

Listening to Antarctica: Cheryl E. Leonard's eco-acoustic creative practice

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Abstract

Listening to the more-than-human world has been a source of musical creativity for centuries, but what does it mean to listen and respond creatively to the world around us in the Anthropocene? This article contributes to a growing body of research on sonic representations of Antarctica, a place often viewed as a barometer of anthropogenic climate change. Although explorers and scientists have visited the icy continent for over a century, it is only in the past 25 years that composers and sound artists have had direct access to listen to the human and non-human sounds of Antarctica and capture them in creative works.

Using composer Cheryl Leonard's multimedia work *Fluxes* (2014) as a case study, this article investigates how Leonard's eco-acoustic compositional practices reflect her listening experiences in Antarctica. We will highlight aspects of Leonard's creative practice that contribute to her complex exploration of non-hierarchical relations between the human and non-human, and how she formulates non-dualistic relationships between nature, the human and technology in her imaginations of the natural world, including through her innovative employment of natural materials and her use of technology in the gathering of sounds and in live performance.

Keywords: Listening, Antarctica, Experimental Music, Sound Art, Anthropocene

Antarctica and the enormous body of water encircling it, the Southern Ocean, play vital roles in driving and regulating our world's climate and in current debates about anthropogenic environmental change (Convey 1; Philpott, "Sonic Explorations" 84–85). The very cold water at the edges of the Antarctic continent descends deep into the surrounding ocean and propels the circulation of currents across all the world's oceans, while the atmosphere above the ice has a similar effect on global atmospheric circulation. The Southern Ocean also absorbs billions of tonnes of carbon dioxide from the atmosphere each year, which is particularly important given that the "present concentration of atmospheric carbon dioxide exceeds any value measured in ice cores covering the last 800,000 years" (British Antarctic Survey). As the Intergovernmental Panel on Climate Change's fifth assessment report (2014) states, it is "extremely likely" that human activities have been the "dominant cause" of the rise in atmospheric carbon dioxide, methane and nitrous oxide levels and the associated "warming since the mid-20th century" (4). While the Antarctic region, including the Southern Ocean, helps to balance out some of the potentially damaging effects of human activities – and it acts as something of a barometer of climate change, with ice cores revealing valuable data about the history of our world's climate – the region is not itself immune to the effects of climate change, with warming leading to increased ice loss in particular areas and negative impacts on numerous species (Wayman; British Antarctic Survey). As has been widely reported, ongoing changes such as these present potentially catastrophic consequences for the rest of the globe through sea level rise and the exacerbation of extreme weather events. With the pressing need for increased public and governmental engagement with and action on climate change, and with the Antarctic Treaty calling on "the contribution of writers, artists and musicians" to disseminate "knowledge about Antarctica" and "reflect, in particular, scientific activity and the

importance of the preservation of the Antarctic environment” (Antarctic Treaty Consultative Meeting 20, Res. 2; Saul and Stephens 285), we ask: how are composers and musicians currently listening and responding creatively to the Antarctic region and how might their contributions help to address some of the major challenges of the Anthropocene?

