: 116) can take precedence over statistical rationales when researchers decide which factors to retain and which to rotate (Eden et al., 2005). Moreover, factors are just statistical abstractions until conferred discursive meaning through interpretation (ibid.). Statistical processing is therefore merely used to facilitate and bolster qualitative interpretation.

A Q-study based on the case of the HSRC

The Q-study in this research was designed to engage with situated interpretations of the desirability and feasibility of OF, that surrounded the HSRC OF experiment. Participants – largely comprised of a sample of on-island residents, but also including off-island HSRC associates – were asked to sort statements according to their understanding of OF as a response to anthropogenic climate change. To acknowledge the local and contingent nature of imaginaries (Jasanoff and Kim, 2009), the sorting instruction (box 1) was designed to ask participants to draw on their interpretation of the HSRC project and to use the Q-sort to consider and represent what the future of OF means to them in more general terms.

"**Alongside the goal of salmon restoration, the Haida Salmon Restoration Corporation hopes to sequester carbon dioxide, through ocean fertilization, in order to reduce the scale of human-induced climate change. How do you feel about exploring ocean fertilization to try to sequester carbon dioxide in the ocean?** Please sort the provided statements in the order that best describes your point of view".

Box 1: The Sorting Statement

Building the Q-Methodology concourse through ethnographic enquiry

A Q-set is usually text-based, and, since the Q-set serves the function of the study sample, Q-statements are constructed by the researcher to represent a spectrum of discourse "broadly representative of the relevant opinion domain" (Watts and Stenner, 2005: 75). The Q-set should be informed by as many standpoints and themes as possible, and allow anyone presented with the sorting instructions to construct a personally meaningful representation of their understanding of the issue (Coogan and Herrington, 2011). Q-sets are often developed from background interviews or from discourse analysis of materials such as publications, websites and newspaper articles. In this research, the Q-set emerged from an interpretative ethnographic engagement with the HSRC, during eight months that one of the authors spent in British Columbia during 2013 and 2014[1].

Local meanings, practices and identities do not exist in isolation, but rather are multiply produced and intricately interwoven into the broader fabric of the social world (Beck, 2007; Tsing, 2004). As a result, commencing from the geographical base on the islands of Haida Gwaii, the fieldsite was constructed through Marcus' (1995: 109-110) tracking strategies of "follow the plot, story or allegory" and "follow the conflict", allowing the research to traverse discourses, people, places and practices surrounding the HSRC project at various sociocultural scales.

Reflective of Anna Tsing's (2004: xi) "zones of awkward engagement", these tracking strategies were implemented through the social experience of participant observation within the research setting. And they were supported by in-depth interviews of varying formality with 44 participants, as well as a focus group (n=13), where participants were sampled through a combination of convenience, snowball and theoretical sampling methods. Media frame analysis and analysis of other texts, records of public meetings, audio and visual material and local media coverage also offered a sense of how the 'conflict, plot, story or allegory' had changed over time.

Comprising multiple possible answers to the sorting instruction statement, the final Q-set – 47 statements listed in full in table 2 below - was a product of this interpretative engagement with the HSRC case study. As far as

[1] This time was largely spent on the islands of Haida Gwaii. However, time was also spent in Vancouver where the HSRC office was based.

possible Q-statements were kept short, expressed a single idea, avoided qualifications and were communicated in language familiar to, and, where possible, used by, participants (Webler et al., 2009). The 'qualitative detail' of the research was filled out through the ethnographic engagement with the subject and through asking participants completing the sort to 'think out loud' as they conducted the sorting process. Thus, having a diverse group of participants conduct the sort and really listening to what they were saying was more important than trying to cover absolutely every conceivable perspective in the Q-set (c.f. Donner, 2001).

The Q-sort was refined following piloting (n=5) and the statements were randomly ordered. The number of statements used in the research was selected to balance statistical criteria, with the ability for participants to construct a personally meaningful representation of their point of view, within a reasonable timeframe (Watts and Stenner, 2012; Webler et al., 2007). 26 participants completed the Q-sort exercise. From the factors generated through the analysis, 'ideal-typical' sorts were constructed, representing an estimate of the Q-statement configuration 'characteristic' of participants that load significantly onto each factor. Triangulated and enriched by the qualitative data collected alongside the sorting exercise, these estimated arrays were then used to construct narrative interpretations of the 'viewpoints', which form the primary output of the Q-analysis. Further details of the statistical and methodological processes through which the Q-sorts were conducted and analysed are provided in the appendix of this paper.

Results

Two factors become three

From the Q-sorts collected in this research we settled on a two-factor solution, explaining 50% of the study variance; a result that compares well with the variance explained by other Q-studies. At the 99% confidence level, 19 out of the 26 participants load significantly onto only one factor. Factor 1 has an eigenvalue[2] of 7.8 and explains 30% of the total study variance. Factor 2 has an eigenvalue of 5.2 and explains 20% of the total study variance.

Factor 1 is bipolar, defined by 12 sorts loading significantly, both positively and negatively, onto this factor. Conceptually, this represents two opposed 'viewpoints' being expressed in one factor. In order to interpret the 'viewpoint' expressed by the sorts that load on the negative pole, bipolar factors must be interpreted twice. Using Q-Methodology software PQMethod, Factor 1 was retained twice and the factor loadings were reversed to form Factor 1b. Only the sorts that were positively correlated with each factor were used in the construction of factor estimates (Brown, 1980). This process resulted in the two-factor solution, becoming effectively a three-factor solution, where Factor 1a and Factor 1b are highly negatively correlated (-0.72). Table 1 identifies the sorts that were used to construct each factor and to generate the factor estimates. The factor arrays are displayed in Table 2 below: By column, the table reveals the comparative ranking of statements which exemplify a given factor.

[2] Eigenvalues are a measure of the explanatory power of an extracted factor. They are calculated by multiplying the number of participants by the variance and dividing this result by 100.

Participant Number	1a	1b	2
P1	-0.5796	**0.5796**	0.1723
P2	**0.6476**	-0.6476	0.4457
P3	0.432	-0.432	**0.5174**
P4	**0.573**	-0.573	0.379
P5	-0.5068	**0.5068**	0.3972
P6	0.3015	-0.3015	0.2374
P7	0.4611	-0.4611	0.3017
P8	**0.5656**	-0.5656	0.3311
P9	0.0273	-0.0273	0.4674
P10	-0.735	**0.735**	-0.1126
P11	**0.7617**	-0.7617	0.2992
P12	0.4751	-0.4751	0.4895
P13	0.5036	-0.5036	**0.6683**
P14	-0.7543	**0.7543**	-0.2029
P15	0.3881	-0.3881	0.4187
P16	0.4159	-0.4159	**0.6401**
P17	0.5888	-0.5888	0.5725
P18	0.1165	-0.1165	**0.7256**
P19	**0.7355**	-0.7355	0.3311
P20	-0.0992	0.0992	**0.5698**
P21	-0.7434	**0.7434**	0.0485
P22	-0.3136	0.3136	**0.5494**
P23	0.0819	-0.0819	**0.6486**
P24	-0.7691	**0.7691**	0.037
P25	0.5438	-0.5438	0.6858
P26	-0.8656	**0.8656**	-0.0412
	% expl.var.	**30**	**20**

Table 1: Factor Matrix Indicating Defining Sorts

Factor loadings, which represent a participant's affinity to a factor and denote the extent to which their sort exemplifies that factor, are shown above. In this research, sorts with a rotated factor loading in excess of 0.51 (significant at the $p < 0.01$ level) were considered to closely approximate the viewpoint of a factor and were used to construct factor estimates. Confounded sorts, which loaded significantly on more than one factor, were not used in the construction of the factor estimates (c.f. Watts and Stenner, 2012).

