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RESEARCH ARTICLE

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Geoengineering at the "Edge of the World": Exploring perceptions of ocean fertilisation through the Haida Salmon Restoration Corporation

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The Haida Salmon Restoration Corporation's (HSRC) 2012 ocean fertilisation experiment introduced a controversial geoengineering technology to the First Nations village of Old Massett on the islands of Haida Gwaii in British Columbia. Local debate centred on conflicting interpretations of the potential environmental impacts of the project and on the Corporation's attempts to align its public brand with the Haida name and proud identity of environmental stewardship. More broadly, the controversy illustrated long-standing arguments about the desirability and feasibility of ocean fertilisation as a geoengineering response to the threat of anthropogenic climate change. Using the HSRC case, this paper reports a novel situated study of public perceptions of geoengineering that combines ethnographic engagement with Q-methodology. Three distinct viewpoints on ocean fertilisation are revealed, shaped by the unique confluence of social, political, cultural and environmental circumstances of Haida Gwaii. These viewpoints on ocean fertilisation reflect different ideas held by local residents about planetary limits, about the way humans attain knowledge of natural systems and about the human values of, and responsibilities toward, nature. Although the revealed viewpoints are constructed through contextually specific local meanings, they engage with debates that emerge across a range of other geoengineering technologies and which reflect contested philosophical positions visible in wider environmental management and restoration discourses. The case of ocean fertilisation off the islands of Haida Gwaii may therefore provide a useful benchmark for reflexivity in geoengineering governance. Our case study shows that engaging with the situated beliefs and values that underpin human attitudes and responses towards novel geoengineering technologies is a *sine qua non* for good governance. Even so, our results suggest such technologies will likely always be contested given the diverse ways in which people understand human relations with the non-human world.

KEYWORDS
geoengineering, Haida Gwaii, ideologies of nature, ocean fertilisation, public engagement, Q-methodology

1 | INTRODUCTION

During July and August 2012, from the back of a black-cod fishing boat known as The Ocean Pearl, 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 the British Columbian archipelago Haida Gwaii (Bird et al., 2013; McKnight, 2013). The project was initiated and led by Russ George, an American best known for founding Planktos Inc., an enterprise with a controversial history of carbon credit ventures and earlier failed attempts at ocean fertilisation (OF) (CBC, 2013). George lacks traditional academic credentials, including most notably an undergraduate degree. Yet he represented himself to the First Nations Haida village of Old Massett as "the world's leading expert" on ocean iron fertilisation (Horton, 2017; Vancouver Registry, 2014) and persuaded the community to part with an initial investment of CAD$2.5 million of village funds to finance the project. In exchange, the residents of Old Massett were promised that OF 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, 2013a).

Haida Gwaii – islands so geographically remote that they are often referred to as "the Edge of the World" (e.g., Musgrave, 2015) – might seem an unlikely location for the world's "largest geoengineering experiment" (Lukacs, 2012). Yet, when the HSRC is discursively situated within local histories and geographies of (post)colonial indigenous subjugation, resource extraction and Haida battles to restore political autonomy, it is easy to understand how this proposal gained traction within Old Massett. The HSRC represents an important moment for research on geoengineering. Until now, deliberative focus-group methods have been the gold standard of research on public perceptions of geoengineering (Bellamy et al., 2016; Bellamy et al., 2017; Macnaghten & Szerszynski, 2013). However, since awareness of geoengineering among the public is generally low, these research designs still, in some senses, have to create the views that they seek to elicit (Buck, 2010; Stirling, 2008). The HSRC, on the other hand, is a "real world" case of geoengineering, anchored in notions of place and identity, which invoked a site of live debate about the desirability and feasibility of OF as a form of geoengineering. Moreover, it embroiled a diverse set of actors, including, through the Haida Nation, indigenous people who have been largely excluded from previous public consultation on geoengineering (Whyte, 2012). The HSRC therefore presents a novel contribution to social research on geoengineering that offers a new empirical perspective through pursuing a more situated engagement with geoengineering that is more closely in keeping with geographical research traditions (see also Jasanoff, 2010; Yusoff, 2013). It does this while "opening up" (cf. Stirling, 2008) existing literatures to a wider range of perspectives.

While situating analysis within an interpretation of the unique confluence of social, political, cultural and environmental circumstances that allowed the idea of geoengineering to find an entry point in the village of Old Massett, in this paper, we put the HSRC case study to work for a specific analytical purpose: To contribute to a small body of empirical (Corner et al., 2013; Macnaghten & Szerszynski, 2013; Nerlich & Jaspal, 2012; Porter & Hulme, 2013) and theoretical (Clingerman, 2014; Galarraga & Szerszynski, 2012; Hulme, 2014; Preston, 2012) social science literature that has argued that narratives of geoengineering construct diverse beliefs about nature and the human identity and place within the world. Geoengineering is only one of the latest in a long line of technological developments that have provoked debate about the desirability and feasibility of humans attempting to control, shape or manage natural systems (Corner et al., 2013; Hastrup, 2013; Macnaghten & Urry, 1998). Through its dual identity as a technological endeavour of both "global" and "intentional" remit (Clingerman, 2014; Galarraga & Szerszynski, 2012), geoengineering has, nevertheless, been argued to have unprecedented potential to recalibrate the parameters through which notions of nature and human agency are constructed. By widening the meaning of what it is to live within the Anthropocene (Crutzen, 2002a, 2002b; Steffen et al., 2007), geoengineering technologies may draw humanity into new relationships with nature (Hamilton, 2013; Preston, 2012).

If, as Clingerman (2014, p. 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. With the aim of supporting such reflexivity, this paper employs an innovative research design that combines ethnographic engagement with the HSRC case study and the use of Q-methodology. Q-methodology is a discourse analysis technique that allows identification of clusters of shared meaning. Thus, it enables us to untangle diverse viewpoints on OF surrounding the HSRC project.

The second section of this paper introduces the context and controversy of the HSRC. The third section explains our deployment of the Q-methodology exercise framed by actors and events surrounding the HSRC project in Haida Gwaii. In the fourth section we present the results of our analysis and suggest three key viewpoints of OF that develop contrasting interpretations of the desirability and feasibility of OF as a response to anthropogenic climate change. The three viewpoints mobilise 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. These viewpoints on

OF, constructed through Q-methodology in Haida Gwaii, engage with ideas and debates that emerge across a range of other geoengineering technologies and also reflect contested philosophical positions that are visible in wider environmental management and restoration discourses. In the final section of the paper, we therefore suggest that the three viewpoints on OF revealed through the HSRC case study may provide a new resource for reflexivity in geoengineering governance, to expose some of the visions being pursued and some of the values being ignored. This is crucial since by interacting with multiple and diverse ways in which people understand human nature in relation to the non-human world, our results suggest that geoengineering technologies are always going to be contested.

2 | THE HAIDA SALMON RESTORATION CORPORATION: CONTEXT AND CONTROVERSY

2.1 | What motivated the village of Old Massett to finance the HSRC?