Although visual artists have had opportunities to visit the Antarctic region and respond creatively to its unique environment for well over a century now, for those working with sound – including composers, musicians and sound artists – similar in-person experiences have only been possible during the last twenty-five years, with the emergence of Antarctic artists and writers residency programs and with increased tourism in the area. Addressing the imbalance between visual and sonic engagement with and representation of the continent is important for several reasons. Firstly, the usual tendency for humans to prioritise the visual over the aural is frequently challenged in the Antarctic; as performance studies specialist Mike Pearson has observed, there is a “primacy there of sound over sight, the ear ever attuned to the cracking of ice” (27). This is obvious in written descriptions of the environment from the beginning of the Heroic Age of Antarctic exploration in the late nineteenth century (in diaries and published accounts from various expeditions) to contemporary nonfiction narratives of Antarctic journeys, many of which vividly describe aural encounters ranging from the eerily quiet to the deafeningly loud (see, e.g. Moyes 21–23; Nicol; Wheeler 269, 286; Philpott and Samartzis 347–48). Secondly, the sounds of the polar regions, including those captured in field recordings by sound artists, can inform scientific research about the behaviour of ice and wildlife, as well as changes taking place within their ecosystems. The research of American glaciologist Erin Pettit, for example, focuses on the sounds emitted by ice and what they can tell us about glaciers, as well as how they affect the behaviour of nearby marine mammals (“Passive Underwater”; Pettit et al. “Unusually Loud Ambient Noise”; Philpott, “Listening *At the Sea Ice Edge*” 108). Pettit explicitly acknowledges the influence of sound artist and composer Douglas Quin, who has spent three decades documenting soundscapes from the polar regions and other parts of the globe, on her sound-related scientific research (Pettit, “Passive Underwater” 121). Similarly, Quin’s ground-breaking recordings of Weddell seals underwater in the Antarctic, which he made using hydrophones, have contributed to scientific understanding of the species and its behaviour (Terhune et al.). Thirdly, musical and sonic art works by those who have spent time in the region have the capacity to capture and convey to diverse audiences the aural experience of Antarctica and the Southern Ocean in a way that is simply not possible within purely visual artworks; they enable large numbers of people who will never experience the region directly to listen to its unique soundscapes. As noted by Pijanowski et al., such engagement with soundscapes can have the knock-on effect of inspiring the “appreciation, management and conservation of the organisms and resources that create them” (1227).

Quin was the first composer and sound artist to travel to the Antarctic on an arts residency when he made the first of his three trips to the region in the mid-1990s. Since that time, most of the composers and sound artists who have travelled there have made field recordings for use within their creative works. Some of these individuals, including Cheryl E. Leonard, have followed in Quin’s footsteps by focusing primarily on recording and showcasing sounds of the natural environment and its nonhuman inhabitants, especially those created by the wind, ice, penguins and seals. For example, the major outcome of Brisbane-based composer Lawrence English’s 2010 trip with Argentina’s Antarctic arts residency program, *Viento/Antarctica* (2015), focuses on one element – wind – and enables listeners to witness the composer’s aural experiences of the windiest continent on earth through raw sound recordings of blizzards at the two largest Argentine bases in Antarctica, Marambio and Esperanza (Philpott, “Sonic Explorations” 89). Other artists, such as Philip Samartzis, Andrea Polli and Craig Vear, have incorporated anthropogenic sounds recorded in Antarctica (including human voices and

mechanical sounds) into their compositions, often alongside sounds of the natural environment. Some of these artists, including Quin, Leonard, Samartzis and Jay Needham, have also experimented with combining their field recordings with sounds performed on instruments – both traditional and unconventional – in compositions performed live and/or released on recordings. Only Leonard appears to have utilised natural objects from the Antarctic as instruments within her compositions. Collectively, this rich body of context-based compositions captures not only the natural soundscapes of the Antarctic, but also reflects the now continuous presence of humans in various parts of the region. Such works are heard in a wide range of contexts, from concerts and other live performances; to exhibits or installations at museums, art galleries and zoos; to sound recordings available on CD, radio, online or in films. Through these diverse media, people from all over the planet can hear and engage with some of the Antarctic’s unique soundscapes. This is particularly important at a time when the region and its soundscape are experiencing unprecedented changes as a result of anthropogenic influences. Sound-based works can not only help us to learn more about the Antarctic region and its unique ecosystems, but can also immerse us in a multisensory experience that enables us to *imagine* what it is actually like to be there and to *feel* a stronger sense of connection to the place as a result, with minimal human impact (Philpott, “Antarctica in Sound”).

This article draws on literature dealing with connections between music and place (Allen and Dawe; Von Glahn; Feisst), and extends this line of inquiry to the environmental humanities (Rose et al; Oppermann and Iovino; Heise et al) and the rapidly growing field of material ecocriticism (Iovino and Opperman; Alaimo; Barad; Haraway; Latour; Cohen; Bennett). We provide insights gained from considering a notion of nature and culture whereby “the world’s material phenomena are knots in a vast network of agencies, which can be ‘read’ and interpreted as forming narratives, stories” (Iovino and Oppermann, 1) within ecocritical music studies. In particular, we draw upon the ideas of Jane Bennett in *Vibrant Matter: A Political Ecology of Things*, whereby she calls attention to a posthuman definition of agency across the full range of things, nonhuman bodies and material processes that affect human subjectivity, and extend them by applying them in a listening and music-making context.