Statement	Factor		
	1a	1b	2
1. People who support ocean fertilization haven't taken time to listen to the earth and to feel its power.	1**	-4	-2
2. Using ocean fertilization to force change in our oceans will change us and we will lose our connection to the earth.	1*	-1	-1
3. Natural systems are so interconnected and complex that every time humans try to affect them in one way, something else is affected too.	3	2	5**
4. Only science can tell us whether ocean fertilization is a good idea or not.	-2**	4**	1**
5. Fiddling around with our environment through ocean fertilization goes against everything that I hold as true and dear.	4**	-5**	0**
6. Iron in the ocean is a natural thing and ocean fertilization mimics the natural rhythms of nature.	-4	2**	-3
7. Carbon credits from ocean fertilization could bring much needed income into communities that invest a lot of time and energy into caring for the environment.	-4**	1**	0**
8. My feelings on ocean fertilization are informed by an understanding that the natural world needs us to step back and leave it alone.	1	-2**	1
9. Ocean fertilization should not be done by private companies.	0**	-3**	3**
10. We have no way of really knowing what the impact of ocean fertilization will be.	2**	-1	0
11. Ocean fertilization will be an excuse for greater global governance.	0	0	-3**
12. Ocean fertilization could easily become an instrument conducive with efforts to oppress less powerful groups in society.	-1	-1	-4
13. If we try to manipulate nature in this arrogant way, the universe will fight back and humans will eventually pay the price.	5**	-4**	1**
14. We have already changed the climate system by emitting greenhouse gases. Trying to change it again with ocean fertilization is no different. At least this time we are doing it with our eyes open.	-2	3**	-2
15. My feelings on ocean fertilization are born from a feeling of connection to the earth and to other forms of life.	1	0	2
16. I have huge faith in human ingenuity, but the scale that ocean fertilization would operate at is just too big.	-1	-2**	0
17. My feelings on ocean fertilization are shaped by an understanding that if we are to save the world from dangerous climate change, we need to think big and do so quickly.	-2	2**	-1
18. Ocean fertilization is humans trying to play God.	5**	-4**	-1**
19. If you think you may have a solution to climate change, then you are morally obligated to pursue it. Ocean fertilization is a good example of this.	-2	3**	-5
20. We need to look for more civilized and precise solutions to climate change than ocean fertilization.	3	-1**	4

21. Ocean fertilization is unlikely to be used for the betterment of all.	0*	-3**	2*
22. Ocean fertilization is a practical response that may help us protect what we have left.	-3**	3**	-1**
23. Ocean fertilization is morally wrong.	4**	-5**	-2**
24. The earth cannot cope with the burden of demands currently placed on it. No technological fix, ocean fertilization included, will get us around that fact.	-1	-2	3**
25. If ocean fertilization appears to be having any negative impacts on the environment we can just stop doing it.	-1**	5**	-4**
26. Ocean fertilization is not dissimilar from the principle of fertilizing our crops, to meet the demands of a rapidly growing global population.	-1	2**	-3
27. I hope that everyone is given the opportunity to understand the science behind ocean fertilization, rather than it being in a small number of hands.	0*	2	3
28. Rather than fertilizing the oceans, humans need to learn to live within the Earth's limits.	2**	0**	5**
29. The need for ocean fertilization has been over exaggerated.	-1	-3**	-1
30. Ocean fertilization could have disastrous consequences for humanity.	4*	-3**	2*
31. Ocean fertilization offers humans the opportunity to grow up and take responsibility for the harm they have caused the environment.	-3	0**	-5
32. I am suspicious of the idea of a 'quick-fix' to climate change.	3	-1**	4
33. Ocean fertilization is just continuing humanity's attempts to dominate and exploit nature.	1	-2**	0
34. Ocean fertilization could give humanity an excuse to carry on emitting greenhouse gases, meaning we miss the opportunity to transform our energy and economic systems.	0	-1**	2
35. I'm worried that people will get greedy, and rush ahead with ocean fertilization.	2	0	1
36. Decision-making on ocean fertilization needs to come from a societal conversation about morality and human values.	3	0	1
37. My feelings on ocean fertilization are shaped by an understanding that human and non-human worlds are entangled. Trying to separate them is meaningless.	1	1	2
38. I find beauty in the idea that through ocean fertilization, humans may be able to acquire the means of stewarding the planet through the challenge of climate change.	-3	4**	-3
39. Ocean fertilization might help us clear up some of the mess we've made, to help bring the Earth back to health.	-4*	3**	-2*
40. Ocean fertilization takes humanity too far into an artificial world and away from the natural order of things.	2	-2**	1
41. My feelings on ocean fertilization are shaped by the understanding that if you take care of the Earth, it is going to take care of you.	2	1	4*
42. We won't know if ocean fertilization will work until we try.	-5**	5**	-1**
43. I think humans are perfectly smart enough to embark on ocean fertilization.	-5	1**	-4

44. Governments are failing to take climate change seriously, so citizens need to develop their own solutions, such as ocean fertilization.	-2**	1*	0*
45. Debate about ocean fertilization is, in large part, driven by a lack of public education.	0	1*	0
46. My views on ocean fertilization are informed by my discomfort with the idea of 'managing' natural systems.	0	0	3**
47. It's too late to just start treading more lightly and polluting less. We need ideas like ocean fertilization to undo some of the harm we've already caused.	-3	4**	-2

Table 2: The Factor Arrays. Factor Q-Sort Values for Each Statement. An asterisk indicates a statement that is placed in a statistically different position ($p < .05$) on the Q-sort grid by participants that load on a given factor, to where participants that load on other factors have placed the same statement. A double asterisk indicates significance at $p < .01$.

Factor interpretation – which considers the ways in which different themes and ideas are configured and connected by participants (Stephenson, 1936) – is a creative process, and the following narrative accounts of the factor arrays seek to offer an interpretation of "how things must *feel* for anybody who shares this viewpoint" (Watts and Stenner, 2012: 158, original emphasis). With this aim, the factors are both named and embellished by the qualitative comments of significantly loading participants. To trace the abductive reasoning through which the factors were constructed, relevant Q-statements are cited within the text[3]. A demographic summary of the participants whose sorts defined each factor is offered in table 3.