For Haida people, Haida Gwaii is home in a practical, spiritual, political and cultural sense. An intimacy with the land and sea pervades accounts of what it means to "be Haida" and lies at the heart of the Constitution of the Haida Nation (CHN, 2010). This relationship with the natural world does not prohibit the Haida from utilising Haida Gwaii's natural abundance. Instead, people in Haida Gwaii are heavily reliant on the islands' natural resources and Haida oral history links the land and the people through the belief that one cannot exist without the other (see Bial, 2001; Jones & Williams Davidson, 2000). The significance of salmon as the "life blood" (Masset resident in Gannon, 2015, p. 142) of Haida people is age old and extensively expressed through Haida art. It is described in the Haida Land Use Agreement as the most important source of nourishment in the Haida diet (CHN & BC, 2007).

While still possessing outstanding diversity and resource richness, present day Haida Gwaii is environmentally impoverished compared with its pre-contact state. Since colonisation, Haida Gwaii has seen its resource base deplete, as billions of dollars of natural resources have been shipped off-island by extractive industries (primarily logging and fishing) (CHN, 2004). Salmon stocks have been a particular casualty of this extraction and, combined with other pressures, including extensive riparian logging, climate change and pollution, sockeye salmon in particular are considered to be in "dire straits compared to their historical abundance" (CHN, 2004, p. 14, see also Cohen, 2012).

Driven by the need for employment, many Haida people have participated in these extractive industries, but have broadly profited only as labourers. And, while Old Massett's economy used to be heavily reliant on fishing and fish-processing activities, access for islanders has become limited by a complex system of fishing permits and competition with large commercial enterprises and sports fishing lodges. "We've been legislated out of fisheries", one Old Massett resident explained (Gannon, 2015, p. 141). As resources have depleted, many of the jobs associated with the remaining resource extraction have been moved off-island. This has led to out-migration (Haida Gwaii Observer, 2012), depressed house prices and business closures. Today, Old Massett's population of approximately 750 people experiences around 60% unemployment (J. Disney, personal communication, December, 2017).

For many Haida people, local environmental degradation and structural exclusion from natural resources is intimately tied to the long history of Euro-Canadian colonial violation of the Haida way of life. This experience has occurred despite the Haida Nation never ceding rights, title, ownership or jurisdiction over Haida Gwaii (see also Dowie, 2017; Gill, 2009). The Haida are estimated to have lost around 95% of their population to European disease epidemics during the 1800s (CHN, 2009; Lee, 2012) and the remaining population has endured Canadian sanctioned assimilation policies which include attempts to separate Haida people from their language, children and traditional practices, foods and governance systems (see especially Collison, 2011; Halpin, 1984; Steedman & Collison, 2011; Samuels, 2012). Legacy of this trauma reverberates around Haida society today (Samuels, 2012) and indigenous populations across Canada are marginalised by nearly every measure of social and economic inclusion.

In the face of these challenges, the Haida have unrelentingly fought to restore Haida rights, traditions and cultural identity lost to what Haida Gwaii Museum Curator Jisgang Nika Collison has called "the silent years" (Collison, 2011). The Haida Nation is consequently now recognised as a powerful political force that has established renowned legal precedents in relation to First Nations title and land management (Dowie, 2017; May, 1990).[1] Within this movement, for many Haida people, protecting and securing access to salmon is fundamental to reclamation of Haida cultural identity and autonomy. The HSRC therefore brought a compelling narrative to the people of Old Massett. In a place where extraction is the norm, the HSRC offered not only a route to restoring a culturally treasured and economically significant resource, fundamental to Haida self-sufficiency and identity. It also tapped into Haida ambitions for greater political autonomy and the opportunity for Old Massett to create its own economic engine, to break free from financial dependency on the Government of Canada.

The appeal of the HSRC did not end there for Old Massett. Although it was actively branded as salmon restoration,[2] the additional premise of carbon sequestration brought support for the HSRC beyond its promised carbon credit potential. In Haida Gwaii, no area of land is more than 20 km from the sea (Lee, 2012) and the community of Old Massett, which is particularly low lying, has experienced periods of drought, water shortage, forest fire threat, as well as washouts and inundation along earthquake evacuation routes. Climate change has accordingly been recognised in multiple Haida forums as a significant threat to Haida Gwaii and its marine ecosystems (CHN, 2007; Haida Fisheries Program, 2009). The islands' news media reveals widespread local frustration with Haida Gwaii's own relatively high per capita greenhouse gas emissions, resulting from its relative geographic isolation, the islands' north grid being powered by diesel generators and the prevalence of wood-burning stoves and large trucks for heating and transport.

Climate change mitigation is therefore high on the Haida Nation's political agenda. Former President of the Haida Nation, Guujaaw, proposed that First Nations leaders in the Pacific Northwest might unilaterally sign the Kyoto Accord given that they are not yet recognised as nation states (Gill, 2009). Old Massett, meanwhile, has recently installed a biomass boiler to heat community buildings, fuelled by wood waste from the islands' sawmill (BC Ministry of Indigenous Relations and Reconciliation, 2017). In comparison, national climate policy under Stephen Harper's Conservative government signalled a markedly different political agenda through, for example, the development of the Alberta tar sands and Canada's withdrawal from the Kyoto accord.[3] With the national Canadian government failing to take climate risk seriously, for some, the HSRC's proposition represented another opportunity for Haida people to take Haida interests into their own hands. "It is an attempt to try and solve some of these problems … we gotta do something or we're all going to sink", one Old Massett resident explained (Gannon, 2015, p. 148); advancing a position that echoes "climate emergency" and "political realism" framings of geoengineering, widely reported in previous studies of geoengineering discourse (e.g., Anshelm & Hansson, 2014; Nerlich & Jaspal, 2012).

2.2 | The HSRC becomes a geoengineering controversy

The HSRC was highly contentious in Haida Gwaii. Described as having "divided families" (Old Massett resident in Gannon, 2015, p. 133), the project caused significant tension within Old Massett, as well as between Old Massett and the village of Skidegate, the other main Haida community on Haida Gwaii which had no voting rights on the project (Brown, 2013; CHN, 2012). Particular contention surrounded the HSRC's business development rationale which linked OF to salmon restoration through local experience of a 34 million strong sockeye salmon run in 2010 in the Fraser River. This gave credence to the hypothesis that plankton blooms in the subarctic North Pacific – seeded through fertilisation by volcanic ash plumes arising from the 2008 Kasatochi volcano in southwestern Alaska (Hamme et al., 2010; Langmann et al., 2010) – had contributed to greater survival of juvenile salmon from increased food availability (see Parsons & Whitney, 2012). Yet critics on and off-island challenged this hypothesis (see McKinnell, 2013; Tauber, 2013; White, 2013b) noting limited empirical evidence that OF could be advantageous for ocean food webs (Royal Society, 2009).