By focusing on the Antarctic work of San Francisco-based composer, performer and instrument maker Cheryl E. Leonard, we investigate a twenty-first century approach to listening and eco-acoustic compositional practice. This article uses Leonard’s multimedia work *Fluxes* (2015), which was developed in collaboration with visual artist Oona Stern, as a case study and argues that Leonard’s compositional practice is demonstrative of a non-dualistic and symbiotic way of understanding human and non-human matter. While a small number of past publications, including by the composer, have explored her journey to Antarctica and some of her related compositions, none of these have previously examined *Fluxes* in any detail (Leonard, “Playing Antarctica”; Leonard, “Meltwater”; Philpott, “Promoting Environmental Awareness”). In particular, we will highlight aspects of Leonard’s creative practice that contribute to her complex explorations of non-hierarchical relations between the human and nonhuman, and how she overcomes the nature-culture and nature-technology divides in her imaginations of the natural world, including through her innovative employment of natural materials and her use of technology in the gathering of sounds and in live performance. To understand how she arrived at the compositional decisions made in her Antarctic pieces, specifically in *Fluxes*, is it necessary to first consider her broader creative practice and interests.

Cheryl Leonard’s compositional practice and Antarctic work

For most of the last two decades, Leonard’s compositional practice has been driven by her deep interest in the natural world and in relationships between the human and nonhuman (Leonard,

“Playing Antarctica” 122). In particular, she has focused on researching natural sounds, materials and structures to inform her development of “musical works that explore and express wild realms and our human relationships to them” (Leonard, “Meltwater” 50). Her compositions, many of which she regularly performs live, typically employ natural objects and substances – such as sticks, rocks, shells, sand and water – as musical instruments, as well as excerpts from her own field recordings of sites where such phenomena are found. Each piece focuses on a particular theme and this is usually apparent not only in its title, but also in its musical construction and characteristics, such as its instrumentation, form, melodic and rhythmic qualities, performance techniques, and/or its field recording excerpts (Leonard, “Meltwater” 51).

Leonard employs a range of playing techniques to draw sounds from her chosen objects and substances. Solid objects such as rocks, shells and bones, for example, can be rubbed, bowed, brushed, tapped, wobbled or spun around, while substances like water, sand and mud can be poured, stirred, filtered or made to drip to produce sounds (Leonard, “Meltwater” 50; Philpott, “Promoting Environmental Awareness” 40). Rather than giving preference to the more audible sounds, she admits to being allured by “the minutia of the very quiet,” and uses condenser, contact and underwater microphones to “explore micro-aural worlds” on land, in water and inside objects that might otherwise go unnoticed by the human ear (“Meltwater” 50). She observes that “each specific item has its own voice” and she prefers to only amplify the original sonic materials, rather than manipulate them electronically (“Meltwater” 50). Similarly, she only minimally edits her field recordings before incorporating them into her compositions. In the composer’s view, the natural materials and field recordings contain “sonorities [that] are so rich and unique ‘as is’ that they give [her] plenty to work with on their own” (“Meltwater” 50).

While Leonard’s early environment-related works explored natural objects and phenomena found close to her studio in San Francisco – and thus are ones regularly encountered by humans in urban locations – she has increasingly focused more on remote and extreme environments, especially those showing the effects of climate change. One of her earliest nature-centred works, for example, *Instruments in Trees* (2003), utilises arboreal materials that she collected in California, including driftwood, branches, bark, pine needles, leaves and pinecones, within its instrumentation and focuses on processes and cycles in the lives of trees. Similarly, her 2009 collaborative work with visual artist Rebecca Haseltine, *Tides: Estuary*, is closely connected to the San Francisco Bay Area; it employs water, salt, kelp, shells, sand, mud and rocks as musical instruments to explore the patterns and cycles of tidal flows in estuaries and several of its pieces were first presented outdoors at Middle Harbor Shoreline Park in Oakland. Around the same time as she was collaborating on *Tides: Estuary*, however, she was also beginning to explore – both physically and through her compositions – places and ecosystems much further afield, in the polar regions.

Leonard’s attraction to “wild” places and her “special fondness for snow and ice” surfaced during her youth in rural Wisconsin and gained strength after she attended college and took up hiking and mountaineering (Leonard, “Re Grants and Article”). She soon discovered that she “was utterly fascinated by glaciers, these elemental forces that shaped vast landscapes seemed alive, and were full of hidden beauties and dangers” (Leonard, “Re Grants and Article”). With her dual interests in composition and extreme environments, applying for an Antarctic arts residency with the United States’ National Science Foundation (NSF) seemed like a logical next step. Leonard confesses: “For me, Antarctica represents the Holy Grail of remote, snowy, icy wilderness ... of course I wanted to go there!” (Leonard, “Re Grants and Article”). She was awarded a place in the NSF’s 2008 Antarctic Artists and Writers Program for her proposed

project titled “Antarctica: Hidden Musical Worlds.” The project aimed to “develop a series of musical compositions based on the forces that shape environments and ecosystems on the Antarctic Peninsula ... focus[ing] on topics of current scientific investigation in the region and highlight[ing] connections ... [to] global climate change” (National Science Foundation). Leonard envisaged each individual work comprising “unique subject matter and instrumentation with sounds coming exclusively from natural sources; playing amplified materials such as ice, rock, water, moss, feathers, shells, and bones as musical instruments” (National Science Foundation). Prior to her trip, she was “especially curious about unique wind, wildlife, water, and ice sounds [she] might encounter there, and was eager to see what new voices [she] might coax out of Antarctic rocks, shells, bones, and ice” (Leonard, “Playing Antarctica” 122).

Like most visitors to the Antarctic Peninsula, Leonard crossed the Drake Passage from South America by ship, which gave her several days to experience the Southern Ocean firsthand and to gain a sense of its power, vastness and changeability, as well as the wildlife it supports (Leonard, “Playing Antarctica” 122). Unlike most visitors, however, she was able to stay on land for longer than just a few days. Her residency enabled her to spend five weeks of the 2008–9 austral summer at Palmer Research Station on Anvers Island, a mountainous island and the largest in the Palmer Archipelago, located off the north-west coast of the Antarctic Peninsula. During that time, she undertook various excursions to nearby islands and explored the surrounds of the station on Anvers Island, making field recordings of myriad sounds from biological and geophysical sources, including penguins, seals, water, brash ice, icebergs, glaciers, wind and blizzards (Leonard, “Playing Antarctica” 122–25) (see Figure 1). Most of her recordings were made on land or above the water (from aboard a zodiac), but she also used a hydrophone to record underwater sounds in meltwater streams and open waters, and embedded the hydrophones in sea and glacial ice. On other occasions, she experimented with making sounds from rocks and ice on location, and after gaining special permission from the NSF, she gathered a small assortment of natural objects – rocks, penguin bones and limpet shells – to take home to her studio in San Francisco to use as instruments within her compositions and performances (Leonard, “Antarctica”; “Playing Antarctica” 126–27).



Figure 1: Leonard recording inside a crevasse in Antarctica.
Photograph by Oona Stern, used with permission.

After returning to San Francisco, Leonard began a detailed aural investigation of the objects she had collected in Antarctica, creating musical sounds with some of them in their natural forms, and assembling others together mounted in driftwood to form innovative sculptural instruments (Leonard, “Antarctica”). Her aim was to “uncover voices and textures ... that evoked elements of Antarctica” (“Playing Antarctica” 127). She then developed and refined (over a period of a few years) a suite of ten pieces – collectively titled *Antarctica: Music from the Ice* – that draws together her Antarctic field recordings and sounds from her natural-object instruments to explore a range of thematic ideas related to the southern continent and its surrounding ocean.

In keeping with Leonard’s usual compositional approach, each piece within *Antarctica: Music from the Ice* explores a specific theme, which is evident in its individual title as well as in its musical materials (Leonard, “Meltwater” 51). Three of the ten pieces focus on nonhuman species whose populations are changing due to anthropogenic influences: *Lullaby for E Seals* (2009), which features field recordings of sleeping southern elephant seals alongside music from kelp flutes, Antarctic limpet shells and rocks; and *Rookerie* (2010) and *White on White* (2012), both of which draw attention to the plight of Adélie penguins and feature sounds made with bones Leonard collected from abandoned Adélie penguin nesting sites, among other objects (Philpott, “Promoting Environmental Awareness” 42–43). The other pieces in the set also include objects from various biological species within their instrumentation (i.e. bones and shells from clams and limpets), but focus thematically on nonbiological or geophysical elements of the environment. Four of the pieces (*Brash Ice*, 2009; *Point Eight Ice*, 2011; *Ablation Zone*, 2013; and *Meltwater*, 2013) explore different forms of ice, from glaciers and icebergs to brash ice and bergy bits, as well as melting processes related to the retreat of

tidewater glaciers and the diminishing extent of sea ice. The remaining three – *Greater than 20 Knots* (2011), *Oceanus Meridiam* (2013) and *Fluxes* (2015) – draw attention to patterns in wind and ocean currents in the Antarctic region, elements that are also affected by anthropogenic climate change and simultaneously play critical roles in global climate processes. Some of Leonard’s Antarctic pieces have been discussed in detail in Philpott’s 2018 article in *Organised Sound*. Here we focus instead on one of the pieces that has not been studied in depth in the literature before now but that nevertheless showcases some of the most important features of Leonard’s compositional processes and engagement with listening to Antarctica and the Southern Ocean in the Anthropocene: *Fluxes*.

Leonard’s *Fluxes*

Completed in 2015, *Fluxes* is an audio-visual work designed for live performance by two musicians on instruments made of natural materials, and incorporates pre-recorded tape and video projection. It combines the sounds of played rock slabs from Breaker Island, Antarctica, Antarctic limpet shells, sand and clam shells with field recordings of water and brash ice in the Southern Ocean. Images of the instruments used in this composition are shown in Figures 2, 3 and 4 below. Video footage was contributed by both Leonard and collaborator Oona Stern, and was shot on the voyage from Chile to Antarctica, with additional footage included from Raudfjorden, Svalbard and Buttermilk Channel, New York. It took Leonard seven years to complete *Fluxes*, as the process involved not only extensive planning and research leading up to her Antarctic residency in 2008, but also the gathering of information, materials, sound recordings, collaboration with Stern, the compositional process, and the creation of a musical score and detailed performer notes. The thematic inspiration for *Fluxes* is twofold: first, “[to] contrast the relative scarcity of life witnessed on the surface of the open ocean while travelling for days across the Drake Passage accompanied by only an occasional albatross or giant petrel, with the sudden profusion of life along the Antarctic Peninsula, an abundance fuelled by the upwelling of cool, nutrient-rich, deep ocean waters”; and second, “[to] evoke distress about the threats that changes in ocean temperatures, currents, and upwelling patterns pose to these vibrant, unique marine ecosystems” (Leonard, “Re Scores”).



Figure 2: Musical instruments made of rock slabs, a sand bowl and sand tube.



Figure 3: Musical instrument made of Antarctic limpet shells mounted on driftwood.



Figure 4: Clam shells and bow.

Fluxes is a six-minute through-composed work that can be loosely divided into three sections. The sounds slowly evolve and morph into each other, and if not referring to the score (particularly when listening only to a sound recording of the piece) it is difficult to discern whether a particular sound has been played in live performance or on the tape track, and whether the sound is derived from a played musical instrument or from a natural field recording. The first section opens quietly, with a gently swelling rumble played on the tape part while both performers remain silent. The tape part is comprised of two overlaid musical parts, an amplified rock slab and tilting sand tube (see Figure 5). Gradually both performers enter, with the first playing on clam and limpet shells with sustained bow strokes, while the second plays an amplified rock slab with foam paintbrushes and string. The intensity and speed of bowed tones increase over the following two minutes and build to a climax, with a sudden drop off around 2'45" ([Sound Example 1](#)). The middle section comprises high-pitched sounds of bowed shells, and lively cracks and pops of melting ice and moving rocks ([Sound Example 2](#)). Eventually, deeper sounds re-emerge, and at around 4'45", underwater wave sounds become

audible, as well as surface sounds of splashing water and brash ice. This final section shares similarities with the first, but with the intensity of recorded lab water swells in the mix, and the absence of the long sand tube (Sound Example 3). The work finishes in the same way it began, with the performers silent and only the tape part audible.

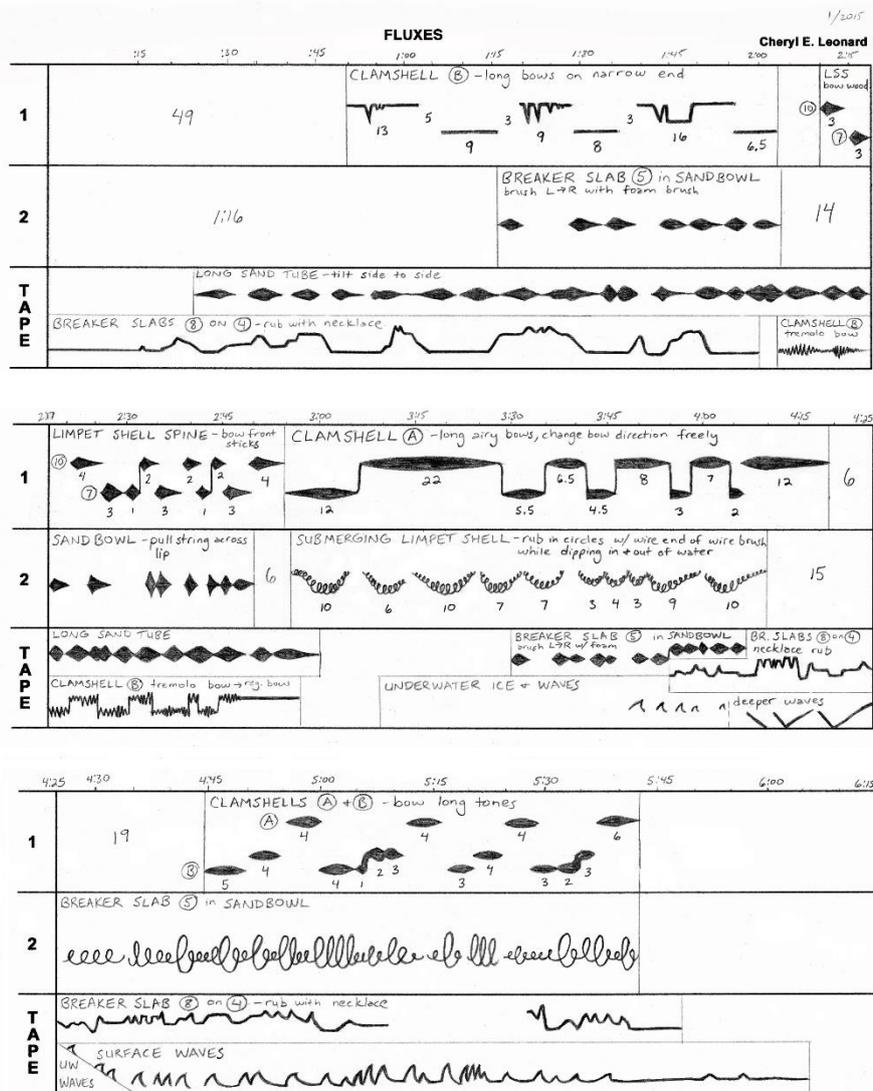


Figure 5: Score for *Fluxes*. Supplied by the composer, used with permission.

In *Fluxes* then, we are listening to a sonic ecosystem; that is, complex and symbiotic interactions between myriad objects including people, things, events, and environmental forces. The remainder of this discussion serves to highlight elements of Leonard’s creative practice that evidence her interpretation of entanglements between “more-than-human” materialities (Iovino and Opperman, eds.; Bennett; Morton; Abram; Gilmurray).

As suggested earlier, Leonard’s creative practice incorporates listening and responding to the resonances of natural objects. Not only do the visual score and performer instructions offer insight into how Leonard explores the sounds of the natural materials, they also specify how the performer should approach the tempo, pitch, dynamic level and duration of each bowed tone (Leonard, “Re: Scores”). Such considerations indicate Leonard’s attentiveness to the sonic properties of the shells. Similarly, Leonard describes being struck by the sonic and conceptual

resonances of rocks on Torgersen Island: “The island is covered in these unusually resonant stones. The Adelies build their nests out of Torgersen's smaller rocks, and the penguins have been using and reusing these for so many years that the stones are polished from wear. The larger rocks that lie along the penguin paths have also been worn down by the birds, their edges smoothed and rounded from all the foot traffic” (“Adelie Footsteps”). Leonard's close investigation of these items is indicative of the way in which she frames them as matter possessing agency through their sonic resonance.

As Figure 5 illustrates, Leonard's specification of how and when the performer should play the instruments is closely aligned with the rhythms and textures of the tape recording. For example, between 4'45" and 5'45", the sustained bowed tones played by Performer One are of specific lengths between 1-6 seconds, and coincide with the rhythms of lapping waves in the field recordings. As the waves increase in frequency and decrease in length, so too do the sounds played on the clamshells. The performer is directed, therefore, to synchronise their live performance with the natural process of water movement. Additionally, as mentioned earlier, both performers begin and end the work with a prolonged period of silence as the tape part plays. Indeed, the conclusion of the work involves both performers silently listening as the tape part plays field recordings of surface waves for nearly thirty seconds. Here in the final statement of the work, Leonard has prioritised the sound of the movements of waves, leaving nonhuman – rather than human-produced – sounds resonating in the minds of the performers and audience members.

The ways in which Leonard treats individual material objects also serve to acknowledge the agency of non-living objects. For example, she describes her first impressions of the musicality of rocks on Torgersen Island before eventually deciding to take them to make musical instruments:

I think the penguins have chosen a very musical island, because Torgersen is covered in dense, fractured, pitched rocks. The Adelies gather the smallest of these stones to build their nests, but even the larger pieces are surprisingly resonant. One of my new favorite sounds is the tinkly music of penguin feet as the Adelies amble back and forth between the ocean and their colonies. I was trying to record their little footsteps today (“Adelie Footsteps”).

Here, Leonard identifies her interest in capturing the resonant rocks as penguins move across them, not in capturing a wider soundscape. Leonard specifies that she wishes to record only the noise of penguin footsteps, and takes care not to include other sounds from the same event such as the penguins' squawking. In focussing so intently on a single sound object rather than a generalised sonic “snapshot” of the moment of recording, the object becomes dislocated across time from the moment, and the audience is invited to imagine other histories of the object as though they were missing parts of the story. If the recording had contained the sounds of the rocks as they formed, what would they have sounded like? We hear the penguins walking across the rocks, but what other objects or species have moved across them, and how did they change the way the rocks resonated? Do ice and snow form over the rocks in winter, and what do they sound like as the ice melts and reforms over the seasons? The ways in which Leonard transforms the natural materials invite the audience to imagine different and usually unheard chapters of the rocks' stories. The vitality of the rocks continues to develop across time and space with further performances and recordings of *Fluxes*, and forms new stories. These stories possess agency of their own in that they serve to promote the type of ecological thought in their audience with which Leonard approaches her own creative practice.

Generally, field recordists go to great effort to avoid or remove any trace of human or machine interference in their recordings of the natural environment; brushes against the microphone,

wind interference, sounds of the field recordist breathing or coughing, the hiss of a preamp, for example, are edited out of most high-quality field recordings in order to present a carefully curated snapshot of a specific time and place. Leonard's descriptions of field recording difficulties on her blog are testament to the fact that there are countless sounds from the time and place of recording that we, the audience, are not hearing: the noisy drips that interfere with the sounds of icicles that she was intending to capture, the roar of wind that sounds as a dull fuzz through speakers, the movements of the recordist who took the field recordings, rendered inaudible with the editing out of microphone movement noises, for instance.

Rather than portraying technology as destructive or obtrusive, aspects of Leonard's compositional approach model the harmonious coexistence of humans, technology and the natural world and use technology as a creative tool to extend human sensory capacity. In an ecocritical reading of *Fluxes*, we hear a complex entanglement of human and nonhuman sounds, most of which are mediated through technology. As suggested earlier, while listening to the audio recording of the piece, it is difficult to discern whether a sound is being played live by one of the performers, or whether it was pre-recorded for the tape part. In the tape part itself, human-generated sounds can be easily mistaken for field recordings of natural processes, and many of the sounds fluidly merge. