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Imagined futures : narrative fiction and climate science (Exegisis only)

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Southern Cross University School of Arts and Social Sciences

IMAGINED FUTURES

NARRATIVE FICTION AND CLIMATE SCIENCE

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Thesis Declaration

I certify that the work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text, and that the material has not been submitted, either in whole or in part, for a degree at this or any other university.

I acknowledge that I have read and understood the University's rules, requirements, procedures and policy relating to my higher degree research award and to my thesis. I certify that I have complied with the rules, requirements, procedures and policy of the University (as they may be from time to time).

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Date: 11 February, 2019

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ABSTRACT

Imagined Futures: Narrative Fiction and Climate Science is a practice-led research project that investigates the question: Is creative writing in the form of narrative fiction a legitimate mode for communication of climate science? It addresses this question by exploring the theoretical, ethical, and novelistic choices, issues and dilemmas encountered in setting a fictional story in a realistic future changed in ways predicted by climate science.

Climate change is often described as a 'wicked problem' (Rittel & Webber 1973). The term is used in a wide variety of disciplines to describe problems that are ill-defined and dynamic. Addressing climate change requires meaningful public engagement with climate science, but science communication is, in itself, a compounding wicked problem. One of the ways that research suggests for solving wicked problems is to use 'forward reasoning' to construct scenarios, in narrative form, based on thinking through plausible future plot lines (Bernstein et al. 2000). Cli-fi (Bloom 2013) is a term coined to refer to an emerging field of literature concerned with creating imaginings of a climate-changed world. By linking facts into an engaging, coherent and personally meaningful narrative, cli-fi may be able to contribute to addressing the compounded wicked problem of climate science communication

Imagined Futures: Narrative Fiction and Climate Science consists of *Warming,* a 35,000 word excerpt from a realist near-future cli-fi novel, and an accompanying 15,000 word exegesis.

Warming aims to personalize climate change by imaginatively exploring how fictional characters experience it. It aims to investigate, through practice-led inquiry, the novelistic issues in world-building and storytelling near-future, realist cli-fi. The exegesis locates *Warming* within the emerging field of climate fiction and reviews research about the efficacy of narrative as a mode of science communication. It then discusses the applicability of a practice-led creative writing methodology to the research question, and goes on to critically reflect on practice through the lens of four strands of issues at the intersection of narrative fiction and climate science communication that were encountered in writing *Warming*. It reflects on the representational challenge presented by the scale and impersonality of climate change, the difficulties in fictional world-building when the process is constrained by scientific realism, the tension between the modelling of climate science and the storyteller's desire for dramatic detail, and the ethical issues in rhetorical use of narrative fiction.

Through critical reflection, it is argued that cli-fi, particularly in the role of climate science communication, presents its own, unique set of dilemmas for the literary imagination, overlaid on the creative and technical challenges in writing any kind of literary fiction.

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Introduction

There is scientific consensus that anthropogenic global warming has already profoundly changed our world, and that the change will amplify (Cook et al. 2016). This research project began with a question: I wonder what life will be like in this climate-changed world? It sparked a series of follow-on questions: What practical skills, assets and relationships, and what attitudes of mind will be relevant? Will it change what it means to be human, to be a good human? Is it possible to really imagine it, with the dense reality of a novel? Would that imagining be pure fabulation, a story that fits best in a science fiction or fantasy genre, or could it, like a good work of historical fiction, bring facts to life?

Imagined Futures: Narrative Fiction and Climate Science is an attempt to answer these questions. It aims to investigate, through practice-led research, the issues and dilemmas in writing narrative fiction that brings the facts of climate science to life. Creative writing as a practice-led research methodology was chosen to allow a two-pronged approach to the research question: through practice, resulting in the novel extract *Warming* as an artefact, and through reflection-in-action documented in this exegesis. This reflection-in-action aimed to capture the issues and dilemmas as they were

encountered, reflecting on the theoretical, creative, and practical thought processes that informed the process, and explicating the tacit knowledge used to suggest and test solutions along the way.

Rationale and Context

The United Nations Secretary-General calls climate change 'quite simply, an existential threat for most life on the planet – including, and especially, the life of humankind' (Guterres 2018). Climate change is so pivotal that the Anthropocene Working Group, advising the International Commission of Stratigraphy, says that it is a compelling argument that our planet has entered a new geological epoch (Waters et al. 2016). Several writers struggling to find adequate terms to describe the Anthropocene refer to it as changing 'everything' (Brooker 2018; Finn 2015; Klein 2015; Szeman 2017). For example, author Naomi Klein says 'the thing about a crisis this big, this all-encompassing, is that it changes everything' (2015, p. 28). Margaret Atwood uses similar language: 'I think calling it climate change is rather limiting. I would rather call it the everything change' (cited in Finn 2015, para. 10). Jane Rawson says climate change is 'part of everything now' (cited in Brooker 2018). Szeman remarks that avoiding catastrophic climate change 'would require changing everything' (2017, p. 63).

Hamilton goes further, to argue that the Anthropocene is 'ontologically distinct'(2017, p. 32). He argues that is not simply a large set of disruptions to the natural environment, but a qualitative change to the 'Earth System' (2017, pp. 11–31), with Earth System capitalised as a proper noun to emphasise that it is a single, integrated entity.

Moreover, he argues that this change to the Earth System 'expresses human will' (2017, p. 32), and therefore human questions of intention and responsibility, ethics, blame and conscience are relevant (ibid.). This makes the existential threat posed by the Anthropocene a tragedy in the classical, literary sense (Aristotle. 1965, p. 48) – a calamity brought on not by blind forces but by a protagonist's fatal flaw or error.

The Emerging Field of Cli-fi

With an existential threat of this magnitude, you might expect an outpouring of arts of all kinds, including literature. This change has, however, as Hamilton suggests, 'come upon us with disorienting speed' (2017, p. 7). Cultural researchers have lagged well behind physical scientists in trying to understand its implications (Haunschild, Bornmann & Marx 2016, fig. 2). Arts practitioners have only recently begun to create imaginings of a climate-changed world. In 2014, Hollo and Rimmer (p. 2) remarked upon the scarcity of artistic representations of climate change. David (2016, p. 14) found relatively little reference to it in literary ecocriticism, and suggested the reason was that fiction relating to the theme was concentrated in genre and science fiction. Novelist Amitav Ghosh claimed 'climate change has a much smaller presence in contemporary literary fiction than it does even in public discussion' (2016, p. 1).

A survey of the field shows that this is rapidly changing (Fernandes 2016). Milkoreit, Martinez and Eschrich discuss the emergence of a cultural movement based around climate change, a 'social and cultural phenomenon' (2016, pp. xiv–xv) that includes climate fiction. Johns-Putra refers to an emerging 'canon of climate change

literature' (2016, p. 267). In 2013, journalist Dan Bloom coined the term 'cli-fi' to describe the burgeoning field of fiction about anthropogenic climate change. By 2017, Leikam and Leyda were able to suggest that cli-fi had transitioned from a 'subcultural colloquialism' to 'a cultural buzzword and staple academic term' (2017, para. 1).

Cli-fi has also diversified beyond the 'clichéd, post-apocalyptic and hero-orientated disaster narratives' (2016, p. ii) that David found, into realist and literary fiction. It has spawned into other fields, such as solarpunk (Flynn 2014), slipstream (Michael 2017), and weird fiction (VanderMeer & VanderMeer 2008). Cli-fi is shifting, in the space of a few years, from being a minor sub-genre of science fiction to being touted to become 'one of the dominant forms of twenty-first century literature' (Thornber 2016, p. 256).

However, Trexler argues that despite the increasing quantity and range of climate fiction, its engagement with climate science is still contingent (2015, p. 65). Atwood describes science fiction, speculative fiction and realist fiction as forming a spectrum without easily defined genre boundaries (2012, pp. 2–8). At one end of this spectrum would sit far-future post-apocalyptic cli-fi novels such as Sam J Miller's *Blackfish City* (2018), Cory Doctorow's *Walkaway* (2017), or Margaret Atwood's *Oryx and Crake* (2003), in which writers freely imagine whatever changes to physical reality and human culture their plot requires. Trexler claims that climate change fiction has been concentrated at this end and that 'scientific knowledge is discarded, ignored, exaggerated, reimagined, and counterinterpreted, for narrative, imaginative, and political reasons' (2015, p. 65).

At the other end of the spectrum are novels such as Barbara Kingsolver's *Flight Behavior* (2012), Ashley Shelby's *South Pole Station* (Shelby 2017a), and Richard Powers' *The Overstory* (2018), that are set in a realistic world, warming simply because it is. Author Kim Stanley Robinson calls these novels 'the realism of our time' (2016, p. ix). Shelby (2017b) introduces the term 'first impact fiction' to describe realist cli-fi that aims to counter the impression that climate fiction is 'merely sci-fi' (ibid.) by providing a view of imminent climate change in a world that is eerily familiar.

Book critic Kathryn Schulz observes that cli-fi is 'displaying a distinct migratory pattern – farther from genre fiction and closer to realism; backward in time from the future and ever closer to the present' (2015, para. 34). In its move towards realism, cli-fi is encountering the constraints of realist representation of climate science, and of its role, intended or not, as climate science communication.

The Wicked Problem of Climate Science Communication

Climate science communication is a 'wicked problem' with so many strands that the term 'super wicked' was coined by Lazarus in 2009 to refer to it (p. 1159). 'Wicked problem' is a term introduced by Rittel and Weber in 1973 to refer to a problem that is not logico-analytical in structure, but ecological. A wicked problem is, according to their definition, entangled with values and perceptions. It has multiple competing formulations of both the problem and the desired solution, and feedback loops that cause the problem definition to be constantly in a state of flux (Rittel & Webber 1973).

Climate change, and how to respond to it, is often used as a classic case of a wicked problem (eg. Australian Public Service Commission 2012; FitzGibbon & Mensah 2012; Garnaut 2008; Head 2014). Haraway (2016) uses Dempster's (2000) concept of 'sympoietic systems' in her discussion of how to understand and respond to the 'damaged but still ongoing living worlds, like the planet earth and its denizens in current times being called the Anthropocene' (p. 33). Sympoietic systems are, in Dempster's terms, 'homeorhetic, evolutionary, distributively controlled, unpredictable and adaptive' (2000, p. 1), which is a very apt description of a wicked problem. In contrast, autopoetic systems are logico-analytical in structure – 'homeostatic, development oriented, centrally controlled, predictable and efficient' (ibid.).

Wicked problems suffer from the availability heuristic (Tversky & Kahneman 1974), in that it is difficult to imagine their outcome, and this very difficulty in bringing an imagining to mind reduces the estimation of their frequency, likelihood and risk (Spratt & Dunlop 2018). Normally, to aid in imagining we have stories built on history and experience, both real and fictional. However, Chakrabarty argues that we can no longer assume that 'past, present, and future are connected by a certain continuity of human experience' (2009, p. 197). If climate change truly is historically discontinuous, as Chakrabarty contends (ibid.), and ontologically distinct as Hamilton contends (2017, p. 32), then it is a wicked problem without historical analogues to aid in imagining it.

If the singular nature of climate change is one problem, the difficulty in communicating science is another that compounds it. Science communication can itself be seen as a wicked problem (Jamieson, Kahan & Scheufele 2017, p. 463). This is due, in part, to 'the complex grammar of science' (Avraamidou & Osborne 2009, p. 1687), with

its 'cumulative discourse and long apprenticeship' (ibid., p. 1684). This model of science communication sees science as having its own language and literacy mastered through long study, and sees the public as 'a body that needs to be educated' (Pearce et al. 2015, p. 619).

However, this 'science deficit' model has been challenged (eg. Kahan 2013, pp. 3–5; Nisbet & Scheufele 2009; Pearce et al. 2015). Research suggests that successful science communication in general (not just climate science communication) has more to do with engagement and resonance with personal experience than it has to do with science literacy (Druckman 2015). The wicked problem of science communication is, therefore, also in part due to the difficulty of reframing knowledge from within disciplinary literacy of science, so that it engages and resonates with the personal experiences of heterogeneous audiences.

Bernstein et al. (2000) suggest an epistemology for considering wicked problems that recognises their ecological structure. They propose a methodology that uses 'forward reasoning' to construct scenarios – stories, narratives – based on plausible future plot lines, that explore a constellation of contingent future outcomes. This epistemology is supported by both theoretical and empirical research into science communication that demonstrates the value of narrative in building engagement and resonance (eg. Dahlstrom 2014; Downs 2014; Krzywinski & Cairo 2013; Niederdeppe et al. 2012). Science writer Jon Christensen succinctly concludes: 'Numbers numb and stories stick' (2017, para. 23).

Climate science communicators are increasingly responding to this research. Citing a large group of studies, Moser claims that storytelling and narrative are now seen by science communication experts as a better way to convey climate change (2016, p.

350). Until recently, climate science communication has focused on presenting complex data in a format that is intelligible to lay persons, rather than presenting images and stories of the human experience of climate change (Wang et al. 2018). As Andersen says, 'nowhere in the reports that IPCC has been publishing for the last 25 years does one find characters forced to live in the future living conditions sketched' (2014, para. 2). Stoknes reviews the literature on the psychology of science communication and argues that successful climate science communication requires a radically altered approach (2014, p. 168). He argues that it needs to change from a model that relies on providing information, to one that relies on psychological engagement and involvement (ibid.). Although Pearce et al. claim that 'climate change remains haunted by a deficit model approach to science communication' (2015, p. 615), climate science communicators increasingly aim to use methods that are 'narrative, interpretive, and even contemplative' (Moser 2016, p. 361).

This approach describes what arts practitioners, in particular creative writers, do best, and suggests the possibility of a role for creative writing in climate science communication. *Imagined Futures: Narrative Fiction and Climate Science* aims to use a practice-led research methodology to explore the overlap between near-future cli-fi at the realist end of the spectrum, and climate science communication at the storytelling end, and to investigate whether, in the overlap, there is a legitimate role for narrative fiction in communicating climate science.

This exegesis firstly discusses the choice of a practice-led creative writing methodology to investigate the research question, and outlines the framework for reflective practice. The four sections that follow critically reflect on the four major

strands of issues encountered at the intersection of narrative fiction and climate science

communication.

A Practice-led Creative Writing Methodology

Several methodologies have been used to explore the relationship between narrative fiction and climate science communication. Eco-critical analysis of the emerging field of cli-fi literature, for example by Trexler (2015), Johns-Putra (2015, 2016), Kerridge (2013) and David (2016), examines and critiques the use of climate science to inform works of fiction. Philosophy of science theorists such as Haraway (2016), Wark (2017), Hamilton (2017) and Morton (2016) discuss the use of storytelling in communicating climate science.

Practice-led creative writing as a research methodology, however, offers particular advantages in enabling a reflective, exploratory, experiential encounter with the research question. It also responds to the research, discussed in the last section, characterising climate science communication as a doubly compounded wicked problem, and the 'forward reasoning' methodology suggested by Bernstein et al. (2000) for addressing it.

Frayling differentiates between three different kinds of practice-led research in creative art: research *into* art, research *through* art, and research *for* art (1993, p. 5 [original emphasis]). Milech and Schilo (2004) adopt a similar framework in differentiating three models for the role of an exegesis as part of a creative writing thesis: the exegesis as context for the creative work, as commentary on it, and as a separate but closely related interrogation of the same research question.

Imagined Futures does involve research *into* art: it includes study and experimentation with the tools and practice of creative writing, especially as it relates to

narrative fiction. It also involves research *for* art: the process of world-building for near-future cli-fi is heavily grounded in climate science research. However, the project is primarily practice-led research *through* art. The process of writing is performative of the research. The creative component and the exegetical component are, in Milech and Schilo's terms, '*independent answers to the same research question'* (2004 [original emphasis]).

A seminal article by Richardson (1998) explores the use of writing practice as a research method – that is, writing used not simply as a method of reporting the outcome of inquiry, but as a method for conducting the inquiry itself. Richardson argues that, in a postmodern, poststructuralist context, creative writing can be a valid way to investigate a research question. It can interrogate a research question imaginatively through characterization, metaphor, analogy, and the process of following the logic of a storyline, yielding insights that are no less useful for being partial, situational and reflexive.

Creative Writing as a Double-Edged Thought Experiment

The research question posed here asks whether cli-fi is, or can be, a legitimate mode for communication of climate science. Elgin provides a philosophical clue:

> Just as thought experiments are fictions in science, works of fiction are thought experiments in art. Both are vehicles for exploration and discovery, providing contexts in which features may be demarcated, their interplay examined, their implications drawn out (1993, p. 26).

This describes a process very like the 'forward reasoning' methodology advocated by Bernstein et al (2000) for solving wicked problems. Bernstein and his colleagues suggest drawing a scenario based on known facts, then creatively devising a plot to work

out how the scenario may evolve: 'Plots have their own logic – sometimes more than one logic – that drive the story forward and suggest the directions in which the uncertainties may resolve' (ibid., p. 56). Dinmore describes a similar role played by the historical novel in historiography: 'the historical novel can act as a "simulacrum" of the world of the past, a speculative "thought-experiment"' (2014, p. 21).

The method used in this practice-led enquiry, then, is to use creative writing practice as a 'forward reasoning' methodology, constructing a thought experiment in both cli-fi and climate science communication at the same time. The thought experiment is in the form of a novel set in a future world, changed in the way modelled by climate science, that explores the human experience of a climate-changed future. The research aims to encounter and explicate the problems for a cli-fi author cum science communicator in doing so.

Schön's (1983) description of how professionals routinely engage in practice-led research provides a model for constructing such an experiment. He describes an iterative process of 'reflection-in-action' in which the practitioner 'shapes the situation in accordance with his initial appreciation of it, the situation 'talks back', and he responds to the situation's back-talk' (ibid., p. 79). As Schön describes the process, the 'shaping' is, in his terms, 'artistic' (ibid., p. 130). The fields of action research (Winter & Burroughs 1989) and research through design (Godin & Zahedi 2014) use this same model.

In all these fields, progress follows a similar pathway. The researcher uses tacit knowledge drawn from a repertoire of images, experience, examples, reading, reflection and imagination to initially frame a problem and suggest solutions. Reflective practice is used to test solutions and evaluate outcomes, which are then used to reframe, or to refine

the problem framing. Scrivener (2000, p. 6) describes this process of identifying and

solving emergent problems in the process of creating an artefact, as the defining

characteristic of practice-led research.

If I apply this model to the practice of creative writing, a 'design' for a story

world, plot and characters that intuitively seem likely to be true to life is drafted.

Continuous reflective practice is then used to iteratively test against Schön's criteria of

coherence, congruence, and the ability to further the exploration of the theme (1983, p.

135). This reflective practice guides a process of 'nosing forward', drafting and redrafting

episodes to avoid implausible storylines, so that the plot resolves in a way that is coherent

and that illuminates themes. Goodall describes this method in action:

> How many times did I literally write myself into a corner? Sometimes by
> putting a character into a situation I couldn't see the way out of,
> sometimes by setting off tension lines that refused to merge as I had
> originally envisaged, sometimes by trapping the action line into a logical
> impossibility (2009, p. 202).

For the purposes of answering my research question, it is necessary to test

whether the thought experiment is coherent and congruent from both perspectives –

narrative fiction and science communication – concurrently. From the narrative fiction

perspective, the test is whether the story has verisimilitude (both external and narrative

realism), and whether it engages readers to imaginatively enter its story world. From the

science communication perspective, the test is whether the story succeeds in making

climate change accessible to human imagination without losing its veracity.

The process of conducting the 'thought experiment' is what Frayling might

describe as a 'practical experiment in the studios' (1993, p. 5), and the novel extract is

thus an 'artefact' in which the thinking is embodied. The exegesis that accompanies the

creative work is a record of the reflection-in-action and its tests for coherence, congruence, and potential for furthering design refinement. It explicates the theoretical, ethical, and novelistic choices, issues and dilemmas encountered, and the considerations and reasoning behind the choices made in resolving them.

A Framework for Reflective Practice

Warming began with a question: I wonder what life will be like in a climate-changed world? This initial problem frame quickly evolved into wondering if creative writing was a way to attempt to imagine it, and from there into wondering what the issues would be in doing so, in attempting to write a cli-fi novel that truthfully represented climate science. This process of reframing followed the process described by Schön: 'The unique and uncertain situation comes to be understood through the attempt to change it, and changed through the attempt to understand it' (1983, p.132). The problem is initially ill-defined and fluid, and the first task of the researcher is to use research, experience, analogy, and imagination to suggest problem frames, discarding them one after another until one offers a potential way forward.

Ideas for the initial problem framing came from diverse sources – experience, reading, conversations, documentaries, images and imagination. From that point, the process followed a path that resembled Schön's (1983) description of practice-led research, and Bernstein and his colleague's (2000) description of forward reasoning, and Stephen King's description of his creative writing practice (2014). In all these, 'you go where the story leads you' (ibid.).

As *Warming* developed, four sets of issues, or strands, emerged. Even as they emerged, my reading of climate science research, research about science communication, ecocritical literature and other works of fiction, my conversations, first hand experience, exposure to media and art, and a myriad of other sources of tacit knowledge, were interacting to suggest ways to approach the problem. Schön (1983) refers to this dialogue between the knowledge drawn from, and knowledge brought to, the interaction with the artefact as defining practice-led research. As he says, the researcher attempts to develop a useful way of framing a problem using 'an overarching theory, an appreciative system, and a stance of reflection-in-action' (ibid., p. 164).

At first the four sets of issues seemed inextricably intertwined, a single undifferentiated wicked problem. As the work developed they became more distinct, but it was only retrospectively that, as King (2012, pp. 200-208) suggests, they could be identified as seams running through the creative work, that could be uncovered and their implications teased out. Once they emerged, these strands provided a useful framework for critically reflecting on the questions and concepts raised. The following sections of this exegesis discuss each of these four strands in turn.

The first section – Human Stories – explores the strand of personalization, that is, the issues to do with intimacy and scale encountered in writing *Warming*. It reflects on the challenge in creating characters with whom readers can empathize, while working on a canvas big enough to portray a change in geological epoch.

The second section – True Stories – discusses the issue of truth and fictionality, that is, the consistencies and contradictions between the scientific concept of objective truth and the literary concept of verisimilitude. It reflects on the challenges in navigating

between the competing aims of setting the story in a scientifically-valid, climate-changed future, and creating characters and imagery that are specific, detailed, true-to-life and believable.

The third section – Engaging Stories – discusses narrative engagement, that is, the issues encountered in writing *Warming* to do with making an exciting and dramatic story within the spatiotemporal span and the probability-based projections of climate change. It reflects on the problem of constructing credible plot lines and generating dramatic tension in the context of means, modes, and millennia, and the challenge of bringing the abstract down to earth and endowing it with immediacy.

The fourth section – Hopeful Stories – discusses the theme of hope and despair, that is, the ethics and artistry of using fiction for rhetorical purpose. It explores the problem of creating writing that is honest and fresh, when climate science projects apocalyptic scenarios that are both disturbing, and that evoke the worn trope of a sandwich-board proclaiming that the end of the world is nigh.

Section 1: Human Stories

The first strand framing this reflective practice is located at the intersection between science communication theories about the value in personalizing messages, and novelistic theories about character development and transportation. It concerns the role of empathy with fictional characters in enabling readers to imagine different states of being. The object of *Warming*, in relation to this strand, was to 'personalize and concretize climate change, opening space for readers to dwell with its large, complex realities' (Siperstein 2016, p. 153).

According to deictic shift theory, transportation is a phenomenological process (Segal 2012). Readers don't just read 'about' stories, they 'get inside of stories and vicariously experience them' (ibid., p. 15). Ian McEwan describes it in the following way:

> If you saw the novel as I do in terms of being an exploration of human nature – an investigation of the human condition – then the main tool of that investigation has to be to demonstrate, to somehow give you, on the page, the sensual 'felt' feeling of what it is to be someone else (2002, para. 8).

The challenge for a cli-fi novel is to transport readers into the 'felt feeling' of a climate-changed world. It is to create fiction that 'walks them through an inner space that is hard to traverse' (Morton 2013, p. 184). This requires creation of characters that readers care about, living through challenges that they can imagine.

In a cli-fi novel, the setting is not incidental. In climate fiction, the macro physical, ecological, social and political environment is what drives events, even if it is

only inferred in the text. Novelist Amitav Ghosh says that in his cli-fi, he writes not only about the experience of characters, but 'about what is there, the geology, the deep time that exists outside the individual, and the immediacy of time, and the times that make up every aspect of the circumstance' (cited in Kumar 2007, p. 103).

Climate science does not easily lend itself to depicting 'times' for characters to live through that are imaginable – the scale is too big, the timeframe too long, the change too unprecedented (Morton 2013). Morton coined the term 'hyperobjects' as a way of describing 'objects' like climate change that are very real, but too 'massively distributed in time and space' (ibid., p. 1) to be directly perceived by humans.

Author James Bradley argues that the novelistic desire to 'make sense of events' (2010, para. 13) does violence to the scale and incomprehensibility of the hyperobject. He claims that 'the things social realist novels are good at – characters, narrative, interiority, social context – are hopelessly inadequate when it comes to something like climate change' (2010, para. 12).

The challenge in writing *Warming* then, was to imaginatively explore how its characters experience and understand the hyperobject of climate change, when all they can directly experience is fragments, external to their sphere of influence but powerfully present.

The Problem of Agency

Realist character-driven novels assume characters have individual agency, within the scope allowed by a realistic story world, and plot outcomes are the result of their

actions (Barthes & Duisit 1975, pp. 256–260; Cohan & Shires 2003, p. 69). This introduces questions of morality into a narrative, because characters are responsible for the outcomes of their decisions (Norris et al. 2005, p. 543). However, this subjective focus on actions and motivations is at odds with the collective agency that is the defining characteristic of the Anthropocene.

Many authors (eg. Bonneuil & Fressoz 2017; Haraway 2016; Hecht 2018; Malm & Hornborg 2014; Moore 2016) would argue against Ford's claim that agency in the Anthropocene is 'an agency operating at the universal level of the human species as a whole – a super-subject beyond all possible subjective experience' (2013, p. 65). Among other contentions, they raise the question of 'who the 'we' are that bear both the historic responsibility and the brunt of the uneven impacts of contemporary environmental crises' (Lane 2018). Nevertheless, they agree that, as Donna Haraway argues, that the concept of 'bounded utilitarian individualism' (2016, p. 49) is an 'old' one (ibid), that is not useful to climate change stories.

Cli-fi has indeed struggled with this issue. Kerridge (2013, p. 361), in his eco-critical review of climate fiction, found that, even in heroic fantasy, cli-fi authors struggle to give characters agency. Latour speaks of 'the total disconnect between the range, nature, and scale of the phenomena and the set of emotions, habits of thoughts, and feelings that would be necessary to handle those crises' (2011, p. 2).

A solution suggested for realist fiction is to explore 'macro concepts via micro moments' (Michael 2017, p. 3), telling the story of one small set of characters as they experience climate change, as it presents in their world. Néle Azevedo (2013) creates this imagery in her public art installations of tiny ice sculptures of people, placed on steps and

ledges in urban landscapes – small, short-lived figures made of very ordinary stuff exposed to the Anthropocene. Literary critic Kerryn Goldsworthy recommends this kind of approach: 'what an excellent near-future/climate-change novel could be made of that, if the writer focused on the daily life of half a dozen families and their behaviour in the face of events' (2010). She quotes novelist and war correspondent Martha Gellhorn: 'War happens to people, one at a time' (ibid., final para.).

Following this advice, *Warming* was first drafted as the hero's journey (Vogler 2007) of a young woman called Zanna as she lived through 'everything change' in her own world. The intention was to explore the macro concept of how a climate changed world might be experienced, through the micro story of how one character experiences it. When a cyclone washes away her home and separates Zanna from her community, she crosses a threshold into a different kind of world (ibid., p. 127). The intention was for this different kind of world to evoke, for a reader, a sense of being vaulted into the macro story of a strange and hostile future. This approach, however, failed to prove satisfying, and with reflective practice leading, the work was redrafted.

The foregrounding of Zanna's experience of a cyclone weakened the focus on climate change. It presented the story in a disaster genre, as being about a hero's journey through a single, natural, extreme weather event. The imagining of climate change as a disaster story was at odds with, and displaced the more difficult task of imagining an Earth System in crisis.

Many theorists use the term 'uncanny' in reference to cli-fi, arguing that it should evoke not a sense of recognition, but a sense of trying to grasp the unimaginable (Andersen 2016; Bradley 2015b; Friedman 2007; Marshall 2015, p. 95; Michael 2017;

Morton 2013, p. 147; Vescovi 2017; Wark 2017). Cli-fi shares with sci-fi this character of being '*the literature of cognitive estrangement*' (Suvin 1979, p. 15 [original emphasis]). While disaster is shocking, the genre of disaster fiction is a familiar one with established genre markers (Meyhoff 2012), and so it defies this sense of weirding. Although disaster fiction may feature large scale destruction (ibid., p. 306), this is different to the scale, both spatial and temporal, and the preternatural signs of planetary regime shift. We have seen disaster before.

In his review of cli-fi movies and mini-series in terms of their value in climate science communication, Murphy concluded that '[t]he weakest are those that most contribute to a sense of a singular disaster, while the strongest are the ones that present a sense of systemic change and catastrophe' (2014, p. 47). My reflections bore this out. Ghosh's novel *The Hungry Tide* (2005), for example, contains a graphic and deeply engaging imagining of the experience of a cyclone in the Sunderban islands of the Ganges delta. This is a part of the world that is extremely vulnerable, in climate change, to exactly this (Mahadevia Ghimire & Vikas 2012). However, the novel can be read entirely within the frame of a disaster story, a story about extreme weather, without invoking climate change at all.

My reflections led me to try widening the story from a single disaster to a world where the climate is treacherous and estranging on many fronts. Many fronts required an ensemble of characters. Like Néle Azevedo's (2013) ice sculptures, the characters in *Warming* are ill-equipped to face a warming world. Individually they experience only tiny fragments of the hyperobject, but *Warming* aimed, by collecting their micro moments into one story, to create an imaginary of the macro concept.

Once again, however, the approach proved unsatisfying. In my reflection, climate change did not have this fractal quality, in which micro moments stand effectively for macro concepts. It is instead scattered, heterogeneous, emergent. The hyperobject of climate change, seemed too large and diffuse a setting even for several, heroes' journeys. Le Guin claims that she came to writing science fiction 'lugging this great heavy sack of stuff, my carrier bag full of wimps and klutzes' (1989a, p. 169), and that 'in it, as in all fiction, there is room enough to keep even Man where he belongs, in his place in the scheme of things' (ibid). Haraway, following her, argues that climate change literature cannot be written as a hero's journey, but must be written within a feminist ontology using 'material-semiotic netbags of little use in trials of strength' (2016, p. 43). This argument resonated, and in the third redrafting, climate change was present as a thing too large and diffuse for characters to feel any sense of individual agency in regard to it.

While providing characters with agency in relation to climate change was problematic, far less so was exploring the paradox this exposes: humans create the eco-catastrophe that they will have to live with, but these particular humans can't see anything they can do about it, and we can understand and empathize with their situation and put ourselves in their shoes. In *Warming*, all the major characters and many of the minor ones struggle with this messy, paradoxical sense of guilt and responsibility mixed with impotence.

The character Zanna, in Byron Bay, is a young adult who has grown up in full knowledge of climate change. She has a vague sense of guilt that drives her to make gestures, such as paying for carbon offsets for flights, although she suspects it is greenwashing (p. 6), or deciding to participate in a gas mining protest march, but then

failing to follow through (pp. 46-47). However, she is unable to translate that guilt into purposeful action. She sees her only real option as 'pulling your head in and hoping it would all leave you alone' (p. 36).

Zanna's sister Kat characterizes herself as an 'eco-warrior' but mocks her neighbour's climate disaster warnings and preparation (p. 12). Their father Phil sets the air conditioning in his home relatively high (p. 16), but not with any aim of reducing greenhouse gas emissions. None of the major characters participate in any political process, or demonstrate any sense of potency as political actors or any faith that political leadership will solve climate change.

A sense of impotence to act on more than a personal scale is a recurring motif. When Zanna is confronted with the enormity of the task of cleaning up after the cyclone, and the lack of political or collective leadership to parcel out roles, she is paralysed, and chooses a small, immediate, personal task instead (p. 107). Her father Phil hopes that some authority will sort out the crisis soon but shows no interest in how they might go about it (p. 118).

The Problem of Scale

Widening the story from a single disaster in a single geographic location, to a world with a planet-wide treacherous climate, created a different set of problems. Whereas the story of a singular disaster can be told from one point of view, in an individual human timespan, the story of climate change spans continents and millennia.

This makes point-of-view an issue, and presents challenges in maintaining engagement and intimacy with characters.

Cli-fi movies often use the form of an ensemble cast and episodic structure. Leyda et al. (2016, p. 18) propose that this is a response to this issue of spatial and temporal scale. Bradley, in his cli-fi novel *Clade* (2015a) explored use of bricolage as a way to embrace the scale and scope of climate change. *Clade* is structured as loosely linked short stories spanning multiple generations, disasters, continents and events. Climate change is present in the form of species extinctions, refugees, floods, epidemics, and technological and biological adaptation, not all at once but spread over multiple stories spanning several generations.

This form captures a sense of the enormity of climate change, but even so, it remains necessarily a keyhole view. Realist fiction is written from a limited, interior perspective, and is necessarily socially partial, the world as seen through the eyes of a limited set of characters who are socially and geographically located in particular and specific places, times, and worldviews. Even a bricolage of stories is not representative of the spectrum of human experiences and perspectives, and, at the same time, risks sacrificing intimacy and empathetic engagement with characters. One review of *Clade*, for example, remarks upon 'the thinness of the social world' (Pierce 2015), and another that '[i]f the landscapes are vivid, the characters are sometimes less so' (Lucy 2015).

In *Warming*, multiple diffuse references are used with the intention of creating an imaginary of a spectrum of extreme events consistent with the predictions of climate science (Cramer et al. 2014). Reference is made, for example to 'countries that scarcely had time to draw breath between disasters' (p. 3), a deadly heat wave in Iran (p. 4), rising

sea levels and storm surges impacting property (p. 6), a war over water between India and Bangladesh (p. 6), a drought and a heat wave in Brazil (p. 9), wildlife extinctions (p. 12), regular heat warning days in Victoria (p. 14), refugees from equatorial countries (p. 16), the disappearance of the Great Barrier Reef (p. 18), crop failures (p 19), flooding in California (p. 20), a polar vortex in China (p. 25), bushfires in Melbourne (p. 38) and a cyclone farther south than normal (p. 69).

In 2012, the leading climate activist organisation, 350.org, staged a performative event called 'Connect the Dots' (McKibben 2012). They asked people around the world to create a 'dot' to geographically mark a personal experience of extreme weather connected with climate change, with the aim of enabling these experiences to be perceived not as isolated events but as part of a pattern. The characters in *Warming* have this kind of personal experience at first or second hand, but cannot connect the story's geographically separated dots. Within their lives, these events are encountered in idiosyncratic personal frames. However, as Norris et al say, '[g]enre knowledge helps readers anticipate and interpret text and helps shape their perspective on events and their focus on what is likely to be significant and salient' (2005, p. 544). The intention was that, for the reader of *Warming*, genre knowledge would create a climate change frame in which all these isolated events are given salience. It invites the reader to connect the dots and perceive the character-driven micro stories in the context of a larger story..

Besides geographic scale, climate change also spans a temporal scale that is at odds with the temporal scale of cause and consequence in conventional narrative. Research converges on the finding that people generally, at least in Western societies, imagine only a generation into the future (O'Neill & Nicholson-Cole 2009, p. 361).

Climate change, in contrast, is 'seriously backloaded' (Gardiner 2006, p. 15.3), that is, impacts created in current timeframes will be temporally dispersed over thousands, even hundreds of thousands of years. Imagining, and engaging with the ethical responsibility of a character for actions that will have an effect into future deep time is inconsistent with this limited temporal horizon.

One way that the Anthropocene time scale is humanized is through the use of the trope of the child. James Bradley, for example, begins his cli-fi novel *Clade* (2015a) with the story of a couple attempting to conceive through IVF, which allows him to explore the issue of responsibility to future generations through the device of characters making a very thought-out decision. Claire Vaye Watkins' novel *Gold Fame Citrus* (2015) is the story of a couple setting off on a journey into an unknown and dangerous future with responsibility for a stolen child. In Cormac McCarthy's *The Road* (2007) the father says to his son, 'My job is to take care of you' (ibid., p. 80).

The trope of the child is, however, loaded with meanings that can complicate a simple rendering of time scale. From a deep ecology perspective, it is critiqued as anthropocentric, suggesting privileging of future generations of humans over non-human nature (Haraway 2016). From a feminist perspective, it carries ecomaternalist connotations of equating maternal care for a child with care for 'nature' (Johns-Putra 2014). From the perspective of queer theorists, use of the trope of the child to explore human ethics in the Anthropocene has been criticized as 'reproductive futurism', as suggesting that heterosexual family reproduction is the source of ethics and care for the planet (Edelman 2004; Leyda 2016, p. 15; Sheldon 2016).

Despite these multiple meanings, Johns-Putra argues that the figure of the child in cli-fi serves both as a trigger for caring about this distant time, evoking an emotional connection, and as a way to critically reflect on the meaning of that caring (2017, p. 11). She contends that novels provide readers with the space for a nuanced imagining that can contemplate multiple meanings, a space 'to think as well as to feel their way around the notion of responsibility to the future' (2017, p. 18).

Characters in *Warming* engage with the trope of the child as a way of considering future time in a very diverse range of ways. All the major characters make individually distinctive decisions. Kat and Sophie decide to try to conceive a child, a decision that is taken very consciously since, as a lesbian couple they will need to take active steps to conceive (p. 42). Sophie mourns the fact that their child will not have the same opportunities and experiences as her own generation, including the experience of sharing the planet with the same wondrous diversity of other species (p. 43). Kaseeb's parents have made enormous personal sacrifices to secure a future for their family, but Kaseeb chooses to remain childless (p. 42). Phil and Maureen must decide whether to give up their economic security to join their daughters (p. 26). Doobie recognises bronzed baby shoes as symbolising hopes for a child never realised (p. 102).

Embedded in these decisions are various answers to Haraway's question 'What is decolonial feminist reproductive freedom in a dangerously troubled multispecies world?' (2016, p. 6). Although it is not explicit, climate change – the state of the Earth System, their ethical responsibility for it, and their capacity to influence or adapt – is a critical factor in the decision making for characters in *Warming*. The diversity of their engagement with the trope of the child aims to create an open-ended imaginary of our

relationship with future beings, a space for contemplation rather than an answer. It aims to allow readers, through empathetic engagement with characters, to imagine, in human terms, the effects predicted by climate science modelling, beyond our own lifetimes.

Section 2: True Stories

The second strand framing this reflective practice is to do with the relationship between scientific truth, credibility and realism. The object of *Warming*, in relation to this strand, was to get the science right, to make the fictional world-building consistent with the modelling of climate science with all its complexity and abstraction, and, at the same time, to make it 'ring true'.

In realist fiction, there is a contract with the reader that while the characters and events may be fiction, the story is set in a world that operates on the same principles as empirical reality. As Ursula Le Guin puts it, '[t]he ploy of the whole realistic genre is to put invented characters into a framework of reproduced actuality – imaginary toads in a real garden' (2004, p. 96). Near-future cli-fi problematizes this contract. The nature of the shared reality in that 'real garden' is not straightforward in philosophy of science, and even less so in near-future cli-fi built on scientific projection rather than observation (Latour 2004).

At the same time, because the empirical reality of climate change is unprecedented, personal recognition of the experience is not available as a mechanism to help it 'ring true'. Suvin introduced the term 'novum' (1979, p. 79) to refer to an invented 'new thing' driving a science fiction narrative. In this context, climate change is simultaneously a cognitively estranging, science fiction-like novum, and a mimetic description of a strange but true material reality.

Narrative psychologist Jerome Bruner differentiates between scientific truth established through formal and empirical proof, and narrative truth established through 'verisimilitude', or a sense of being 'true to life' (1986, p. 11). For cli-fi to be a legitimate mode for communication of climate science, it must satisfy both – the requirement of realist fiction to 'ring true' and the requirement of science communication to represent evidential truth. The two criteria have a complex, reciprocal, and idiosyncratic relationship.

What makes a story 'ring true'? Frigg (2010) discusses the philosophic underpinnings that link fictional representation with empirical reality through construction of story models. He argues that readers recognise and compare situations and characters in novels with those from their own experience (ibid., p. 8). Verisimilitude is built partly on recognition. Readers recognise in a novel an experience, an emotion, a reaction, a scene, that they know first-hand. They add their real-world knowledge to the fictional information provided in the novel, to construct a mental image of a story world.

Bruner goes further and contends that within an empiricist culture, logico-scientific evidence, acquired second-hand, is also an important part of the construct (1986, p. 11). That is, along with personal experience, readers use learned knowledge about empirical reality that they cannot directly observe. Brusselle and Bilandzic (2008, p.b256) similarly argue that the reality schema of a story model is a composite of external realism (congruence with what is known about the real world) and narrative realism (plausibly explained within the story), and that violation of either will interrupt transportation.

Tan (2008) proposes a dual awareness model to explain narrative realism. In this model, people use two 'spaces' simultaneously to navigate within a story world – 'entertainment space' and 'executive space' (ibid., pp. 38-42). In 'entertainment space' readers are transported – willing to suspend disbelief and emotionally engage with the reality of the story world. In 'executive space', attention is given to the reality or unreality of the imagined events, and the realism of the story world is critically appraised: Is the story world believable? Does what is learned there transfer into 'real life'? The two spaces operate in concert with each other, heightened transportation leading to heightened appraisal of realism, and conversely lowered appraisal of realism leading to lowered transportation.

It follows, therefore, that transportation rests, in part, on recognition, or congruence with personal experience, and also, in part, on congruence with what the reader knows or believes about empirical reality. Conversely, beliefs about what is externally real are influenced by transportation, or the 'realism' of the narrative. This is particularly problematic in cli-fi because so much of what is true seems unbelievable. For a cli-fi author, it raises the dilemma that events or scenes based in scientifically accurate projections of climate science risk jerking a reader out of suspension in a transported state. Waldman (2018) notes, in her review of an Amazon collection of cli-fi short stories, that the poetics of climate change present a 'shared set of challenges' for all seven authors in the collection, one of which is 'how surreal it all seems' (ibid.).

Shelby suggests that, in readers' perception, many works of cli-fi are 'as reassuringly unlikely as androids dreaming of electric sheep in a nuclear irradiated San Francisco' (2017b). This is a reference to the 1968 novel *Do Androids Dream of Electric*

Sheep? (Dick 1968) that was made into the film *Blade Runner* (Scott 1982). Dick's novel

falls in the genre of soft sci-fi, and includes many unrealistic elements besides humanoid

robots, including Martian colonies, hovercraft and the extinction of almost all animals.

The reference implies that cli-fi shares with soft sci-fi a genre expectation of fantastic

elements. For example, that many of our coastal cities will almost certainly be inundated

by sea level rise, within the lifetime of the children growing up in them now (Nerem et al.

2018), seems so unlikely that it cannot be readily assumed that a reader will not put it in

the same category as the 'androids dreaming of electric sheep', a made-up, fantasy

element.

Compounding this sense of the surreal that surrounds climate change, the reality

schema of a storyworld incorporating climate change will also, necessarily, be based in

knowledge that is complex, qualified, abstract and contested. It will be multi-

dimensional, hedged, and full of provisos and probabilities. Climate change modelling is

more accurately expressed mathematically, in graphs and statistics and abstract,

interactive models demonstrating a range of outcomes, than in stories. The IPCC's

Climate Change 2014 Synthesis Report Summary for Policymakers, for example, has, in

its thirty-two pages, no less than seventeen detailed and information intensive graphics,

several of them taking up a full-page. (IPCC 2014b). However, the accuracy gained by

mathematical models may be obtained at the expense of engagement and resonance, a

sense of recognition and transportation. Mathematical modelling is not easy to transfer to

a narrative. As Marx et al. argue, in narrative structures, 'concepts such as relative

frequency and sample size tend to be neglected because they cannot easily be imagined

correctly' (2007, p. 48). Many climate scientists argue that the credibility of the science

depends on sustaining these qualifications and mathematical abstractions. Druckman, for example, argues that science communicators should '[e]xplicitly state the uncertainty in research' and 'present them in probabilistic terms' (2015, p. 63). Norris et al. say:

> Our conjecture is that the narrative genre is not sufficiently attuned to the requirement that scientific writing be cautious, circumspect, and tentative. […] Exposition and argumentation are adopted for good reason in science — they not only effectively carry the reasoning that connects scientific methods and data to conclusions; they also carry the precision of description demanded for replication, test, and critique (2005, p. 560).

In the introduction to *Anthropocene Fictions*, Trexler (2015) provides an example of the dilemma this poses for fiction writers. He includes an extended description of the predictions of climate science. If we look at these predictions –'will become more extreme', 'more common', 'face risks', 'is likely to', 'would likely', 'perhaps even', 'will lead to', 'will face decreased', 'will be disrupted', 'much less potential' (ibid., p. 7) – they are clear examples of writing that conforms to Norris and his colleagues' exhortation to be 'cautious, circumspect, and tentative' (2005, p. 560). Trexler's description of predictions is accurate, but not engaging or transporting or evocative.

So, the issue here is that being faithful to accuracy risks transportation, the very same transportation that is needed to counter the sense of climate change as unbelievable and surreal. Or, to put it another way, the sense of recognition on which verisimilitude rests is difficult to find within counter-intuitive, complex, abstract, equivocal and indistinct reality schemas, but reducing complex reality to concepts that can easily be imagined risks sacrificing scientific truth, alienating readers and disrupting transportation. The challenge is, as Johns-Putra puts it, 'the difficulty of translating scientific information, with all its predictive uncertainty, into something both accurate

and interesting to the average reader' (2015, para. 8). Writing *Warming* so that it met these two criteria simultaneously required using both practice-led research *for* art (Frayling 1993, p. 5 [original emphasis]) to establish accuracy, and practice-led research *through* art (ibid.) to make that accuracy interesting.

Research *for* Art

Translating scientific information into something that meets Johns-Putra's first criteria, 'accurate', required the third kind of practice-led research differentiated by Frayling and discussed earlier: 'research *for* art' (1993, p. 5 [original emphasis]). Whiteley, Chiang and Einsiedel claim that 'there are important connections between CF [climate fiction] and SF [science fiction] that allow us to discuss the former within the SF domain' (2016, p. 29). One of those important connections may be genre expectations about the standard of adherence to scientific truth. Hard science fiction is defined as literature based on 'either established or carefully extrapolated science' (Wysocki 2012 p. 9). McLeod contends that the science fiction readership is more critical and 'quick to pick up on science errors or implausibilities' (2010, p. 173) than the readership of any other type of literature, and that, because of this, science fiction authors are held to a different standard of scientific truth-telling.

The critical reception of Michael Crichton's best-selling cli-fi novel *State of Fear* (2004) demonstrates this same genre expectation applied to climate fiction. The novel was roundly condemned by many reviewers for misrepresenting facts. Trexler's critique of it is scathing. 'Despite its vast popularity, the novel is too easily dismissed as pulp

fiction, climate denial masquerading as scientific argument' (2015, p. 45). Miller's review is even more censorious: 'Crichton paints a picture of climate science that is one-sided, error-ridden, and undeserving of notice from experts in the field' (2006, p. 94).

Historical fiction, too, can share this characteristic of being held accountable to an elusive and contested 'truth', particularly historical fiction that deals with sensitive history. Australian invasion narratives (for example Kate Grenville's *The Secret River* (2006)), and Holocaust narratives (for example Amy Matthews' *End of the Night Girl* (2011)) have been taken to task for their lack of adherence to 'facts' (Clendinnen 2006; Doetschman 2011). If we substitute the word 'scientist' for 'historian', and 'scientific' for 'historical', then Brown's analysis of the distinction between history and historical fiction could easily describe the distinction between climate science and cli-fi.

> The historian's approach is necessarily broader, examining historical complexities in greater depth and using digressions and footnotes to qualify and explain. Novelists, on the other hand, forego the expansive canvas that historians use in order to create clear characterizations and forward-moving plot lines […] A danger, for the novelist, lies in achieving that objective at the expense of excluding significant nuances and complexities (1998, para. 9).

So, for example, in *Warming*, the character Kat refers to 'a drought and a heat wave in Brazil that killed off a quarter of the world's coffee bushes in one bad month' (p. 9). The character Phil wonders whether to 'treat themselves to the last of the coffee' (p. 15). Research *for* art means establishing that coffee is a crop that is vulnerable in a climate-changed future. For *Warming* to function as legitimate climate science communication, every aspect of the world-building required this kind of research. What temperature could a heat wave in Melbourne be expected to reach? How vulnerable

would the cherry industry be to reduced chill factor? What effect will global warming

have on cyclones, on polar vortexes, on El Niño?

This kind of research is challenging, not only because of the aforementioned

'highly nominalised vocabulary' (Avraamidou & Osborne 2009, p. 1687), but also

because none of these questions is 'settled science' (Mills 2015) with a simple, easily

footnoted, authoritative answer. Part of the disciplinary literacy of science is mastery of

reading strategies that appraise sources, follow scientific debate, make sense of

competing claims, and judge the standard of evidence (Cook & Dinkins 2015, p. 4).

Nevertheless, this kind of research is familiar to novelists. Historical novelists too

must appraise sources, follow disciplinary debate and make sense of competing claims to

build an authentic story world. More distinctive, problematic, and also important, is the

issue of dealing with 'predictive uncertainty' (Johns-Putra 2015, para. 8). The IPCC's

Guidance Note on framing uncertainty has a seven-point scale, from 'virtually certain' to

'exceptionally unlikely' (Mastrandrea et al. 2011, p. 3). A key dilemma encountered in

writing *Warming* was the need to make a judgement as to what point in that scale a

prediction becomes 'factual' enough to be included in fictional world-building, while still

having the fictional world show 'real' climate science. This is a question with no

definitive answer, and, adding to the dilemma, sources other than the IPCC do not

include any such helpful guide.

Blackadder (2013, pp. 81–82) suggests that writers of historical fiction

increasingly use paratextual additions to acknowledge sources and discuss degrees and

levels of fictionality. White refers to historical facts established by '(professionally

determined) admissable [sic] evidence'(2005, p. 148). This technique is not commonly

used in cli-fi, and there are barriers to using it. In climate science, professionally

determined admissible evidence is contested and controversial (Tol 2017). Braun says of

the IPCC, for example, 'pressing questions arise about what counts as expertise and how

and by whom knowledge is constructed, stabilized, trusted, or contested' (2015, p. 240).

Crichton's cli-fi novel *State of Fear* (2004) was extensively footnoted in order to

create an impression of scientific authenticity, but the footnotes were exactly what was

most galling to many reviewers. Slovic, for example, says that '[w]hat is particularly

egregious about Crichton's novel is how it trespasses on the territory of scientific

discourse' (2008, p. 107), echoing Clendinnen's (2006) critique of Grenville's trespass on

the territory of historical discourse in her historical novel *The Secret River* (2006).

Blackadder describes historical fiction as 'dangerous territory where truth and fiction

mingle, opening up the potential for conflict and transgression' (2013, p. 74), and the

same description could equally be applied to cli-fi. As historian Tom Griffiths says, 'The

stakes are high' (2009, p. 74.9).

Research *through* Art

Meeting the second of Johns-Putra's criteria, translating scientific information,

into writing that is 'interesting to the average reader' (2015, para. 8), involves practice-

led research of Frayling's second kind: research *through* art (1993, p. 5 [original

emphasis]). This is research conducted through the process of creative writing itself. In

writing *Warming*, it meant exploring ways to embed the scientific information necessary

to the plot, and to the climate science communication function, in the narration, without long passages of exposition.

The challenge here is that, while scientific truth requires that the facts of climate change in the story world are right, verisimilitude requires that what the characters know or think about them is not right. The main characters in *Warming* are not climate scientists. Climate change, told from their point of view, is not climate science communication.

In his discussion of reliable, unreliable and deficient narration, Phelan (2017) examines the tension between the two purposes of character narration – 'the character narrator's telling functions and her character functions' (2017, p. 95) – that is between narration designed to tell the story and narration designed to reveal the character. In *Warming*, in relation to the climate science, these two functions are at odds.

The characters in *Warming* share a characteristic common in the general public of their time, and of ours, of seeing the science as impenetrable, uncertain, and of no use to them in living their daily lives. Therefore, they pay scant attention to it and have only a hazy understanding. Their terminology is incorrect. They cannot assess the credibility of reports and express doubt and uncertainty. Without instruments and records, they cannot perceive statistical anomalies, so they cannot separate the local effects of climate change from normal variability. Zanna, for example, wonders 'how bad was meat and dairy compared to a cut-price ticket on a flight to Melbourne?' (p 6). She knows that '[s]omewhere there would be a calculator' (ibid.) but she never answers the question, for herself or for the reader. Phil says, 'It was supposed to be supposed to be two degrees hotter than it ever used to be' (p. 15) but adds 'so they said' (ibid.). Narration supporting

the character functions of the main characters in *Warming* required that, if they were to ring true, they must be unreliable narrators of climate science.

Unreliable narration is generally used in fiction to increase a reader's sense of estrangement from a character (Phelan 2017, p. 94). However, Phelan notes that 'authors have also found ways to use unreliable narration to decrease distance of one or more kinds' (ibid.). He refers to 'bonding unreliability' (Phelan 2007, p. 225) in which 'the discrepancies between the narrator's reports, interpretations, or evaluations and the inferences of the authorial audience have the paradoxical result of reducing the interpretive, affective, or ethical distance between the narrator and the authorial audience' (ibid.).

In *Warming*, unreliable narration was used to help make characters more realistic in having only a sketchy, unsure and flawed understanding of climate science, and human in being abashed or defensive about it. Its purpose, therefore, was to increase empathetic engagement and thus decrease affective distance. In my reflections, I also considered the possibility that it could affect ethical distance, causing readers consider their own alignment with characters on the ethics of paying scant attention to climate science.

At the same time though, for *Warming* to function as legitimate climate science communication, it is not enough that the reader shares and identifies with the characters' befuddlement. In order for the characters in *Warming* to ring true, they must be unreliable narrators, but if their explication of hazy climate science stands unchallenged, then the novel fails as science communication. The unreliable narration in *Warming* needed to simultaneously decrease affective distance, and increase interpretive distance, allowing readers to understand facts and events in a different frame to characters.

Phelan argues that, when characters in a work of narrative fiction narrate a story, the implied author is using 'a single text to address at least two different audiences (her own and the character narrator's narratee) to accomplish at least two different purposes (her own and the character narrator's)'(2017, p. 95). To function as legitimate climate science communication, character narration in *Warming* had to tell an informed and accurate climate science story to the authorial audience (the imagined reader), and a different, naïve and sketchy story to the narrative audience (the audience within the story world).

Some cli-fi authors have tried to solve this problem by having scientists as characters, disguising exposition in dialogue. Barbara Kingsolver, for example, in her novel *Flight Behavior* (2012), uses the device of characters who are scientists explaining the science to naïve characters. Kim Stanley Robinson in his *Science In The Capital* Trilogy (2015) uses a similar device. However, these characters are difficult to fully realise and the device is very visible.

In *Warming*, I have instead experimented with overcoming the problem by crowdsourcing knowledge, that is, by gleaning the science in tiny increments from multiple sources within the story world. As an example of this strategy, climate science predicts that heat waves in the Middle East, particularly in the area along the Arabian Gulf coast, will become so severe as to make the region uninhabitable (Lelieveld et al. 2016; Pal & Eltahir 2015). The character Phil grew up in Cairns and travelled through the Middle East as a young adult, so he can refer to his own experience to imagine a heat wave there (p. 16). His daughter Zanna envies him the adventure but the heat wave has made travel to the area impossible for her generation (p. 4). A German backpacker at

Zanna's dinner party talks about how heat wave refugees with enough money for visas have overrun universities in Europe (p. 34). Zanna's mother, Maureen, refers to refugees pushing up property prices in Melbourne (p. 25).

None of the characters in *Warming* is well informed about climate science and the vulnerability of the Arabian Gulf coast to deadly heat waves, but all of these characters have diverse personal reasons for having an interest in, and knowledge of different aspects of it. They each have snippets of information and a plot-driven context to refer to it. Their narration performs 'character functions' (Phelan 2017, p. 95). However, in the process they collectively tell and corroborate a climate change story, weaving the science into a story world, achieving the 'telling functions' (ibid.) of character narration in tiny increments.

Section 3: Engaging Stories

The third strand framing this reflective practice concerns detail and specificity. It considers the issues in creating an absorbing plotline from a panoply of possibilities and probabilities, many of them distant in time and place.

Science gains its predictive power from generalisability (Campbell & Stanley 1963, p. 17). Narrative fiction though prefers 'particular occurrences involving particular actors at a particular place and time' (Norris et al. 2005, p. 545), that is, events that are distinctive and proximate. Moffett for example, says: 'The essence of story is once upon a time. Once. Unique and unrepeatable events—not "recurring" events, as in science' (1968, p. 121).

Rigby (2011, p. 68) gives an example of the lack of power that non-specific predictions have to move us. She discusses the data about the rate of extinctions predicted by climate science and says 'I suspect that, for most of us, such bland talk of biodiversity loss is too abstract to truly engage our hearts and minds' (ibid.). By comparison, Barbara Kingsolver, in her novel *Flight Behavior*, includes an imagining of the extinction of just one species, the Monarch butterfly.

> After the storm on Tuesday Ovid had told her they were still on the trees up there, a few million butterflies frozen onto the branches beneath a covering of snow. […] Survival wasn't possible, he said, given the mortality under that snow. It would take a crowd of variations and mistakes and resilience, at least a million individuals, he thought, to add up to survival of a species (2012, p. 421).

Warming needed, therefore, to vividly imagine specific events and episodes, but to function as climate science communication, these events could not be cherry-picked for dramatic plot purposes, but must also legitimately represent the science. Exemplification theory provided a theoretical basis for plot decisions.

Exemplification Theory

Exemplification theory (Elgin 2010) provides a theoretical basis for choosing detail that is both scientifically valid and also specific enough to be woven into a story. Elgin defines an exemplar as 'a telling instance of the features it exemplifies. It presents those features in a context contrived to render them salient' (1993, p. 17). Kingsolver's Monarch butterfly, then, can be considered an exemplar of the kind of species extinction predicted by climate science.

An instance that is a good exemplar is, however, not necessarily an instance that increases dramatic tension in a plot. Dahlstrom (2014) discusses how writers of mass media fictional stories with science themes routinely use 'flexible realism' or 'fictional conceit' (2014, p. 13617). They choose instances that are dramatic over instances that are good exemplars, for example, by using worst-case scenarios or by using 'facts' that are possible (and exciting) but not necessarily probable.

By contrast, Kingsolver (2012) privileges scientific accuracy over dramatic impact. It would increase the dramatic tension for her characters to witness the death of the very last butterfly but she chooses a more scientifically accurate scenario. Some

thousands of butterflies survive, there is another population, the extinction will be long and slow and due to loss of genetic diversity. It is a better exemplar.

The challenge for *Warming*, then, was to choose as a plot device an exemplar of the hyperobject of climate change, that was both based in legitimate science, and proximate and dramatic enough to provide momentum for a story. A tipping point was a candidate for such a device.

Tipping Points and Critical Thresholds

The most recent *Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC 2014a) provides an example that illustrates some of the difficulties in storifying climate change. The report projects that, given the medium emission scenario of representative concentration pathway (RCP) 4.5, global mean sea level rise in the period through to 2065 is very likely to be 0.25 metres (Wong et al. 2014, p. 369). There are multiple problems for a fiction writer in basing a story on this.

Besides the obvious one of decoding the specialist language in terms like 'medium emission scenario', 'representative concentration pathway', and 'global mean sea level rise', there is the problem that it is not particularly exciting or dramatic. The timeframe is too long; the threat to characters is not proximate enough to generate suspense and engagement. The predicted rise is not specific; there are nested uncertainties in both scale and place. The threat is not severe and dramatic enough to cause readers to care deeply about how characters deal with it.

Climate science projects a panoply of consequences like this – sea level rise, extreme weather, crop failure, species extinction, ocean acidification, new diseases and pathogens, each of them an example of 'long emergencies of slow violence' (Nixon 2011, p. 3). The *Fifth Assessment Report* from the Intergovernmental Panel on Climate Change (IPCC 2014a) divides them into separate chapters, which tends to further separate the consequences into a multitude of small effects. Taken individually, they tell a story that is confusing and hard to comprehend, slow and attritional, without focus or impetus. As Macfarlane says, 'it presents the literary imagination with a series of difficulties: how to dramatise aggregating detail, how to plot slow change' (2005, para. 10).

But if, as Clive Hamilton says, climate change represents a 'qualitative leap from disturbances of ecosystems to disruption of the Earth System' (2017, p. 17), then what is lacking is a weaving of all these separate but interdependent quantitative effects into a systemic, qualitative change. The representational challenge is to portray them as facets of a whole, a planet-scale hyperobject, rather than discrete local events.

Zalasiewicz et al. refer to a 'substantial elapsed (and in part irreversible) change to the Earth System' (2017, p. 206). Like Zalasiewicz et al., Hamilton puts the term 'Earth System' in capital letters to emphasize 'the qualitative leap' (2017, p. 17) from isolated (if prolific) disturbances to ecosystems, to reconfiguration of the singular, integrated physical and biochemical makeup of the planet. The Earth System is more poetically called Gaia (Lovelock 1972), but the term 'Earth System', importantly, references the field of systems theory (Bertalanffy 2003) which describes the way systems of all kinds transition from one stable state to another through large, abrupt

changes known as regime shifts (Scheffer 2009). It raises the spectre of abrupt, sweeping change to an entirely new kind of planet. In climate science, the concept of this kind of qualitative change is captured in the concept of a tipping point. A tipping point in Earth System science is a point where 'a small additional 'forcing' or 'nudge' takes a complex system abruptly into a qualitatively different state' (O'Riordan, Lenton & Christie 2013, p. 6).

The term 'tipping point', though, like 'Anthropocene', has moved beyond its etymology to acquire metaphoric as well as literal meaning. It has migrated out of systems theory to poetics. The term has come to mean crossing a critical threshold, beyond which the inbuilt resilience of any system – physical, ecological, psychological or socio-economic – fails, and it becomes unstable or uncontrollable (Carleton & Hsiang 2016, p. aad9837-11).

The motif of a tipping point resolves the problem, typifying climate change, of 'very small, conventionally trivial actions and immense consequences, a relationship that obscures the scale on which moral consciousness and narrative normally operate' (Kerridge 2013, p. 352). It provides the frame that amalgamates them into a coherent threat at an engaging scale. The story then becomes one of a cascade of socio-economic and environmental shocks that create a sudden, systemic, qualitative change to the characters' world. Kim Stanley Robinson credits his discovery of tipping points as the keystone that allowed him to write the *Science in the Capital* trilogy. It allowed him a plot device that was 'very possible, very huge in its ramifications, and a story that did not span centuries, which was something I wanted to avoid in that story' (cited in Rohn 2007).

Warming makes use of this motif of a tipping point. It considers 'what if', on top of underlying vulnerability created by climate change, several extreme weather events at once, some close and personally experienced by characters and some distant, precipitate a socio-economic tipping point. So for Zanna, the cyclone that hits Byron Bay and washes away her home and her livelihood and separates her from her friends and community, is not an isolated disaster but a tipping point. The cyclone is part of a constellation of eco-catastrophes that includes bushfire and drought in Australia and storms and blizzards in the northern hemisphere, and that together constitute the 'nudge' that precipitates an economic and political tipping point.

Up till this point Zanna has been living in a world that is not dramatically altered, but feels insecure and unstable. The term 'uncanny' is widely used to describe the 'shifting sands' feel of a world made unfamiliar by climate change (eg. Andersen 2016; Bradley 2015b; Friedman 2007; Marshall 2015, p. 95; Michael 2017; Morton 2013, p. 147; Vescovi 2017; Wark 2017). It is echoed in the term 'global weirding' (Friedman 2007). Disasters are elsewhere, unimaginable, and not totally believable. Zanna is not at first perturbed. She expects that, as always before, government and service providers will repair disaster damage and she will return to her familiar patterns. She is a victim of the blindness that Scheffer et al. note: 'It is notably hard to predict such critical transitions, because the state of the system may show little change before the tipping point is reached' (2009, p. 53).

However, although there is research about tipping points in the world economic system (Burke, Hsiang & Miguel 2015; Keen 2017; Kompas, Ha & Che 2018; Korowicz 2012), predicting them does not have the same level of confidence or consensus as the

physical science of global warming. Modelling of economic tipping points does not include a seven-point scale from 'virtually certain' to 'exceptionally unlikely' as does the IPCC's *Guidance Note* on framing uncertainty in physical modelling (Mastrandrea et al. 2011, p. 3). This predictive uncertainty adds another layer to the problem of exemplification discussed at the beginning of this section. It raises the question: just how probable does a scenario need to be to qualify as a good exemplar?

In *Warming*, the tipping point motif aimed to provide a cohesive and dramatic plotline to thread through the 'systemic stories of the linked metabolisms, articulations, or coproductions (pick your metaphor) of economies and ecologies' (Haraway 2016, p. 48) that represent climate change. Its purpose was to enable the 'connection beyond an episodic or chronicled catalogue of happenings' (Worth 2004, sec. 3) that a narrative requires. However, while it solved the problem of a plot device, it also nudged the novel along a spectrum from realist towards speculative fiction.

Section 4: Hopeful Stories

The fourth theme framing this exegesis is to do with hope and despair. This discussion came into prominence with the July 9, 2017 publication of David Wallace-Wells' article 'The Uninhabitable Earth'. Within five days, this article had become the most read in the history of *New York Magazine* (Wallace-Wells 2017, para. 1), and had provoked an intense public debate, the majority of it directed not at the accuracy of the science but at the ethics and efficacy of the communication (eg. Christensen 2017; Holthaus 2017; Wilt 2017). The main thrust of the criticism was that 'it feeds a paralyzing narrative of doom and hopelessness' (Mann 2017).

Apocalyptic stories are well-used literary and artistic tropes that evoke images of Noah's ark and end times and punishment for sin (Stoknes 2014, p. 168). The literary question is whether these 'genre expectations' (Andrade 2009, p. 2) confound a fresh and unencumbered envisioning of a climate-changed world. Heer suggests that visions of apocalypse have become so pervasive that '[t]he collapse of civilization has become its own narrative cliché' (2015). The science communication question is whether it is tactically and strategically useful to evoke an 'end times' trope, to spread 'doom and gloom'. Moser, for example, concludes that one of the persistent challenges is how to avoid adding to the perception in many audiences that climate change is already beyond hope of solving (2016, p. 353).

So within this strand, the object of *Warming* was to attempt to truthfully imagine a climate-changed world without either losing engagement to overwhelm, or succumbing to overworked apocalyptic tropes.

Soft Denial and Manipulating the Message

Climate scientists concerned that the message is not being heeded, that scientific warnings are not translating into popular culture or politics, have begun paying attention to the psychology of communication, and in particular to the research finding that people turn off to messages they don't want to hear. Wibeck, for example, reviews the literature on climate change communication to find that fear-based communication is repeatedly found to be ineffective (2014, sec. 6.2.1). Donna Haraway describes climate change stories as 'too-big' and inviting 'disengaged denunciations' (2016, pp. 55–56). Rayner and Minns find that researchers in general conclude that using fear is a risky strategy in climate science communication and should be used cautiously if at all (2015, p. 13).

Dismissing dystopian stories is made easier because apocalyptic tropes are all too familiar, a 'core story in our Christian, Western culture' (Stoknes 2014, p. 168). They have archetypical weight and 'roots in ancient myths and parables' (Whiteley, Chiang & Einsiedel 2016, p. 28). Andersen makes the 'perhaps obvious epistemological point that a phenomenon such as anthropogenic global warming does not enter our consciousness in a straightforward and uncomplicated way' (2016, p. 856). As Latour points out, they invite the 'perfectly plausible argument that apocalyptic pronouncements are just as ancient as humans' (2011, p. 11), and the world has not ended yet.

The issues surrounding the audience appeal of apocalyptic storytelling are further complicated by the question of whether 'tactically and strategically useful' is a criterion that can ethically be applied to science communication at all. Is it manipulative to avoid apocalyptic stories, or is it simply attending to the cultural dimension of communication? Wallace-Wells has defended his article saying 'there is journalistic and public-interest value in spreading the news from the scientific community, no matter how unnerving it may be' (2017, para. 4). Ytterstad makes a similar claim: 'We should not label truly alarming statements alarmist' (2015, p. 15).

The closely related literary issue is whether fiction has (or should have) any rhetorical purpose, whether the efficacy or not of its message in motivating people to act in a particular way is relevant to any question of literary worth. Cli-fi reviewer Amy Brady argues that fiction has a role and social purpose in promoting climate change education and activism (Brady 2018). Novelist Ashley Shelby describes the goals of near-future cli-fi as unashamedly informative: 'By rendering a First Impact world, where readers see both the familiar and the slightly strange, we may be able to, through art and imagination, send the message that scientists and journalists have thus failed to effectively deliver' (2017, para. final). Tim Winton disagrees:

> A novel isn't a very good rhetorical tool. It poses better questions than answers. The novels with the most polemic, the most bald-face attempts to persuade, are those the reader turns away from most quickly, so instinctively. You really have to bend a story out of shape to fulfil an ideological mission. (Mitchell 2007).

One response to the research about apocalyptic climate change stories has been a rise in what some climate scientists are calling 'soft denial' (eg. Hoexter 2016; Munsch 2017), where the reality of climate change is not contested but the scale of threat is

understated in order to minimize disengagement. At the same time, literature has seen the rise of solarpunk. Solarpunk is a field or sub-genre of (variously) science fiction, fantasy, weird or realist fiction, (Williams 2018). Its stories envisage climate change as an opportunity for wholesale societal change incorporating green technology and social and political resistance (Hamilton, J 2017). With its metamodernist sensibility (Kadagishvili 2013), its positive, solution-oriented imagery and its stance of radical hope, solarpunk shares the viewpoint that 'while the future might be an overwhelming prospect, it doesn't have to be frightening, and it doesn't have to hurt' (Sylva 2015).

Lenton finds the argument that it is alarmist to discuss tipping points and their potential to cause abrupt and catastrophic climate change 'morally challenging, because as a scientist I am trained to "tell it like it is" as clearly as I can' (2013, pp. 23–24). However, while it might be the role of the scientist to 'tell it like it is' as clearly as possible, the science communicator has the additional task of trying to enable the reader to 'hear it like it is', and, as Le Guin says, 'the unread story is not a story; it is little black marks on wood pulp' (1989b, p. 198).

Narrative fiction as science communication then, must navigate the line between being acceptable enough to be read, and avoiding the propaganda of hiding the truth, however frightening. However, 'acceptable' does not necessarily mean cheerful. O'Neill and Nicholson-Cole argue that the research about the effectiveness of fear-based climate change communication consistently finds that its success depends upon a 'perceived sense of self-efficacy' (2009, p. 361) in readers. By contrast, they found that if the threat is perceived as outside their locus of control, people attempt to avoid fear by refusing to seriously engage with a text, by refusing the invitation to co-create the story (2009,

pp. 375–376). Feinberg and Willer (2011) explain this with reference to the 'just world theory'. This theory holds that individuals need to believe that their fortunes are controllable, and that they are in control, that calamity is not random and that they can keep themselves safe from harm through their personal skill, knowledge and actions (2011, p. 34). If climate change is portrayed as apocalyptic and characters are simply victims, it threatens a just world view.

The role of hope and optimism in engaging readers is of increasing interest to researchers (Moser 2016, p. 352). Rayner and Minns argue that climate science communication is most effective when communicators are not simply 'narrators of doom' (2015, p. 3), but provide stories that embody 'active hope' (ibid.). Arnold concludes that, in the interests of both truth and engagement, climate change stories must diversify from 'a steady drip of catastrophic visions' (2018) to include positive stories. Research thus suggests that stories that contain hope – that is, stories about human agency, mitigation and adaptation – are stories that will be entertained and accommodated even when the fictional world-building is based in alarming climate science.

In writing *Warming*, I did not set out to be either hopeful or alarmist. I set out simply to use the methodology of 'forward reasoning' (Bernstein et al. 2000) to construct a scenario, set within the current projections of climate science, following the internal logic of plot and character, and see where it led. The imagining of a hopeful and adaptive scenario follows artistic rather than rhetorical lines of inquiry. It is the result of answering the questions: What would happen then? How would that feel? What would they do? It follows from giving characters agency and seeing how they might try to resolve the problems that a legitimate exemplar of a climate change scenario might present to them.

However, on reflection, I find that by allowing the scenario to develop following the plot's own logic (ibid., p. 56), characters come to embody the 'active hope' that climate science communication theorists advocate.

Adaptation and Mitigation

Within the logic of the story world, the cyclone that displaces Zanna is a local manifestation of a systemic tipping point that produces a cascade of social and economic consequences across the globe. There is a breakdown in economic and social institutions that throws the characters back on their own resources, but it also creates an opening, an opportunity. In response to the crisis, the characters in *Warming* explore a large number of adaptation strategies – it is difficult to imagine people doing anything else. In their world, they are simply solving immediate personal issues of food, safety, health, transport, energy, medicine and communication. However, to do so they must adapt to a world in which familiar sources and institutions are no longer available, familiar social and political arrangements fail, and familiar relationships with the natural world are lost.

Flynn (2014) defines solarpunk as literature that explores human 'ingenuity, generativity, independence, and community' in the face of crisis, and this is what the main characters in *Warming* show. They are examples of the 'active hope' (Rayner & Minns 2015, p. 3) and 'sense of self-efficacy' (O'Neill & Nicholson-Cole 2009, p. 361) that researchers suggest make the dire messaging of climate science readable.

Albrecht coined the term 'solastalgia' to refer to the distressing sense of displacement brought about by 'transformation or destruction of the physical

environment (home) by forces that undermine a personal and community sense of identity and control' (Albrecht et al. 2007, p. 46). It is a sense of unwelcome change that brings loss of a loved place and time, along with loss of the comfort, familiarity and sense of belonging that it holds. Albrecht argues that the term can extend to include the earth as home (ibid.). The term 'solastalgia' has gained currency with reference to climate change (Watts et al. 2015) and *Warming* attempts to show characters experiencing, adapting to, and mitigating it. They worry about loved ones, make difficult decisions about child-bearing, try to figure out their personal and moral responsibility for strangers, grieve the loss of orangutans, frogs and reef, and solve the daily challenges needed to survive in a world where their familiar modes of being are disrupted.

However, at another level, these adaptive strategies are also mitigation strategies. In the process of struggling to maximise their well-being in the face of an economic crash, characters could discover for themselves the synergies between adaptation and mitigation proposed by the IPCC (Denton et al. 2014). The idea that economic collapse would have a positive effect in terms of existential climate risk is well supported by research (Obani & Gupta 2016). The close and direct relationship between greenhouse gas emissions and economic growth is modelled in the 'Shared Socioeconomic Pathways' currently being developed for the IPCC's *Sixth Assessment Report* (Riahi et al. 2017). Naomi Klein presents evidence that the collapse of the Soviet Union in the 1990s and the global financial crisis in 2008 both demonstrate a strong and direct relationship between economic collapse and a sustained and significant drop in greenhouse gas emissions (Klein & Wright 2017, p. 34).

The growing field of environmental virtue ethics (Thompson & Bendik-Keymer 2013) defines the term 'eudaimonia', meaning human flourishing or the well-lived human life, an ethical life with enough material possessions but no more (ibid., p. 10). The term breaks the nexus between the current consumption-based economic system, and well-being. It is increasingly being used in climate change contexts in the application of well-being theory to the economics of climate change mitigation (Lamb & Steinberger 2017). Importantly, Creutzig et al. use the term in their analysis of social and demand-side aspects of mitigation to be included in the next IPCC report (2018, p. 269-70). They argue that a focus on eudemonia can have a real world effect on climate change, by orienting mitigation efforts towards that definition of lowest cost options (ibid, p. 270), rather than definitions based on economic terms such as gross domestic product.

The extension of this idea that is of interest to cli-fi novelists is the effect of *imagining* eudemonia in a climate changed world. The imagining of eudemonia can, Appadurai (1996) suggests, have a real-world effect. He discusses the agency of the 'social *imaginaire*' (1996, p. 30 [original emphasis]) and argues that 'the image, the imagined, the imaginary' (ibid., p. 31) creates a 'constructed landscape of collective aspirations' (ibid.). Ilstedt and Wangel (2014) similarly argue that cultural narratives create expectations, which in turn influence where our collective social agency is directed. They argue that creating fictional worlds in which characters live eudaimonic lives could create 'positive and engaging visions of the future' (2014, p. 2). This could have a real-world effect of orienting social effort. At the same time, this positive and engaging vision might reduce the disengagement risk and help a cli-fi novel avoid Le

Guin's suggested fate of ending up as just 'little black marks on wood pulp' (1989b, p. 198).

This suggests a direction for the novel to progress, and provides a basis for believing that the Part One excerpt that is *Warming* has not ended at a dead end, that it meets Schön's criteria for successful practice-led research: coherence, congruence, and the 'perception of potentials for coherence and congruence which he can realize through his further enquiry' (1983, p. 135).

The characters in *Warming* are engaged in discovering the best version they can of eudaimonia in a climate-changed future as an adaptive strategy, but if, as this reflection-in-action suggests, it turns out that it is also a mitigation strategy, *Warming* has the potential to develop as a story of human agency and resilience rather than an apocalyptic story. As Sandilands argues, literary fiction can create imaginings of what 'mitigation and adaptation involve and feel like, and of understanding the personal, social and psychological complexity of climate change impacts' (Sandilands 2016, pp. 2–3). Imagining eudaimonia in a climate-changed world can be a story of solastalgia, despair, innovation and hope, all at once. As such, it can be a story that is neither 'soft denial' nor a prophecy of doom, but something else again.

Conclusion

In a recent interview, author James Bradley said of climate change: 'it spreads everywhere, it touches everything, it's completely unbounded' (cited in Ross & Street 2018). The word 'everything' is often used in similar contexts in relation to climate change (Atwood 2015; Brooker 2018; Hamilton, C 2017; Klein 2015; Szeman 2017). It implies a profound and confounding shift in the experience of being human. One might expect such a significant shift to be pervasive in all kinds of art and literature, as novelist Kim Stanley Robinson says, 'just to be accurate to the feel of this moment in history' (2016, p. x).

It is, therefore, surprising that the humanities and arts have been much slower than the physical sciences to engage with climate change (Haunschild, Bornmann & Marx 2016, fig. 2). Rawson suggests that, in the case of literary fiction, this is now changing. She proposes that all contemporary realist fiction is, by definition, climate fiction: 'Realist novels that don't have climate change as part of the contemporary landscape are fantasies, genre novels' (cited in Brooker 2018). However, in *Imagined Futures* I adopt Martinez's much narrower definition of climate fiction. She defines it as 'stories in which climate change was not merely a backdrop or a context, but was a powerful determiner in how characters in the story thought, acted, and configured their values' (Horton 2016, para. 9). By this definition, the field is still very much emerging (Johns-Putra 2016, p. 268).

The term cli-fi has gained currency in popular, critical, and academic contexts to refer to this kind of fiction (Leikam & Leyda 2017, para. 1). Cli-fi is famously genre-defying. Johns-Putra prefers to call it 'a topic found in many genres' (2016, p. 267). She identifies cli-fi within science fiction, dystopia, fantasy, and thriller genres, as well as realist fiction (ibid.). Within this spectrum are novels that are set in worlds very different to our own, that give scant attention to climate science (Trexler 2015, p. 65). There are also novels set in the near future, informed by scientific prediction and modelling, that attempt to imagine what life might be like in a realistic, climate-changed future (ibid.). *Imagined Futures* investigates whether this latter kind of cli-fi can be a legitimate way to communicate climate science, and what the issues are in doing so. It explores the overlap between writing creative fiction and writing science communication. It considers the commonalities and tensions in this overlap.

Imagined Futures uses a practice-led research methodology to construct a 'thought experiment' in the form of an excerpt from *Warming*, a near-future realist cli-fi novel that imaginatively explores, through world-building and storytelling, a future changed in ways modelled in the science. The process of writing the creative work is performative of the research. This exegesis uses reflection-in-action to examine the issues and dilemmas it encounters. Four frames – personalization and concretization, realism and verisimilitude, exemplification and fictional conceit, and hope and despair – emerged from the work as useful frames for reflection.

Within the first frame of personalization and concretization, the disconnect between the temporal and spatial scale of climate change, and the human scale of realist, character-driven novels emerged as a challenge. The Anthropocene reality of collective

human agency made it difficult to place the characters in *Warming* in any situation in which they could act in any way upon climate change. Kerridge's claim that 'the spatial, temporal and dimensional gap between action and consequence is too great' (2013, p. 361) rang true.

However, this exact paradox is part of our own experience of climate change: collectively we have altered the physics of a planet, and yet individually we are powerless to do anything about it (Hamilton, C 2017, p. 36). Rather than show characters acting upon climate change, *Warming* sought to invite empathetic identification with characters as they encounter this paradox, as they struggle to conceive the scale of the hyperobject that is climate change, their personal lack of agency to affect it, and their moral responsibilities to family, community, strangers, future generations, and non-humans.

Within the second frame of realism and verisimilitude, *Warming* encountered the problem of writing climate change in a way that was, at the same time, both true and believable. In order to function as both legitimate climate science communication and as a near-future realist novel, it needed to be both consistent with evidential truth, and recognizable to a reader as 'true to life'. Both of these were independently problematic, and together their problematic aspects compounded each other.

Although there is broad scientific consensus on the reality of anthropogenic climate change, there is, in scientific jargon, variance in 'confidence levels' about detailed projections (Mastrandrea et al. 2011). Modelling is not the same as observation. There are also, as in historical fiction, broad areas of specifics and detail that can only be filled with imaginings. For example, a major story element in *Warming* is a cyclone that

hits Byron Bay. There is a sound evidential base for imagining that climate change might bring about cyclones that are more intense and that track farther south than present day (Abbs 2012; Kossin, Emanuel & Vecchi 2014; Leslie et al. 2007; Ramsay 2014). However, climate science cannot predict where or when such a cyclone might occur, its intensity, its relationship to tides, the specific damage it might cause, or the amount of warning available. The boundary between 'hard fact' and 'completely made up' is necessarily fuzzy. 'Consistent with evidential truth' was therefore not a straightforward concept.

This was further problematized by the difficulty in both knowing about and imagining something as immense as climate change. Morton, writing about the difficulty in thinking about the Anthropocene, says: 'Art is thought from the future. Thought we cannot explicitly think at present. Thought we may not think or speak at all' (2016, p. 1).

Since one of the key characteristics of a hyperobject is that it is too big to be apprehended by any individual (Morton 2013), then realism required that what individual characters in *Warming* knew or believed about climate change was incomplete and unreliable. Phelan's work on 'bonding unreliability' in character narration was useful (1996, 2007, 2017) in considering how to decrease affective distance and sponsor empathetic engagement between readers and characters. At the same time, communicating climate science in this context required character narration to tell different stories to the authorial audience and the narrative audience, increasing interpretive distance between readers and characters.

Within the third theme of exemplification and fictional conceit, *Warming* encountered the problem described by Nixon: 'How do we bring home—and bring

emotionally to life—threats that take time to wreak their havoc, threats that never materialize in one spectacular, explosive, cinematic scene?' (2011, p. 14).

The basic principle of narratology is that a series of events are connected, both chronologically, and with some kind of causal, motivational, or relational linkage (Carroll 2001). Creating a plotline in cli-fi that conformed to this required a device that linked the creeping, diffuse, dispersed risks of climate change into a series of specific, coherently related, proximate events, relevant to characters. For *Warming* to also function as legitimate climate science communication, the events could not be cherry-picked just to advance the plot, but needed also to be legitimate exemplars of the science.

The motif of the tipping point provided one possible answer to the question posed by Nixon. Imagining local disasters as the local manifestation of a global socio-economic and ecological system that had reached a point of critical instability allowed characters to encounter the effects of climate change in a relatively short timeframe. It also, though, pushed the novel further towards speculative fiction and complicated genre expectations.

Finally, the creative work encountered the question of the moral responsibility of the author for the real-world effects of a work of fiction. Apocalyptic images conjure emotions such as fear, guilt, despair and disbelief that may interfere with climate science communication and paralyse decisive action to mitigate global warming (Rayner & Minns 2015, p. 13). At the same time, such images have such strong and ubiquitous cultural associations that they invite intertextual reading, intended or not (Stoknes 2014, p. 168). There are, however, ethical and practical implications in manipulating both the warnings of climate science, and the narrative arc of creative writing, for a rhetorical purpose.

Johns-Putra in a review of the 'recent literary and publishing trend' of climate fiction claims 'Cli-fi is all the more noteworthy considering the creative challenge posed by climate change' (2015). *Imagined Futures* bears this out, both in theory and in practice. Cli-fi presents its own, unique set of perplexities for the literary imagination, overlaying the creative and technical challenges in writing any kind of literary fiction. Attempting to use it to truthfully and effectively communicate science fact adds yet another set.

Writing *Warming* so that it fitted in that space required navigating multiple, intermeshed and tangled strands of a compounded wicked problem. Many of the problem's strands looked, at the outset, to be polar opposites, pulling against each other in tension from such distance as to be irreconcilable: to look at the hyperobject of climate change through the intimate, interior lens of social realism, to express the abstract, mathematical modelling of climate science in a lucid story, to make an engaging plot from a panoply of erratic, widespread crises, to contemplate existential threat without sounding apocalyptic. However, in practice these strands turned out not so much opposites pulling against each other as problem frames interacting to modify each other in the kind of dynamic, open-ended system of looping feedbacks characteristic of wicked problems. The research question proved to be not binary but a sympoietic system of contingent and subjective problem frames, 'homeorhetic, evolutionary, distributively controlled, unpredictable and adaptive' (Dempster 2000, p. 1).

Warming, then, is not an answer, but one design solution to a wicked problem. The writing of it was performative of the research, exploring a route through the tangles created by an open-ended set of inconsistent objectives. A large part of finding a design

solution to a wicked problem is in surfacing, understanding, and iteratively reframing the

problem. Through reflection-in-action, *Imagined Futures* aimed to do this, and so

illuminate the shape of the problem's tangled strands. The tangles themselves, though,

will impact uniquely on each story told through creative writing, and each story will

balance and juggle the objectives in a different way to find its own unique path.

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