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 was also challenged (Hume, 2012; Pearson, 2013; Suzuki, 2012). This reflects the highly contested and relatively undetermined status of scientific evidence that suggests OF could sequester carbon dioxide in significant volumes and with any permanency (Boyd et al., 2007; Buesseler et al., 2008; Cullen & Boyd, 2008; Williamson et al., 2012). 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. The (il)legality of the project was also a source of significant debate, particularly in light of the commercial intent of the project design. Further, while the story of the HSRC may not yet be over (Tollefson, 2017), with no market or mechanism for verifying carbon credits from OF currently in existence, it remains unlikely that Old Massett's investment – let alone the "guaranteed" profits from the project (White, 2013a) – will ever be returned to the village.

Amidst these other concerns about the HSRC project, local debate surrounding the desirability and feasibility of the HSRC was especially concentrated around two prominent concerns: conflicting interpretations of the potential environmental impacts of the HSRC's OF project and, second, the HSRC's attempts to align its public brand with the Haida name and proud identity of environmental stewardship and cultural connection to the land and oceans. Russ George's framing of the HSRC broadly positioned OF as "an intentional act of nurture" (George, 2014), designed to support the health and recovery of ocean and climate systems (cf. Nerlich and Jaspal's [2012] conceptual metaphor, "the planet is a patient"). Written largely by Russ George, who is not Haida, the HSRC's first website made sense of the HSRC project through George's own versions of Haida oral histories and stories, as well as through interpretations of Haida political ambitions and relationships

to the land and salmon[4] (see also Horton, 2017; HSRC, 2013). These ideas found salience with some members of the Old Massett community, who, for example, conceptualised the HSRC's aims and activities in the context of Haida oral history and traditional practices of "giving back" to the ocean. As one Old Massett resident explained:

> There are stories about how we returned the [salmon] bones to the ocean … [so] we've always had ways of fertilising. We observe even animals do it. The bear takes the fish into the forest and it's fertilising the trees. (Gannon, 2015, p. 138)

For others, however, George constructed a notion of environmental stewardship that was deeply at odds with their own interpretation of the Haida land ethic and the HSRC – a project largely designed and executed by non-Haida off-islanders – represented a profound form of cultural appropriation. When asked how she thought people in Haida Gwaii will tell the story of the HSRC in the future, one prominent Haida matriarch responded:

> [They will say that] a handful of Haida … [were] so arrogant as to assume that they understood the dominion, the area of which the Supernaturals have authority. And they overstepped their rights [and put] things off balance … So much so that they created the [October 2012] earthquake … and something so precious, so spiritual, so wonderful to us as the hot springs was shut off to us.[5] (Gannon, 2015, pp. 137–138)

Indeed, in the months that followed the HSRC project, the belief that the project bore significant, unreasonable and poorly understood risks to the marine environment was an idea raised by Haida and non-Haida islanders alike (Brown, 2013; Haida Gwaii Observer, 2013). This position broadly reflected statements expressing disapproval of OF from both the London Convention on Ocean Dumping and the Convention on Biological Diversity. It also resulted in local environmental conditions, such as the extended closure of razor clam fisheries due to persistent paralytic shellfish poisoning, being qualitatively linked to the HSRC project (e.g., Tauber, 2013).

3 | METHODS

The paper now turns to unravelling some of these conflicting notions of environmental stewardship constructed around the HSRC project. To do this, we employed Q-methodology among purposively sampled Haida Gwaii residents and off-island HSRC affiliates who were actively engaged in debate about the desirability and feasibility of the HSRC. Q-methodology is a discourse analysis research method that can be used to structure the interpretation and comparison of key shared and contested "points of view" that surround a given issue or topic (Coogan & Herrington, 2011). Since Q-methodology has been widely used across the social sciences – indeed it has been employed within the geoengineering literature to identify a "framing gulf" among influential, or "expert" geoengineering actors from diverse disciplinary backgrounds and sectors (Cairns & Stirling, 2014) – here we outline the method only briefly. However, a more detailed account is offered within the paper's supporting information, see Appendix S1.

3.1 | Q-methodology

In Q-methodology, a small number of theoretically sampled participants sort a diverse set of statements about a specified topic onto a fixed and approximately normally distributed, single dimension and face-valid grid (see Figure 1 below). The set of "Q-statements" are selected by the researcher and should be designed to broadly reflect the diversity of opinions surrounding the subject of interest. This should be accomplished in such a way as to allow anyone presented with the exercise to construct a personally meaningful representation of their understanding of the issue (Coogan & Herrington, 2011). Participants then rank the statements on the grid according to what they deem to be meaningful and significant. These "Q-sorts" are then compared in terms of the entire configuration of responses produced by participants, in a by-person factor analysis, which identifies patterns of association between the sorts and generates a small number of factors that are used to help interpret shared meanings within the data (Stephenson, 1965; Watts & Stenner, 2012; Webler et al., 2007, 2009).

For our research, Q-methodology therefore provided a route to characterising some of the diversity within notions of environmental stewardship constructed around the HSRC project, by modelling "attitudes of mind held in common" (Stephenson, 1965, p. 285). The highly contested and controversial nature of the HSRC case study made Q-methodology a

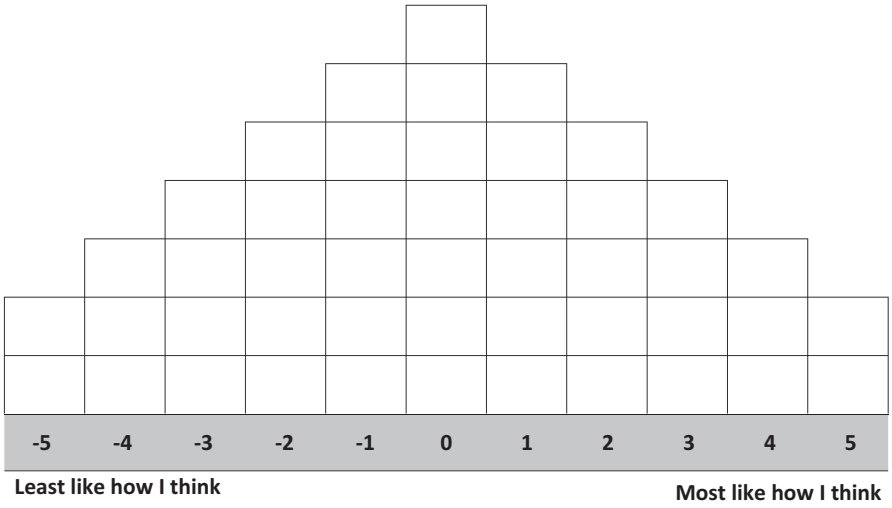

FIGURE 1 The Q-sort matrix used in the study.

particularly productive analytical avenue, since Q-methodology can help situate key attitudes pertaining to a given object of study within the context of others. As well as clarifying differences between perspectives, Q may identify less controversial dimensions of a debate and areas of consensus (Dnner, 2001; Eden et al., 2005). Moreover, it can do this without bringing actors together into potentially emotional and highly charged focus group settings (Danielson et al., 2009) which, given local sensitivities surrounding the HSRC, was an important ethical research criterion.

3.2 | A Q-methodology study focused on the case of the HSRC

Some literature suggests that people find debates about climate change to be abstract and hard to relate to their daily lives (see Jasanoff, 2010). In Haida Gwaii, however, amidst the concerns about local vulnerabilities to climate risk and frustration with national climate policy outlined above, the HSRC sparked often sophisticated debate about the desirability and feasibility of OF as a geoengineering response to the threat of anthropogenic climate change. This opened up the opportunity to recruit Q-participants who were generally familiar with the basic scientific principles surrounding the carbon sequestration ambitions of the HSRC and allowed us to frame the Q-methodology exercise in the same terms. Recognising the local and contingent nature of imaginaries (Cresswell, 2004; Jasanoff & Kim, 2009; Livingstone, 2003), the sorting instruction (Box 1) asked participants to reflect on the HSRC and to use the Q-sort to consider and represent what the future of OF, as a potential geoengineering response, means to them in more general terms.

In Q-methodology, the statements that participants sort comprise multiple possible answers to the sorting instruction and these 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" was developed from interpretative ethnographic engagement with the HSRC during eight months that the lead author spent in British Columbia during 2013 and 2014.[6] Alongside participant observation, this ethnographic enquiry was supported by a focus group (n = 13) and semi-structured in-depth interviews of varying formality (n = 44), with participants selected through a combination of convenience, snowball and theoretical sampling methods. It was also informed by discourse analysis of other texts, records of public meetings, audio and visual material and local, national and international media coverage.

The analysis of these multiple lines of ethnographic enquiry benefitted from De Witt's (De Witt et al., 2017; Hedlund-de Witt, 2012) Integrative Worldviews Framework. With the aim of making an otherwise amorphous concept more readily researchable, De Witt breaks down the notion of "(ecological) worldviews" into five major aspects. The first three, "ontology", "epistemology" and "axiology", constitute the dominant subject areas in philosophy. The fourth and fifth aspects, "anthropology" and "societal vision", are effectively subsets of ontology, and ontology and axiology, respectively. These are further differentiated to encourage researchers to explicitly investigate (1) conceptions of nature and the role of the human being (anthropology), and (2) conceptions of how society should be organised and societal problems addressed (societal vision). The Q-statement sampling process in this research pursued a fluid and interpretative approach that sought to sample the Q-statements based on an understanding of the overall character of the discourse, rather than according to a sample quota of pre-defined thematic categories. However, within the Integrative Worldviews Framework De Witt

BOX 1 The sorting statement

Alongside the goal of salmon restoration, the Haida Salmon Restoration Corporation hopes to sequester carbon dioxide, through ocean fertilisation, in order to reduce the scale of human-induced climate change. How do you feel about exploring ocean fertilisation to try to sequester carbon dioxide in the ocean?

Please sort the provided statements in the order that best describes your point of view.

formulates a set of exemplary questions for each of these five aspects. This set of questions proved a useful analytical lens through which to more comprehensively scrutinise the data and to identify as many standpoints and themes as possible (see Hedlund-de Witt, 2012).

The final Q-set comprised 47 statements[7] listed in Table 1. In the spring of 2014, 26 participants sorted these statements onto a grid (Figure 1) along a scale from −5 (least like their point of view) to +5 (most like their point of view). Participants largely comprised a sample of on-island residents, but also included off-island HSRC associates. They were identified during the ethnographic phase of research and selected on the basis that they (1) were anticipated to add unique perspectives to the study, and (2) were sufficiently interested and engaged with the subject to be able to do so effectively. The majority of these sorts were conducted in face-to-face interviews, although three participants completed their sorts through an online application developed using the software FlashQ. The factors produced by Q-methodology are just statistical abstractions until conferred discursive meaning through interpretation (Eden et al., 2005). To support this interpretation, and to fill out the "qualitative detail" of the factors, participants completing the sort in person were asked to "think out loud" as they conducted the sorting process. With this same aim, we understood listening to what participants were saying during this process to be more important than trying to cover absolutely every conceivable perspective in the Q-statements (cf. Donner, 2001).

Purpose-built Q-software, PQMethod was used to run the by-person factor analysis and centroid factor analysis was used to extract factors based on similarly organised sorts. Importantly, 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, since in this interpretivist application of Q-methodology statistical processing is merely used to facilitate and bolster qualitative interpretation, the solution had to be substantively meaningful and make good "sense" of the data (Coogan & Herrington, 2011; Watts & Stenner, 2012).

Retained factors were rotated using varimax rotation to produce the most orthogonal (uncorrelated) factors possible. Factor loadings produced following rotation measured a participant's affinity to a factor. Those participants who had statistically significant factor loadings ($p < .01$ level) were used in the construction of "factor estimates" wherein the weighted average of their sorts was used to construct "ideal-typical sorts", representing an estimate of the Q-statement configuration "characteristic" of participants that load significantly onto each factor (presented in the original response scale −5 to +5). 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.

4 | RESULTS

After full exploration of the data (Watts & Stenner, 2012), we settled on a two-factor solution, explaining 50% of the study variance, which is a result that compares well with the variance explained by other Q-studies. One of these factors was "bipolar", defined by 12 participants' Q-sorts, some of which were highly positively correlated with this factor and some of which were highly negatively correlated with this factor. Bipolar factors indicate two groups of participants who sorted their statements in almost opposite ways. In order to interpret the "viewpoint" expressed by each of these groups, the bipolar factor 1 was therefore split into two separate factors (Brown, 1980). This process resulted in the two-factor solution, becoming a three-factor solution, where factor 1a and factor 1b are highly negatively correlated (−0.72). By column, Table 1 reveals the comparative ranking of statements which exemplify each viewpoint. Table 2 identifies the sorts that

TABLE 1 The factor arrays. Factor Q-sort values for each statement

Statement	Factor 1a	Factor 1b	Factor 2
1. People who support ocean fertilisation haven't taken time to listen to the earth and to feel its power	1**	−4	−2
2. Using ocean fertilisation 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 fertilisation is a good idea or not	−2**	4**	1**
5. Fiddling around with our environment through ocean fertilisation goes against everything that I hold as true and dear	4**	−5**	0**
6. Iron in the ocean is a natural thing and ocean fertilisation mimics the natural rhythms of nature	−4	2**	−3
7. Carbon credits from ocean fertilisation 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 fertilisation are informed by an understanding that the natural world needs us to step back and leave it alone	1	−2**	1
9. Ocean fertilisation should not be done by private companies	0**	−3**	3**
10. We have no way of really knowing what the impact of ocean fertilisation will be	2**	−1	0
11. Ocean fertilisation will be an excuse for greater global governance	0	0	−3**
12. Ocean fertilisation 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 fertilisation is no different. At least this time we are doing it with our eyes open	−2	3**	−2
15. My feelings on ocean fertilisation 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 fertilisation would operate at is just too big	−1	−2**	0
17. My feelings on ocean fertilisation 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 fertilisation 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 fertilisation is a good example of this	−2	3**	−5
20. We need to look for more civilised and precise solutions to climate change than ocean fertilisation	3	−1**	4
21. Ocean fertilisation is unlikely to be used for the betterment of all	0*	−3**	2*
22. Ocean fertilisation is a practical response that may help us protect what we have left	−3**	3**	−1**
23. Ocean fertilisation is morally wrong	4**	−5**	−2**
24. The earth cannot cope with the burden of demands currently placed on it. No technological fix, ocean fertilisation included, will get us around that fact	−1	−2	3**
25. If ocean fertilisation appears to be having any negative impacts on the environment we can just stop doing it	−1**	5**	−4**
26. Ocean fertilisation is not dissimilar from the principle of fertilising our crops, to meet the demands of a rapidly growing global population	−1	2**	−3

(Continues)

TABLE 1 *(Continued)*

Statement	Factor 1a	Factor 1b	Factor 2
27. I hope that everyone is given the opportunity to understand the science behind ocean fertilisation, rather than it being in a small number of hands	0*	2	3
28. Rather than fertilising the oceans, humans need to learn to live within the Earth's limits	2**	0**	5**
29. The need for ocean fertilisation has been over exaggerated	−1	−3**	−1
30. Ocean fertilisation could have disastrous consequences for humanity	4*	−3**	2*
31. Ocean fertilisation 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 fertilisation is just continuing humanity's attempts to dominate and exploit nature	1	−2**	0
34. Ocean fertilisation 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 fertilisation	2	0	1
36. Decision-making on ocean fertilisation needs to come from a societal conversation about morality and human values	3	0	1
37. My feelings on ocean fertilisation 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 fertilisation, humans may be able to acquire the means of stewarding the planet through the challenge of climate change	−3	4**	−3
39. Ocean fertilisation 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 fertilisation takes humanity too far into an artificial world and away from the natural order of things	2	−2**	1
41. My feelings on ocean fertilisation 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 fertilisation will work until we try	−5**	5**	−1**
43. I think humans are perfectly smart enough to embark on ocean fertilisation	−5	1**	−4
44. Governments are failing to take climate change seriously, so citizens need to develop their own solutions, such as ocean fertilisation	−2**	1*	0*
45. Debate about ocean fertilisation is, in large part, driven by a lack of public education	0	1*	0
46. My views on ocean fertilisation 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 fertilisation to undo some of the harm we've already caused	−3	4**	−2

*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.
**Significance at $p < .01$.

were used to construct each factor and to generate the factor estimates. Table 3 offers a demographic summary of the participants whose sorts defined each factor.

4.1 | Factor interpretations

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 each factor seek to offer an interpretation of "how things must *feel* for anybody who shares this viewpoint" (Watts & Stenner, 2012, p. 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 in square brackets within the text e.g., "[18]".

TABLE 2 Factor matrix indicating defining sorts

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

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 $p < .01$ level, shown in bold) 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 (cf. Watts & Stenner, 2012). At the 99% confidence level, 19 out of the 26 participants load significantly onto only one factor.

TABLE 3 A demographic summary of the participants whose sorts defined each factor

Factor	Title	Significantly loading participants[a]	HSRC affiliates:non-affiliates	Ethnicity Haida: non-Haida	Gender Male: female
1a	Ocean fertilisation is morally wrong. We need to preserve the natural order	$n = 5$	0:5	4:1	2:3
1b	Ocean fertilisation 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 fertilisation is very risky	$n = 7$	0:7	0:7	5:2

[a]Participants with confounded sorts are not included within the number of significantly loading participants.

The factor interpretations that follow draw out key differences in accounts of the desirability and feasibility of OF from the HSRC case study. The factors invoke 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, about what matters, what is desirable, and equally, what should be avoided. The emergence of the bipolar factor hints at how deeply entrenched some of these competing values and perspectives may be. Factor 1a offers an interpretation of OF which sees humans overstepping their place in the natural order and intruding into realms in which they do not belong [18]. 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]. 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 [43] and of natural systems themselves [28].

The factor interpretations also highlight a number of Q-statements that were ranked similarly across the factors but which, within the factors' entire configuration of statements, signal more subtle differences in perspectives (Brown, 1980). An enduring notion of "environmental stewardship" and a general sense of human responsibility for supporting the health and wellbeing of the environment, for example, pervades all three factors [e.g., 41]. This imbued most participants with a strong commitment to their particular prescription for the role of OF and often reflected a feeling of connection to, and dependence on, the earth and other forms of life [e.g., 15]. Statement 37 – "my feelings on ocean fertilisation 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. Yet analysis reveals differences in understandings of this statement across factors. For factor 1a, statement 37 speaks 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] and an inherent natural order threatened by OF [18]. Meanwhile, for factor 1b and factor 2, this statement has 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.

A general role for scientific enquiry in decision-making about geoengineering is similarly described by each of the factors, yet again the nature of that role varies 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. This factor describes the scientific method as the *only* route through which reliable knowledge about the desirability and feasibility of OF can be attained [4]. Factor 2, meanwhile, offers a more cautious and sceptical interpretation of the potential of the scientific method [3], while factor 1a sees scientific knowledge as one form of truth among many and positions science alongside different forms of cultural, spiritual, moral and experiential knowledge [36]. By distilling these distinct viewpoints and offering an interpretation of where key commonalities and differences between perspectives lie, Q has proven a useful means of putting different geoengineering "stories in conversation" (Buck, 2010, p. 9).

4.1.1 | Factor 1a: Ocean fertilisation is morally wrong. We need to preserve the natural order

Five participants' Q-sorts (P2, P4, P8, P11, P19) load significantly onto only this factor. Four out of these five participants identify as ethnic Haida. However, the results do not suggest this perspective is uniquely Haida. Including P11, three non-Haida participants also load significantly onto factor 1a; although two of these sorts are confounded, also loading significantly onto factor 2.

Factor 1a expresses a commitment to the idea that the world has an inherent "natural order" (cf. Castree, 2005), and that by "fiddling around" with the environment through OF humans risk overstepping their place in this order [5, 38, 33]. Whether "nature" is revered simply for "nature"s' sake, or understood as divine creation, deep ecology values are emphasised, which afford inherent value to the "integrity" of the natural order itself [2, 5, 30, 23]. OF meanwhile is humans "playing God" [18] (cf. Fleming, 2007; Hamilton, 2011). "The creator didn't put us here to diddle around with what he'd made perfect in the beginning", P4 explained. Intentionality in human agency itself forms a basis to these objections. "I don't agree with this, because we are manipulating it", responded P8, while P11 argued that "[OF] is another step" [14] (cf. Jamieson, 1996). For factor 1a, OF therefore risks bringing humans into a fundamentally "artificial" relationship with nature [2, 6, 40] (cf. Carr et al., 2012; Clingerman, 2014; Corner et al., 2013; Elliott, 1997; McKibben, 2003 [1989]; Sandler, 2012).

In this viewpoint, there is no potential for communities such as Old Massett to benefit from OF [7] since OF is unrealistic [22, 43, 16], morally wrong [23, 5, 38] and likely to produce severe irreversible consequences [22, 30, 25]. "We can't manage natural systems. Whenever we try, it's a hopeless disaster … It's not up to us", P4 explained. Indeed, this

viewpoint holds that the earth has its own untameable power [1] – or even agency – and could "fight back" in response to OF, as punishment of human hubris [13, 33, 23] (cf. Corner et al., 2013; Macnaghten & Szerszynski, 2013). P2 explained:

> Everything that we learn here in Haida Gwaii from our cultural teachings, is that 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.

P19 similarly noted: "after the story [of the HSRC] broke ... that's when we started [getting] earthquakes here ... you don't call them acts of God for no reason". As illustrated here, this viewpoint highlights the importance of instinct, experiential knowledge and moral reasoning in geoengineering decision-making [13, 36] and resists the positivist assumption that science on OF is policy prescriptive [4]. For Factor 1a, there is no need to live the "global social experiment" (Macnaghten & Szerszynski, 2013, p. 465), since we can know that OF will not work in advance of deployment [42, 39, 22]. "It's in our instincts and our culture. And reasoning and morality can tell us that as well" (P2).

Drawing on local experiences of colonial subjugation and disempowerment, this viewpoint also expresses concern about the potential for OF to " [put] the power of altering global climate conditions into the hands of a few" (P11) [11]. "These global people have no idea how we feel on Haida Gwaii but they go ahead and make decisions for us anyway. Like the decision to take all our children away from us in the late 1800s", P4 explained. OF "shouldn't be done by anybody" (P11) this viewpoint denotes. But it especially should not be done by private companies [9], which are driven by profit [35] rather than by the interests of all [21] and who might "buy the right to pollute" (P19) [34]. Climate change is very serious [29, 44], but it will not be solved through a "quick-fix" like OF [32, 17]. Instead, redress will only be possible through humility and preservationist commitments to live within the Earth's limits [28, 47, 46, 8]. We need to "make people return to the fact that they are only part of the earth ... we are not greater... [and we need to work] in union with all things that are of this Earth" this viewpoint attests.

4.1.2 | Factor 1b: Ocean fertilisation 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 only this factor. Five of these participants were, or had been, affiliates of, or employed by, the HSRC.

In contrast to factor 1a, factor 1b rejects the idea that the human race just needs to learn to live within the Earth's limits [28, 47]. "That train has sailed", P1 explained [44] (cf. Anshelm & Hansson, 2014; Bellamy et al., 2012; Nerlich & Jaspal, 2012). Ideas of a "natural order" and of "playing God" are similarly dismissed as irrational and hypocritical [40, 5, 8, 46, 33]. "One could apply this [idea] to almost anything we do, our agriculture, our medicine, our energy sources" P26 noted. "I am all about managing. There are no natural systems left ...", P1 explained [14]. Instead, alongside transformation of our energy and economic systems [34], factor 1b attests that we need immediate, and practical, solutions to climate change to meet the needs of humanity [26] and to undo some of the harm we've already caused [47, 29, 17, 39]. The viewpoint therefore calls for immediate application of the scientific method to assess the potential of OF [22]. "I am not a screaming crying preservationist and conservationist ... [what] I want to know is how do we make this planet work for us", P24 explained.

Notions of OF as a potential tool for the "protection", "restoration" and "development" of natural resources were prevalent within this viewpoint. Some participants loading onto this factor suggested that OF may offer humans the opportunity for redemption, to take responsibility for the harm they have caused the environment and to help bring the Earth back to health [22, 39] (c.f. Leopold, 1986 [1933]; Monbiot, 2013; Nerlich & Jaspal, 2012). Both of the Haida participants that loaded significantly onto this factor constructed accounts of OF that reflected some of these ideas, conceptualising OF as "giving back" to the environment. "Coming from a First Nation's perspective, we are stewards of the land ... In a sense, [through OF] we're just giving [the ocean] what it need[s]" (P5) [41, 37]. At other times, however, factor 1b positioned exploration of OF within broader human innovation and technological development trajectories and among technologies that have expanded the frontiers of modern society in response to increasing resource pressures (cf. Porter & Hulme, 2013). In this way, factor 1b is effectively advocating the "good Anthropocene" (Revkin, 2014) by making natural systems work harder, to ultimately make the world a better place (cf. Boyd et al., 2001). For factor 1b, OF is therefore not dissimilar to fertilising terrestrial crops, to help meet the demands of a rapidly growing global population [26].

In all its variants, this viewpoint constructs a powerful sense of human responsibility for our collective trajectory (Lynas, 2011), affording humans responsibility for technological innovation, to steward the planet through the challenge of climate change and to support the wellbeing of future populations [24, 21, 9]. Interest in OF is premised on an account of classic techno-optimism that assumes that humans are a powerful, creative force that, with the right investment and resourcing, have capacity to innovate and develop the means of overcoming environmental challenges like climate change [32, 24, 13, 43, 1]. At the very least, it assumes assessing the potential of OF is within the remit of human capabilities [4, 43] and any risks of OF can be monitored, assessed and managed by "go[ing] down the path slowly and carefully … learn[ing] every step of the way" (P10) [25, 30, 13, 10, 16, 1] (cf. Cairns & Stirling, 2014; Galarraga & Szerszynski, 2012).[8]

Alongside "political realism" narratives [44] (cf. Anshelm & Hansson, 2014), among some HSRC affiliated participants this confidence in empiricism manifested as a moral obligation to pursue OF [19, 23] (cf. Sikka, 2012):

> If you have an idea whereby you can sequester carbon [and] enhance ecosystem productivity, to not do it seems irresponsible … [there's an] obligation … to those people who are the most affected by climate change; which is [people like the Haida in Old Massett who are] poor, living in low lying areas, who get most of their food from the land or the ocean. (P24) [38]

Indeed for Factor 1b, active human management of climate and ocean systems – exercising the power of science and instrumental reason – such as through OF, is actually likely to be safer and more desirable than the impacts of unmediated greenhouse gas emissions (cf. Macnaghten & Szerszynski, 2013) [21]. "Conscious, measured manipulation of ecosystems is preferable as it requires an entity or individual to take responsibility", P24 explained. Either way, this factor employs broadly positivist rhetoric that suspends the need for normative judgement and democracy in decision-making [36, 5, 13, 1, 45, 12, 27]. Only science can tell us whether OF is a good idea or not [4] and we won't know if OF will work until we try [42].

4.1.3 | Factor 2: Climate and ocean systems are dynamic and interconnected. Ocean fertilisation is very risky

Seven participants are significantly associated with only 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 (0.59). 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 Q-sorts were also confounded between factor 1a and factor 2. Together these features imply that individuals may blend these viewpoints (Coogan & Herrington, 2011).

Participants that load significantly onto factor 2 tend to empathise with why proponents have come to express interest in OF [29]. "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", P20 explained. Yet the idea that a "quick-fix" to climate change might be found in OF is regarded as deeply suspicious [32, 22]. This reluctance to explore OF is not because OF is in some way "playing God" [18], as was described in factor 1a. Nor is "intervention in natural systems" reprehensible per se [23]. Indeed, like factor 1b, seeking to reconcile intrinsic and extrinsic values of nature [5], factor 2 is 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 (cf. Clingerman, 2014; Corner et al., 2013). Instead, for this viewpoint, objections to OF are derived from a pragmatic assessment of risk based on a cautious and sceptical interpretation of technological capacity. It emphasises uncertainties and the finitude of human knowledge [43, 24] in the face of complex and interconnected ecological systems [3].

A key condition of OF's acceptability for factor 2 is that research is able to predict and manage the impacts of implementation [4] (cf. Macnaghten & Szerszynski, 2013). Yet, based on the understanding that when humans try to affect change in one part of the system something else may be affected too [3], 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]. Since predicting the consequences of OF is very difficult – even impossible – this factor fears OF may set-off a chain of reactions and runaway impacts with ongoing consequences for humanity [25, 30, 46] (Carr et al., 2012; Clingerman, 2014; Corner et al., 2013; Porter & 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. As one interview respondent explained:

> Haida Gwaii is a good example of human created problems . . . [When] deer were introduced about 100 years ago . . . I don't think anybody had a perception of what [they] would actually end up doing in terms of how we would lose berry production; that the understory of the islands would be basically stripped clean by the deer.

Careful human management of the natural environment remains an important human responsibility for factor 2. "We live in a world where there's an ecology, where we all have our part to play", explained P16 [41, 3, 15, 37]. Yet, for this viewpoint, action should avoid "over management of natural resources" (P3) [31, 38, 20, 8] and be oriented around restructuring economic and energy systems to align with the Earth's carrying capacity [28, 34, 24]. Technological innovation meanwhile should be pursued cautiously and employ simpler and more precise approaches [20] with "known impacts" (P16) [26]. "The bigger the experiment . . . the more danger we have of making problems that we don't anticipate . . .", argued P18 [17]. Participants loading on this factor sometimes suggested "contained" (P18) (i.e., encapsulated; Bracmort & Lattanzio, 2013; see Royal Society, 2009) geoengineering approaches may therefore be preferable to unencapsulated forms of geoengineering, such as ocean fertilisation.

Factor 2 attests that OF is likely to just compound the challenges humans face from climate change. Or, in the words of P13, "put more dung on the heap". Yet, since risk mitigation is the primary agenda of this viewpoint, several significantly loading participants also suggested that under certain possible climate futures 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". As argued in factor 1a, for factor 2, whatever happens, OF should be kept out of the hands of private companies [9], where "greed prevails" (P16) and it requires rigorous democratic oversight [21, 27] (cf. Macnaghten & Szerszynski, 2013).

5 | DISCUSSION AND CONCLUSIONS

5.1 | Locally contingent perceptions of geoengineering connect with wider cultural meanings surrounding the human relationship with nature

The HSRC was a project conducted "by people in a place" (Buck, 2014). As participants completed their Q-sorts, they did not speak about geoengineering in isolation from the textures of their daily life and their wider experiences and perspectives on the world (cf. Jasanoff, 2010). Instead, the ways in which these ideas unfolded were contextually unique, embedded within local histories, geographies and attachments to the landscape and reflective of distinctive cultural, political and geographical context. Although these locally contingent meanings were abstracted by the Q-methodology process, the factor interpretations reflected all of the following: Haida oral history and cultural teachings, experiences of colonial subjugation, Old Massett's vulnerability and exposure to climate risk, recent local geophysical events and Haida Gwaii's experiences with non-native introduced species.

The precise "ways of talking" about geoengineering and the specific cultural features of "geoengineering" discourse were unique to this case study. Yet in our factors, locally specific meanings interact with familiar global discourses and interpretative resources, which have deeper roots and reflect the contested philosophical underpinnings of wider environmental management and restoration debates. The factor interpretations we have been able to construct supplement and develop 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 factors share, for example, much interpretative ground with the contested narrative of "messing with nature" identified in Corner et al.'s (2013) UK deliberative focus groups. Our factors echo Corner et al.'s analysis, for example, by making visible contested ideas about whether OF is "manageable", "fallible" or within divine control; about whether OF has the potential to support a healthy relationship between nature and society; about whether OF may solve or store up problems for future generations; about whether OF represents an (un)desirable interference in nature; and about whether OF threatens the value of nature itself.

It is an interesting finding in itself that recognisable 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 – find parallels within the analysis of this place-based experience of OF in Haida Gwaii. Geoengineering technologies have very different philosophical, ethical, risk, legal and governance profiles

(Hulme, 2014; Royal Society, 2009; Vaughan & Lenton, 2011). Yet, perhaps in light of the intentionality that is invoked with the idea of "managing the climate" in all forms, this suggests that some of the interpretative resources within the case study discourse 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 & Szerszynski, 2013).

Our factor viewpoints also have interesting interpretative overlap with other literature that has sought to characterise dominant social understandings of the relationship between nature and humanity in contemporary Western societies. Alongside development of the Integrative Worldview Framework described above, Annick De Witt (De Witt & Hedlund, 2017; De Witt et al., 2017; Hedlund-de Witt, 2013, 2014) posits a set of three ideal-typical worldview heuristics, suggested to characterise dominant Western worldview structures. Reflecting conventions of earlier research (Inglehart, 1997; O'Brien, 2009; Taylor, 1989), she labels these "traditional", "modern" and "post-modern" worldviews. De Witt then delineates a provisional interpretation of the primary assumptions, themes and concerns of each of these ideal-typical worldviews, which she structures through the Integrative Worldview Framework lenses of "ontology", "epistemology", "axiology", "anthropology" and "societal vision", detailed above. These heuristics are designed to offer only "sweeping generalisations of the complexities and ambiguities of reality" (Hedlund-de Witt, 2014, p. 8316) and are presented as neither exhaustive nor definitive. Yet De Witt's work suggests that these ideal-typical worldviews may shape pro-environmental attitudes and sustainable lifestyle choices (Hedlund-de Witt, 2013), as well as dominant social responses to industrial biotechnology (De Witt et al., 2017). Parallels between our Q-study factors – constructed to express participants' views *vis à vis* OF – and De

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

	De Witt's "Traditional" Worldview **Factor 1a: Ocean fertilisation is morally wrong. We need to preserve the natural order**	**De Witt's "Modern" Worldview** **Factor 1b: Ocean fertilisation should be urgently explored. Through science we can respond to the challenges of climate change**	**De Witt's "Postmodern" Worldview** **Factor 2: Climate and ocean systems are dynamic and interconnected. Ocean fertilisation is very risky**
Ontology A perspective on the nature of reality	Nature as embodiment of meaningful imposed order with its own logic or agency (e.g., God's creation/Mother Nature)	Nature as instrumental resource for humanity to use. Apparent planetary limits can be overcome by technology Secular cosmology	Nature as complex and interconnected The Earth has natural limits Secular cosmology
Epistemology A perspective on how knowledge of reality can come about	Different forms of moral, experiential and religious knowledge are afforded particular value	Trust in science, technology and instrumental reasoning (Post)positivism Reality as objectively knowable	Philosophical pragmatism Systems view
Axiology A perspective on what constitutes "the good life"	Intrinsic, deep ecology values Humility Respect for tradition, community, sacrifice	Materialist-value orientation Protection of individual freedoms	Post-materialist values Social justice dimensions emphasised
Anthropology A perspective on the human identity, role and purpose	Humans subject to meaningful natural order that they must not overstep	Self-optimising human being develops and manages nature to advance human wellbeing	Humans part of natural systems and in cautious relationship to nature
Societal vision A perspective on how society should be organised and address issues	Technological intervention in nature a priori unacceptable	Technological optimism. Innovation as the pathway to progress	Techno-cautious

Constructed from the section on "Factor interpretations" and from Table 1 in De Witt et al. (2017, p. 74).

Witt's "traditional", "modern" and "post-modern" worldview heuristics are not neat, complete or consistent. However, Table 4 highlights the ontological, epistemological and axiological assumptions that find *some* interpretative salience across De Witt's three ideal-typical worldviews and our three factors.

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

Q-methodology does not aim to generalise findings to wider populations (Watts & Stenner, 2012), or to establish what proportion of these populations might identify with one factor over another (Brown, 1980). Moreover, 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's Q-sort aligned perfectly with any Q-factor. Nevertheless, as discussed, analysis of our factors has highlighted interpretative overlap with ideas enduring across geoengineering literature, other technological and environmental debates and broader Western cultural currents in human meaning-making. This emphasises that ideas of geoengineering are situated within the legacy of an expansive history and underlines that accounts of geoengineering serve as vectors for more general social and cultural anxieties, as well as issue-specific concerns and problem definitions. But it also begins to suggest that our analysis of geoengineering at the "Edge of the World" might have some value for helping to make sense of some of the ways in which geoengineering debates are constructed elsewhere.

Finely curated grand narratives hold their own potential to "close down" debate and to disempower, marginalise, exclude and oppress alternative perspectives. Yet as argued by Douglas (2003), making categories explicit may also offer the opportunity to generate heuristic insight into the seeming chaos of social reality, whilst allowing these typologies to be treated reflexively and improved upon. We therefore propose that the Q-study factor interpretations could potentially serve as useful mnemonics for helping to conceptualise more general homologies of perspective. They might also capture 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 & Hedlund, 2017).

Further research is needed to test the factors' usefulness for other geoengineering technologies, especially outside of Western contexts. The factors must also be understood as provisional orienting heuristics, rather than as some kind of comprehensive explanatory theory (Mamadouh, 1999). Nevertheless, such heuristics may 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. This may 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 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. Such orienting heuristics also have the potential to make an important contribution to existing formalised frameworks for assessing geoengineering. These typically consider only limited technocratic, risk-based metrics (Bellamy et al., 2012), overlooking the different values, meanings, rights, responsibilities, instincts and aspirations that this research suggests vie for influence in public debates about the (un)acceptability of geoengineering.

Mainstream Eurocentric approaches to management of the global environment have a long history of privileging solutions that fit within their own problem definitions (Bird Rose, 2004; Bravo, 2009; Howitt & Suchet-Pearson, 2006). Indeed, the IPCC process has not been immune to this ontological and epistemological hegemony, with interpretative, place-based and indigenous knowledges becoming particular casualties of the IPCC's epistemological framing (Beck, 2012; Bjurström & Polk, 2011; Ford et al., 2012; Hulme & Mahony, 2010). Factor 1b in this research similarly structures its own rhetorical closing down of geoengineering decision-making through the narrative of "scientific neutrality" (cf. Sikka, 2012). Yet this research suggests that geoengineering technologies are always going to be contested because they interact with the multiple and diverse ways in which people understand human nature in relation to the non-human world. This study 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, Havnen and Veland (2012, p. 48) argue that global environmental challenges like climate change "should be addressed as opportunities for decolonization". In the case of geoengineering, this can only be realised through a clearer focus on the beliefs and values that underpin different attitudes and responses towards different technologies. Such a focus would provide the opportunity for geoengineering interventions to be governed in a more creative, inclusive and equitable manner. Yet the case of the Haida Salmon Restoration Corporation shows how difficult this will be and how easy it will be for geoengineering technology deployments to perpetuate or reinforce existing asymmetrical power relations. This is a

salutary lesson given the rapidly growing attention now being given to new carbon dioxide removal technologies in light of the hugely ambitious goals of the Paris Agreement.

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NOTES

[1] The most renowned example of this is captured in the 1988 South Moresby Agreement which transformed the landscape of clear-cut logging and led to the establishment of Gwaii Haanas National Park and the 1993 Gwaii Haanas cooperative management agreement that protected around 52% of the land base of Haida Gwaii (CHN & BC, 2007).

[2] The company changed its name from "Haida Climate" to the "Haida Salmon Restoration Corporation" in 2011.

[3] The Enbridge pipeline proposal to bring oil from the tar sands in Alberta to the Pacific Northwest, and ultimately oil tankers into the waters of Haida Gwaii, is another powerful local example of this disconnect (northerngateway.ca, 2014). Enbridge has been passionately resisted on island, including through exhibits at the Haida Gwaii Museum; an animated "save our waters" music video; poster and t-shirt campaigns, which have been worn and displayed at most high-profile Haida events; statements of objection from the Council of the Haida Nation; and the removal of two hereditary chiefs' titles for supporting the proposal.

[4] "Our company draws its strength and competence from the traditional ties its people have to homes of land and sea as well as the best of modern world understanding of science and technology" the HSRC website proclaimed, for example. "We are working to achieve a state of wisdom in, with, and on behalf of the natural world and all its inhabitants … plants, animals, people, and those mythical spiritual in-betweens" (HSRC, 2013).

[5] A 7.8 magnitude earthquake struck Haida Gwaii shortly after news of the HSRC broke in international media (Bird & Lamontagne, 2015). No major injury was reported as a result of the quake, but it was linked with the islands prized hot springs drying up.

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

[7] The number of Q-statements used must balance statistical criteria, with the ability for participants to construct a personally meaningful representation of their point of view, within a reasonable timeframe (Watts & Stenner, 2012; Webler et al., 2007) (see Appendix S1).

[8] This dynamic in the HSRC's experiment was captured by an interview respondent: "Doing what we did in an Eddy, which spins like a washing machine, you can watch it, you can see [the plankton bloom]. You know what it's doing, you know where it's going. Which means a lot more control … It doesn't hurt to try something that seems measurable and calculated. It was a calculated risk … What went on was very controlled".

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.
Appendix S1. The Q-methodology research design.

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