Factor	Title	Significantly loading participants*	HSRC Affiliates: Non-Affiliates	Ethnicity Haida: Non-Haida	Gender Male: Female
1a	Ocean fertilization is morally wrong. We need to preserve the natural order.	n=5	0:5	4:1	2:3
1b	Ocean fertilization should be urgently explored. Through science we can respond to the challenges of climate change.	n=7	5:2	2:5	6:1
2	Climate and ocean systems are dynamic and interconnected. Ocean fertilization is very risky	n=7	0:7	0:7	5:2

Table 3: A demographic summary of the participants whose sorts defined each factor. * Participants with confounded sorts are not included within the number of significantly loading participants.

[3] The statements' factor array rankings are also highlighted in the text. In brackets, the relevant statement is identified, and is preceded by a colon and its accompanying factor array score. If a statement is a distinguishing statement for that factor – occupying a statistically significant position on the Q-sort grid to those occupied by the other factors – this too is highlighted using a single asterisk to indicate a statistically different position at $p < .05$ and a double asterisk to indicate a statistically different position at $p < .01$.

Factor interpretations

Factor 1a: Ocean fertilization is morally wrong. We need to preserve the natural order. Five participants (P2, P4, P8, P11, P19) are associated with this factor at the 99% significance level. Four out of these five participants identify as ethnic Haida. However, results do not suggest this perspective is uniquely Haida. Including P11, three non-Haida participants load significantly onto this factor (at the 99% significance level); although two of these sorts are confounded, also loading significantly onto Factor 2.

Participants that load onto Factor 1a typically express a commitment to the idea that the world has an inherent 'natural order' (c.f. Castree, 2005) and that through OF, humans risk overstepping their place in this order and intruding into realms in which they don't belong. Whilst 'nature' may be revered simply for 'nature's' sake, rather than necessarily being understood as divine creation, these concerns find expression in the nomenclature that through OF humans are effectively 'Playing God' (18: +5**) (c.f. Fleming, 2007; Hamilton, 2011a).

Under this factor, the act of humans adding iron to the ocean is considered 'unnatural' (6: -4) and the intentionality of human agency often formed the basis of these objections. "*I don't agree with this, because we are manipulating it*", responded P8. "*It's another step*", P11 explained (14: -2). Since the perceived natural order is itself of inherent value, humans "fiddling" around with the environment through OF, is seen as offensive and vulgar (5: +4**, 38: -3). OF is therefore morally wrong (23: +4**) and risks bringing humans into a fundamentally 'artificial' relationship with nature (2: +1*; 40: +2) (c.f. Carr et al., 2012; Clingerman, 2014; Corner et al., 2013; Elliott, 1997; McKibben, 2003[1989]; Sandler, 2012).

As far as Factor 1a is concerned, humans do not have the capacity to successfully implement a project on the scale of OF (43: -5) or to anticipate the impacts of such an intervention (10: +2**). This makes OF impractical (22: -3**) and means communities, such as Old Massett, won't ever benefit from carbon credits from OF (7: -4**). "*Well we can't manage the natural systems. Whenever we try, it's a hopeless disaster… It's not up to us. The creator didn't put us here to diddle around with what he'd made perfect in the beginning*", P4 explained. It also means that there are likely to be severe consequences for attempting to try to manipulate the ocean and climate systems through OF (30: +4*).

These consequences may not just result from failing to sufficiently understand the systems involved (see factor 2). Rather, for some the earth has its own untameable power, which OF proponents overlook (1: +1**). OF is an act of hubris and human arrogance, which represents humanity attempting to dominate and exploit nature (33: +1). It could therefore result in karmic retribution and punishment as the universe fights back and humans pay the price for their egotism (13: 5**) (c.f. Corner et al., 2013; Macnaghten and Szerszynski, 2013). "*Everything that we learn here in Haida Gwaii from our cultural teachings, is that you don't disrespect the environment. You don't play with nature. And, if you do, there's big consequences. So, fighting fire with fire isn't going to put out the flames of climate change*" (P2). Accordingly, this perspective suggests that it may not be possible to just reverse the effects of OF, once we've embarked upon doing it. Actions have consequences in interconnected natural systems (3: +3) and OF may set in way a chain of negative impacts on the environment for generations to come (25: -1**).

In the words of Macnaghten and Szerszynski, (2013: 465), for Factor 1a, there is no need to live the "global social experiment", since we can know that OF won't work in advance of deployment (42: -5**; 39: -4*; 22: -3**). Laboratory studies and smaller-scale field trials may have a role to play in geoengineering decision-making, but this viewpoint underscores the importance of other forms of knowledge, including instinct, experiential knowledge and moral reasoning (13: 5**). This viewpoint also resists the positivist assumption that science on OF can be policy prescriptive (4: -2**). "*Science isn't the only gauge of whether it's a good idea or not. I mean morality doesn't always coincide with science*" (P11). Instead, it suggests that decision-making on OF needs to be informed by a reflexive societal conversation about morality and human values (36: +3).

Local experiences of colonial subjugation and disempowerment were drawn on by participants loading onto this viewpoint, to express concern about the potential for OF to draw decision making outside of the communities that decisions affect and "*putting the power of altering global climate conditions into the hands of a few*" (P11) (11: 0). OF "*shouldn't be done by anybody*" (P11) this viewpoint denotes. But it especially shouldn't be done by private companies (9: 0**), which are driven by profit (35: +2), rather than the interests of all (21: 0*). OF could facilitate companies exploiting the environment and "*buying the right to pollute*" (P19) (34: 0). Humans are,

nevertheless, not afforded a passive role in this viewpoint (8: +1; 46: 0), which is deeply concerned about human impact on the planet (29: -1) and current inaction to address climate change (44: -2**). Resolution is not thought to be achievable through a 'quick-fix', like OF (32: +3; 17: -2). Instead redress is sought through preservationist commitments to treading more lightly and polluting less (47: -3). Humans need to learn to live within the Earth's limits (28: 2**) and OF arises from people failing to recognise this need.

Factor 1b: Ocean fertilization should be urgently explored. Through science we may respond to the challenges of climate change. Seven participants (P1, P5, P10, P14, P21, P24, P26) are significantly associated with this factor. Five of these participants were, or had been, affiliates of, or employed by, the HSRC (P5, P10, P14, P24, P26). In contrast to Factor 1a, participants that load onto Factor 1b tended to express frustration with the idea that the human race just needs to learn to live within the Earth's limits (28: 0**). "*That train has sailed*", P1 explained, (44: +1*). Indeed, reflecting climate emergency rhetoric (Anshelm and Hansson, 2014; Bellamy et al., 2012; Nerlich and Jaspal, 2012), this factor suggests that those who continue to perpetuate the 'myth' that anthropogenic climate change can be resolved solely through mitigation are naïve and their attitudes dangerous. Instead, the need for immediate, and practical, solutions to climate change – to undo some of the harm we've already caused (47: +4**) – is very real (29: -3**). We need to think big and do so quickly (17: +2**, 35: 0).

Echoing 'political realism' framings (Anshelm and Hansson, 2014), in the face of deficient global governance on climate change (11: 0), this factor therefore makes space for citizens (44: +1*) and private companies (9: -3**) to explore the potential of OF. Among some HSRC affiliated participants that loaded on this factor, this narrative manifested as a moral obligation to act (23: -5**, 19: +3**). As P10 reasoned, "*Canada is going in the wrong direction as fast as it can go. Therefore, if you're informed… and you think you have a solution, you're morally obligated to do something about it*" (c.f. Sikka, 2012).

In many ways, this factor is premised on an account of classic techno-optimism. Humans are an incredible, powerful, creative force and, with the right investment and resourcing, have amazing capacity to innovate and develop the means of overcoming environmental challenges like climate change (32: -1**, 1: -4, 24: -2, 13: -4**, 43: +1**) (c.f. Lynas, 2011). This viewpoint acknowledges that oceanic and climatic systems are complex and interconnected (3: +2). However, for the most part scientists are deemed sufficiently proficient to be able to account for and manage the complexity of these systems (16: -2**, 1: - 4) (c.f. Cairns and Stirling, 2014; Galarraga and Szerszynski, 2012). In this viewpoint, at the very least exploring and assessing the potential of OF, is therefore within the remit of human capabilities (43: +1**). Captured in this same promissory rhetoric about the power of science (4: +4**), the barriers to making this assessment are held to be political – such as securing sufficient investment – rather than technical. "*I think we have the capability to successfully do OF projects... Yeah I think we have the know-how and capability to really fix global issues, it's just nobody can get on the same page*", remarked P5.

Because we can figure out the impacts of OF by "*go[ing] down the path slowly and carefully... learn[ing] every step of the way*" (P10) (10: -1), any risks of OF can be monitored, assessed and managed. Further, if OF appears to be having any negative impacts on the environment we can just stop doing it (25: +5**), so it is unlikely that OF would have any disastrous consequences (30: -3**, 13: -4**). OF then, is a practical response that may help us protect what we have left (22: +3**, 20: -1**). Either way, in Factor 1b, only science can tell us whether OF is a good idea or not (4: +4**) and we won't know if OF will work until we try (42: +5**). Indeed, participants that load significantly onto this factor tend to employ broadly positivist rhetoric, that suspends the need for normative judgement in decision-making (36: 0; 5: -5**, 13: -4**, 1: -4, 45: +1*). Because science holds the ultimate authority in this viewpoint, there is less need to democratise OF decision making (12: -1, 27: 2). However, education will help resolve contestation about OF (45: 1*, 27: 2**).

In contrast to the viewpoint in Factor 1a, in Factor 1b the idea that the human agency inherent to OF damages some pristine natural state is rejected as hypocritical, given the scale of existing human influence over the global environment (40: -2**; 5: -5**, 8: -2**, 46: 0, 33: -2**). "*I am all about managing. There are no natural systems left...*" P1 explained (14: +3**). Similarly, the metaphor of humans 'playing God' through OF is deemed irrational or illogical (18: -4**). As P26 elaborated, "*one could apply this [idea] to almost anything we do, our agriculture, our medicine, our energy sources, etc*". Instead, notions of 'restoration' and 'development' of nature are at the heart of this viewpoint. Some participants loading onto this factor suggested that OF may offer humans the opportunity to clear up some of the mess they've made, to help bring the Earth back to health (39: +3**) (c.f.

Nerlich and Jaspal, 2012) and even to take responsibility for the harm they have caused the environment (11: 0) (c.f. Leopold, 1986[1933]; Monbiot, 2013). An interesting variant of this viewpoint was offered by both Haida participants that loaded significantly onto this factor, who described OF as 'giving back' to the environment, in keeping with traditional Haida teachings (15: 0). "*Coming from a First Nation's perspective, we are stewards of the land… It's kind of what we did with OF. In a sense we're just giving it what it need[s]*" (P5) (41: +1, 37: +1).

Others suggested that OF is not dissimilar to other resource management responses such as fertilizing our crops, to meet the demands of a rapidly growing global population (26: +2**). In this way, respondents linked OF to broader human innovation and technological development trajectories, which have emerged to meet the demands of increasing resource pressures and which continue expanding the frontiers of modern society. Continuing this trajectory is fundamental to advancing the wellbeing of all (21: -3**) and to sustaining future populations (24: -2), this factor denotes. Our lives would therefore be "*pretty mean spirited*" (P1) if these technological advances weren't allowed to happen. Indeed, in this factor, technological innovation to steward the planet through the challenge of climate change, holds its own intrinsic value (38: +4**). "*[OF] would be elegant, just like a simple solution that would let us do all these things and exploit the economic development of fossil fuels, while not destroying our planet. Wouldn't that be nice*" (P1).

As this viewpoint sees it, we have already changed the climate system by emitting greenhouse gases, so trying to change it again with OF is no different. At least this time we are doing it with our eyes open (14: +3**, 2: -1). Thus, whilst there is some hesitation about unfettered management of natural systems writ large (46: 0), given that OF only involves giving natural systems "*a little tweak*" (P10), the intentionality of active human management, exercising the power of science and instrumental reason, means OF is likely to be safer and more desirable than unmediated greenhouse gas emissions (c.f. Macnaghten and Szerszynski, 2013): "*Conscious, measured manipulation of ecosystems is preferable as it requires an entity or individual to take responsibility. The business as usual belief system understands that our actions are having an impact on natural systems but takes no responsibility... we need to better understand the natural system and learn to work with it for the betterment of all*" (P24) (21: -3**). A more legitimate concern of OF, for this view point, however, is that it could give humanity an excuse to carry on emitting greenhouse gases, meaning we miss the opportunity to transform our energy and economic systems; which is still fundamentally needed (34: -1**).

Factor 2: Climate and ocean systems are dynamic and interconnected. Ocean fertilization is very risky. Seven participants are significantly associated with this factor (P3, P13, P16, P18, P20, P22, P23). None of these participants identify as ethnic Haida, or have ever been employees of the HSRC. Factor 2 is significantly correlated with Factor 1a ($p < .01$). Nevertheless, Factor 2 was retained as a unique factor since different priorities and emphases found expression within the factor estimate, capturing a qualitatively distinct point of view. Two sorts were also confounded between Factor 1a and Factor 2. Together this implies that individuals may blend these viewpoints (Coogan and Herrington, 2011).

At the heart of the Factor 2 viewpoint, is the Malthusian assumption that the Earth has a finite carrying capacity and that it cannot cope with the demands currently being placed on it (24: +3**). Anthropogenic climate change is indicative of this strained carrying capacity and of deficient climate governance (11: -3**) and there is therefore an urgent need for remedial action. Participants that load significantly onto this viewpoint consequently tend to empathise with why proponents have come to express interest in OF (29: -1). "*To suggest that the need for OF has been over-exaggerated would suggest that climate change isn't that bad, or that we don't need solutions to climate change",* explained P20.

Yet, in contrast to Factor 1b, the idea that a practical response, or a 'quick-fix', to climate change can be found in OF is regarded as deeply suspicious (32: +4; 22: -1**). "*It didn't happen quick and it's not going to end quick*", P13 explained. This reluctance to explore OF is not because OF is in some way 'playing God' (18: -1**), as was described in Factor 1a. Nor is 'intervention in natural systems' morally 'wrong' per se (23: -2**). Indeed, participants that load significantly onto Factor 2 tend to be less committed to the idea of a 'pristine' natural order and more open to the idea of 'rambunction' (Marris, 2011). "*We already do a lot of artificial things*", P20 explained (c.f. Clingerman, 2014; Corner et al., 2013). Instead, the primary objection to OF in Factor 2, is based on a cautious and sceptical interpretation of technological capacity. For Factor 2, a key condition of OF's acceptability, is that research is able to predict and manage the impacts of implementation (4: +1**) (c.f. Macnaghten and Szerszynski, 2013). Yet, attesting to the finitude of human knowledge and the complexity of

interconnected climate and ocean systems, this viewpoint does not believe such conditions can be met. "*We can't do the math… The system is too big. There are some things that we just can't understand*", P22 explained (43: -4).

In this viewpoint, natural systems are so interconnected and complex that predicting the consequences of OF is very difficult – even impossible – and thus OF may set in way a chain of reactions and runaway impacts (3: +5**, 46: 3**, 25: -4**) which could have grievous consequences for humanity (30: +2*) (Carr, Mercer and Palmer, 2012; Clingerman, 2014; Corner et al., 2013; Porter and Hulme, 2013). "*It's like dropping a pebble into a pond and you've got a ripple going out... everything will be affected. And this OF thing, you can stop doing it, but you can't negate what's already been done"* (P3). Consequences arising from the introduction of non-native species to Haida Gwaii was held as a particularly salient local example of how a "*cascade of impacts*" may arise from attempts to alter natural systems by introducing new elements. "*Haida Gwaii is a good example of human created problems...*", one respondent explained. "*Deer were introduced about 100 years ago... When it happened in the late 1800's I don't think anybody had a perception of what their action would actually end up doing in terms of how they would lose berry production, that the understory of the islands would be basically striped clean by the deer*".

This viewpoint emphasizes ecological relationships (3: +5**) and the interconnectedness and interdependencies between human and non-human worlds (37: +2, 15: +2). "*We live in a world where there's an ecology where we all have our part to play"*, P16 explained. Thus, this viewpoint attests that 'if you take care of the Earth, it is going to take care of you' (41: +4*). But since no technological fix, OF included, will get around the fact that the earth cannot cope with the burden of demands currently placed on it (24: +3**), in Factor 2 'taking care' of the Earth denotes a more restricted role for human agency than Factor 1b; advocating an approach oriented towards withdrawing human influence (8: +1), and avoiding "*over management of natural resources*" (P3) (38: -3, 31: -5, 20: +4).

Factor 2 calls instead for a refocusing on the structural reasons for why the planet 'is being stretched to its limit' (34: +2, 24: +3**). "*If something like OF is seen to be an instant 'fix' to our very complicated social-ecological systems throughout the world, humanity may feel as though we can continue with our growing oil and gas culture and economy instead of looking to change our relationship with each other and with the earth*" (P25). Rather than fertilizing the oceans, humans need to be willing to change and to learn to live within the Earth's limits (28: +5**), using more simple and precise means (20: +4), which prioritise reduced consumption.

This should be pursued alongside cautious technological innovation, employing as far as possible approaches with "*known impacts*" (P16) (26: -3). Alongside their Q-sorts, participants loading on this factor sometimes suggested "*contained*" (P18) (i.e. encapsulated geoengineering; see Royal Society, 2009; Bracmort and Lattanzio, 2013) approaches should be prioritised. But for this factor, any strategy should be approached slowly and cautiously. "*I think we need to [respond to climate change]… quickly but small. Because we don't know the outcomes. I think the bigger the experiment if you will, the more danger we have of making problems that we don't anticipate...*" (P18) (17: -1). OF, Factor 2 concludes, is therefore likely to just compound the challenges we face. Or, in the words of P13, "*put more dung on the heap*".

Whilst this was the prevailing viewpoint described by this factor, several significantly loading participants did however suggest that some of their rationales may break down under certain climate futures and that, depending on the severity of future climate risks, unbridled resistance to OF may be 'naïve'. As P16 explained; "*all of these things [geoengineering proposals] represent tremendous risks, okay. And if your mind-set is that we're at the precipice, well then maybe you have to take those risks. I don't think we're at the precipice now".* Whatever happens, as argued through Factor 1a, for Factor 2, OF should be kept out of the hands of private companies (0: +3**), where "*greed prevails*" (P16) and it requires rigorous democratic oversight (21: +2*, 27: +3) (c.f. Macnaghten and Szerszynski, 2013).

Discussion

Perceptions of geoengineering as locally contingent

The HSRC, was a project conducted "by people in a place" (Buck, 2014). For research participants, meaning-

making surrounding the 'geoengineering' ambitions of the HSRC depended on local specificities and attachments to the landscape (c.f. Jasanoff, 2010). Local vulnerability to anthropogenic climate change, as well as social vulnerabilities, such as ongoing Indigenous disadvantage, shaped perceptions of the project, and of the desirability and feasibility of OF more generally. An extensive local history of natural resource extraction and depletion, as well as local familiarity with pursuing carbon credits in exchange for environmental protection, were influential to its reception. Reactions to the project also tapped into the ongoing desire to rekindle greater Haida cultural identity, political autonomy – and even national sovereignty – following a painful history of European colonial atrocities and the dispossession of Haida rights, language and traditions.

In a similar vein, debate about the HSRC became embroiled in enduring issues of land rights and contestation about resource access and permits and about the permissibility of different forms of local industry. Additionally, participants often made sense of the HSRC project through deep spiritual and practical relationships to the land and sea, taught in Haida oral history. Most visibly these included Haida cultural and spiritual affiliations with local salmon runs and local dependence on natural resources for livelihoods and nutrition. People similarly often understood the HSRC project through earlier experiences with the Canadian federal government and through a history of outsiders attempting to speak for Indigenous people.

Geography and place were centrally implicated in how people understood the HSRC project. The natural abundance of local biodiversity, recent fluctuations in local salmon runs, the island's experiences with non-native introduced species and concerns about the Enbridge pipeline proposal to bring oil tankers to surrounding waters, for example, all shaped interpretations. So too did recent geophysical events, such as Earthquakes and the 2008 eruption of Kasatochi volcano. Emphasizing the interrelatedness of people, knowledges and places, national debates about the Alberta Tar Sands and about the Canadian government's participation in global climate governance structures also visibly shaped the reception of the project (see also Gannon, 2015). Participants in this case study therefore did not speak about 'geoengineering' in isolation from the textures of their daily life and their wider experiences and perspectives on the world. Instead debate about the desirability and feasibility of the 'geoengineering' ambitions of the HSRC spoke to different notions of identity, place, ethnicity and community.

Comparing and contrasting viewpoints through Q-Methodology

These locally contingent meanings were abstracted by the Q-Methodology process, and, since Q-Methodology is essentially a data reduction process, the factor interpretations inherently constrain socio-cultural relativism. Nevertheless, we believe that Q-Methodology has proven a valuable means of structuring our analysis of the HSRC case study, as the factors have helped to highlight key differences in accounts of the desirability and feasibility of OF through the HSRC case study (Eden et al., 2005). Factor 1a, for example, offers an interpretation of OF which sees humans overstepping their place in the natural order and intruding into realms in which they don't belong (18: +5**). Yet, for Factor 1b and Factor 2, this type of reasoning holds little credibility. Factor 1b instead prefers to rationalise exploration of OF as part of a wider socio-technical project of human development, in which only science and instrumental reasoning can connote the value of OF (42: +5**). Factor 2, meanwhile, positions OF within storylines about the complexities of natural systems, suggesting optimal solutions emerge from reflection on the limits of human capacity (32: +4) and of natural systems themselves (28: +5**).

The Q-analysis has also highlighted a number of Q-statements that were ranked similarly by participants that loaded onto all factors, which suggests that some statements were less controversial among the study participants. Apparent consensus statements should not be over-interpreted, since, as will be seen below, their seemingly similar rankings may conceal differences in understandings of the statements across factors (Brown, 1980). Nevertheless, these items are worth some reflection for opportunities that they may present for constructive dialogue between perhaps non-consensual, but non-confrontational aspects of participants' accounts (Webler et al., 2009).

Statement 37 – 'my feelings on ocean fertilization are shaped by an understanding that human and non-human worlds are entangled. Trying to separate them is meaningless' – was the statement ranked most similarly by the factors. For Factor 1a, Statement 37 spoke to a sense of interconnectedness between human, non-human – and at times supernatural – worlds, premised on an account of reverence for the natural world (13: +5**) and an inherent natural order (18: +5**). Meanwhile, for Factor 1b and Factor 2, this statement had more resonance

with literatures that have labelled the current era the 'Anthropocene' (Crutzen, 2002a, 2002b; Steffen, et al., 2007); an age in which humans have become the dominant force of change on Earth and in which human and non-human worlds are linked in a common trajectory of mutual dependence and self-actualisation.

Similarly, a general role for 'scientific enquiry' in decision-making about geoengineering was described by each of the factors, yet the nature of that role varied significantly. For Factor 1b, empirical enquiry offers humans the ability to observe, measure and record the impacts of OF on the marine and climatic systems, and the factor describes the scientific method as the *only* route through which reliable knowledge about the desirability and feasibility of OF can be attained. Factor 2 meanwhile, offers a more cautious and sceptical interpretation of the potential of the scientific method, while Factor 1a sees scientific knowledge as one form of truth among many and positions science alongside different forms of vernacular, cultural, spiritual, moral and experiential knowledge.

Furthermore, all factor interpretations also appeared to be broadly shaped by a general sense of responsibility for ensuring the health and wellbeing of the environment (e.g. statement 41), and often reflect a feeling of connection to, and dependence on, the earth and other forms of life (e.g. statement 15). Indeed, participants loading on all factors often used the term 'stewardship' to describe this role. Descriptions of the role that OF could play in such 'stewardship' diverged. Nevertheless, that participants typically described a sense of entangled interdependence between themselves and their environment – and that this imbued most participants with a strong commitment to their particular prescription for environmental protection – is perhaps an encouraging area of consensus, that should not be overlooked in the quest for constructive dialogue on OF.

Putting familiar geoengineering storylines 'in conversation'

Through the diverse interpretations of the desirability and feasibility of OF, captured within the factors, analysis has illustrated the constructed nature of geoengineering (c.f. Hulme, 2009). The HSRC invoked a discursive arena in which people can be seen telling fundamentally different stories about what they think of as common sense in the world and, more normatively, what matters, what is desirable, and, equally, what should be avoided. The factors construct different notions of 'nature' and 'naturalness', offer diverse interpretations of the human role and purpose, construct different boundaries between 'natural' and 'human' worlds, are shaped by different secular, spiritual and religious beliefs, afford different forms of 'nature' value and afford different forms of knowledge legitimacy. The emergence of a bipolar factor in this paper begins to hint at how deeply entrenched some of these competing values and perspectives may be. Yet it is notable, that such contestation is largely ignored by existing formalised frameworks for assessing geoengineering, which typically consider only limited technocratic, risk-based metrics (Bellamy et al., 2012).

The factor interpretations in this research cannot be understood to have any uncomplicated correspondence with participants' lived experience of OF; not least because no participant loaded perfectly onto any Q-factor. They do, however, offer interpretations of general homologies of observed similarities in participant perspectives and thus they serve as useful heuristics that offer an interpretation of where key commonalities and differences between perspectives lie. Q has therefore proven a useful means of putting different geoengineering "stories in conversation" (Buck, 2010: 9); allowing us to situate perspectives within the context of others. In the context of the local tension surrounding the HSRC in Haida Gwaii, it is also relevant that it has allowed us to do this without bringing actors together into a potentially very emotional and highly charged focus group setting (Danielson et al., 2009).

As described, the precise 'ways of talking' about 'geoengineering' and the specific cultural features of 'geoengineering' discourse were inexorably unique to this case study; situated in and interpreted through local experience. Through discourse about the 'geoengineering' ambitions of the HSRC, this paper has, however, within the factor narratives themselves, also traced, supplemented and developed discourses, frames, storylines, explanations, phrases, metaphors, themes, images, tropes, exemplars, lexical choices, policy positions and evaluations that are familiar to earlier geoengineering social science literatures.

The fact that recognizable routines of meaning-making, described through more abstract entry points into thinking about the idea of geoengineering – and deployed in relation to a range of geoengineering technologies, including solar radiation management proposals – can be traced from this place-based experience of OF, is an

interesting finding in itself. Geoengineering technologies have very different philosophical, ethical, risk, legal and governance profiles (Hulme, 2014; Royal Society, 2009; Vaughan and Lenton, 2011). Nevertheless, familiarity of some of the interpretative resources within the case study discourse suggests that, in light of the intentionality that is invoked with the idea of managing the climate in all forms, many of these are likely to continue to find resonance across a range of entry points into thinking about geoengineering. It also suggests that earlier deliberative methods have done well to create ostensibly meaningful dialogues and public consultation exercises that have overcome some of the methodological challenges that arise from exploring geoengineering 'upstream', where awareness of geoengineering is typically low (e.g. Bellamy et al., 2016; Corner et al., 2013; Macnaghten and Szerszynski, 2013).

Connecting 'geoengineering' in Haida Gwaii with literatures on ecological worldviews

Q-Methodology does not aim to generalize findings to wider populations (Watts and Stenner, 2012), or to establish what proportion of these populations might identify with one factor over another (Brown, 1980). Yet, there are other reasons to suggest that 'geoengineering' at the 'edge of the world', might actually have some value for helping to make sense of some of the ways in which 'geoengineering' debates are constructed elsewhere. Contestation about the role and nature of 'nature' and human agency, seen in our case study factors, draws on a long history of debate about the relationship between nature and humans. Indeed, reflecting the inevitably 'informed' approach to grounded analysis (Thornberg, 2012), the factors start to highlight contested philosophical ground of wider environmental management and restoration discourses and connect with cultural meanings expressed and debated in other domains.

Interpretative parallels with the work of 'worldviews' scholar Annick De Witt warrants particular consideration. De Witt (Hedlund-de Witt, 2014; De Witt and Hedlund, 2017; De Witt et al., 2017) posits the existence of, at least, three major worldview structures in the West which, reflecting conventions of earlier research (Inglehart, 1997; O'Brien, 2009; Taylor, 1989), she labels 'traditional', 'modern' and 'post-modern' worldviews (De Witt and Hedlund, 2017: 318). As well as having a widespread "cultural caché" (Hedlund-de Witt, 2013: 251) that allows them to be grasped relatively intuitively, she suggests that these labels reflect the "historical-developmental trajectory of cultural epochs and worldviews in the West, described by philosophers of Western thought, historians, and social scientists" (De Witt and Hedlund, 2017: 315).

De Witt tentatively depicts 'logically constructed' models of these 'ideal-typical' worldviews, to delineate a provisional interpretation of the primary assumptions, themes and concerns of each of the ideal-typical worldviews. She constructs these using an organising scheme, depicting what she describes as the five major aspects of worldviews: Ontology, epistemology, axiology, anthropology and societal vision (Hedlund-de Witt, 2012; De Witt and Hedlund, 2017). These heuristics are designed to offer only "sweeping generalisations of the complexities and ambiguities of reality" (Hedlund-de Witt, 2014: 8316) and are presented as neither exhaustive nor definitive. Yet, De Witt has applied these heuristics with some convincing results to suggest that these ideal-typical worldviews may shape pro-environmental attitudes and sustainable lifestyle choices (Hedlund-de Witt, 2013). She also suggests that they inform different visions of 'development' and 'quality of life' (Hedlund-de Witt, 2014) and that they underlie the dominant social responses to industrial biotechnology (De Witt et al., 2017).

Some notable interpretative overlap can be traced between the configuration of ontological, epistemological and axiological, assumptions constructed through our Q-study factors and the ontology, epistemology, axiology, anthropology and societal vision delineated in De Witt's ideal-typical 'traditional', 'modern' and 'post- modern' worldview heuristics. Factor 1a 'Ocean fertilization is morally wrong. We need to preserve the natural order' shares some broad consistencies with De Witt's 'Traditional' worldview heuristic. Factor 1b 'Ocean fertilization should be urgently explored. Through science we can respond to the challenges of climate change', shares some general similarities with De Witt's 'Modern' worldview heuristic. While Factor 2, 'Climate and ocean systems are dynamic and interconnected. Ocean fertilization is very risky', in some ways echoes the configuration of assumptions described through De Witt's 'Post-Modern' worldview heuristic. These parallels are not neat, complete or consistent. However, table 4 below highlights some of the ontological, epistemological and axiological assumptions that find *some* interpretative salience across De Witt's ideal-typical worldviews *and* our Q-study factors; themselves constructed to express participants' views vis-à-vis OF.

	De Witt's 'Traditional' Worldview	De Witt's 'Modern' Worldview	De Witt's 'Post-Modern' Worldview
	Factor 1a: 'Ocean fertilization is morally wrong. We need to preserve the natural order'.	**Factor 1b: Ocean fertilization should be urgently explored. Through science we can respond to the challenges of climate change.**	**Factor 2: Climate and ocean systems are dynamic and interconnected. Ocean fertilization is very risky.**
Ontology	Nature as embodiment of meaningful imposed order (e.g. God's creation/Mother Nature).	Nature as instrumental resource for humanity to use. Secular cosmology	Nature as complex and interconnected. The Earth has natural limits. Secular cosmology.
Epistemology	Different forms of moral and religious knowledge are afforded particular value.	Trust in science, technology and instrumental reasoning. (Post)positivism.	Philosophical pragmatism. Systems-view.
Axiology	Humility. Respect for tradition, community and sacrifice.	Materialist-value orientation. Protection of individual freedoms.	Post-materialist values. Global justice dimension emphasised.
Anthropology	Humans subject to meaningful natural order.	Self-optimizing human being develops nature to advance human wellbeing.	Humans in cautious relationship to nature.
Societal Vision	Technological intervention in nature a priori unacceptable.	Technological optimism.	Techno-cautious.

Table 4: Interpretative parallels between de-Witt's ideal-typical 'traditional', 'modern' and 'postmodern' worldviews and the configuration of ontological, epistemological and axiological assumptions interpreted from the Q-Methodology factors. Constructed from factors interpretations in section 3.2 and from Table 1 in (De Witt et al., 2017: 74).

Q-factors as provisional orienting heuristics for reflexivity in decision-making

That the study factors construct ideas familiar to, and enduring across, other technological and environmental debates emphasizes that ideas of 'geoengineering' are situated within the legacy of an expansive history. It also underlines that accounts of 'geoengineering' serve as vectors for more general social and cultural anxieties, as well as issue-specific concerns and problem definitions. However, interpretative parallels with broader Western cultural currents in human meaning-making also suggests that the homologies of perspective captured in the Q-study factor interpretations, could potentially serve as useful mnemonics for helping to conceptualise more general homologies of perspective; and some of the deeper contested values, assumptions and epistemologies about the role and nature of 'nature' and human agency, that drive public contestation about geoengineering in the contemporary West (De Witt and Hedlund, 2017).

Further research would be needed to test the validity of this claim for other geoengineering technologies; especially outside of Western contexts. And the factors must be understood as provisional orienting heuristics, to be treated reflexively and improved upon; rather than as some kind of comprehensive explanatory theory (Mamadouh, 1999). Finely curated grand narratives hold their own potential to 'close down' debate and to disempower, marginalise, exclude and oppress alternative perspectives. Nevertheless, provided that the limitations of these factors are acknowledged, such provisional orienting heuristics hold the potential to help open up reflexivity in geoengineering debates. They could encourage critical self-reflection among policy makers on the core assumptions and motivations shaping different geoengineering problem diagnoses and policy prescriptions, which could help decision-makers to reconstruct their approach to geoengineering with a clearer focus. Indeed, the factor interpretations need not be 'comprehensive' or universally salient to be able to perform some form of heuristic role in this regard. The factors may also be able to serve some purpose as a scaffold for communication and for developing mutual understanding around some of the values and motivations that shape alternative perspectives in respect to geoengineering.

Mainstream Eurocentric approaches to management of the global environment have a long history of privileging

solutions that fit within their own problem definitions (Bravo, 2009; Bird Rose, 2004; Howitt and Suchet-Pearson, 2006). The IPCC process has not been immune to such ontological and epistemological hegemony. By seeking global knowledge "*convergence* and *uniformity"* (Beck, 2012: 3) the IPCC validates and legitimates certain types of scientific evidence through its very selection of sources. Its literatures reflect geo-political power imbalances; with experts from developing countries having limited participation in the drafting of the reports (Hulme and Mahony, 2010). And interpretative, place-based and indigenous knowledges have been particular casualties of the IPCC's epistemological framing (Hulme and Mahony, 2010; Bjurström and Polk, 2011; Beck, 2012; Ford et al., 2012).

This research suggests that geoengineering technologies are always going to be contested because they interact with multiple and diverse ways in which people understand human nature in relation to the non-human world. This paper has therefore revealed that any claim to one 'unanimous', 'comprehensive', 'rational', 'correct' or otherwise 'superior' knowledge of geoengineering, would be an inherently political act, only achievable in settings where the multiplicity of competing values and beliefs has been silenced. Howitt et al. (2012: 48) argue that global environmental challenges like climate change "should be addressed as opportunities for decolonization" (Howitt et al., 2012: 48). Exploring diverging standpoints and generating a better understanding of the beliefs and values that underpin different attitudes and responses towards the idea of geoengineering will, therefore, be fundamental to ensuring a more productive, creative, inclusive and equitable debate about this issue of vast global consequence.

Conclusions

Russ George and his off-island colleagues found an entry point to bring the idea of 'geoengineering' to the village of Old Massett through a unique confluence of social, political, cultural and environmental circumstances. Despite literature which suggests that people find debates about climate change to be abstract, and hard to relate to their daily lives (see Jasanoff, 2010), the HSRC's OF project provoked a site of extensive, and often sophisticated, discussion about the desirability and feasibility of OF as a geoengineering response to the threat of anthropogenic climate change. This provided a novel opportunity to consider public understandings of geoengineering within a 'real world' and situated context.

This research has shown that debate about the desirability and feasibility of exploring the geoengineering potential of OF through the HSRC took shape around fundamentally different values, meanings and expectations about the nature and condition of natural systems, about the types of knowledge that can be considered valid and about the role of human beings. 'Geoengineering' in Haida Gwaii was imbued with debate about values and meanings, about rights and responsibilities, and about instincts and aspirations about how the world is, and how it should be. The emergence of a bipolar Q-Methodology factor hints at how deeply entrenched some of these competing values and perspectives may be.

The ways in which these debates unfolded through the HSRC were contextually unique, embedded within local histories, site specificities and attachments to the landscape; and reflective of distinctive cultural, political and geographical context. In this place-based experience of geoengineering, locally specific meanings interacted with familiar global discourses and interpretative resources, reflecting the interconnected nature of global people, knowledges and places (Beck, 2007). This situated the 'local' within the 'global', placed 'ocean fertilization' within debates about other geoengineering technologies and connected 'geoengineering' in Haida Gwaii with wider cultural meanings and literatures that consider the human relationship with nature.

The HSRC case study has started to open up geoengineering debates to a wider range of perspectives. Indeed, to the authors' knowledge, this is the first empirical study of perceptions of geoengineering to consult indigenous people. Through the Q-Methodology factors constructed in this research, this paper has also developed new tools for reflexivity in geoengineering governance; to expose the visions being pursued and some of the values being ignored. Such reflexivity will be fundamental if geoengineering – at any spatial scale – is to avoid becoming anything other than a simple expression of hegemony.

Conflict of Interest
The authors declare no conflicts of interest.

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Appendix

Conducting and analysing the Q-sorts

Q-Methodology does not employ large numbers of participants. In statistical terms participants are the variables and Q convention denotes that, at a minimum, the analysis must have a smaller number of Q-participants than Q-statements (Watts and Stenner, 2012); indeed a ratio of 1:3 is often advocated (Webler et al., 2007). Diversity of opinion should be maximized among the participants, since, theoretically, participants are selected to represent the breadth of opinion in the population, rather than the distribution of beliefs (Brown, 1980). The ethnographic phase of the research allowed us to purposively sample a total of 26 participants who we believed would both add unique perspectives to the study and who were sufficiently engaged with the subject to do so effectively[4].

Most of the Q-sorts were conducted in person, using a printed distribution chart and numbered Q-cards. This allowed supporting qualitative data to be easily collected alongside the sorting process. Three of the participants conducted their Q-sorts through an online application developed using the software FlashQ[5]. Free, purpose-built Q-software, PQMethod was used to run the by-person factor analysis and centroid factor analysis was used to extract factors. Varimax rotation, a facility available within PQMethod, was used to produce the most orthogonal (uncorrelated) factors possible. Centroid factor analysis does not resolve itself into a single acceptable factor analytic solution and instead researchers must make decisions about which factors to retain and rotate. To be retained, factors had to meet some basic statistical criteria (e.g. Guttman, 1954; Kaiser, 1960) and account for a reasonable portion of the study variance. But, most importantly, the solution had to make good 'sense' of the data (Coogan and Herrington, 2011; Watts and Stenner, 2012).

Factor loadings produced following rotation measured a participant's affinity to a factor. Those participants that had statistically significant factor loadings were 'flagged' in PQMethod and used in the construction of factor estimates. To calculate these estimates, the contribution of each of the statistically significant sorts to a factor estimate is weighted according to its factor loading. To permit cross-factor comparison, PQMethod converts these total weighted scores into standardized z-scores, from which exemplifying Q-sorts were produced. Taking the form of a single Q-sort, this 'ideal-typical' sort is presented in the array format in which the data was originally collected.

[4] Notably the literacy requirement of this design prevented at least one otherwise willing and suitable potential participant from participating.

[5] Two of these respondents participated in face-to-face interviews at other points during the research.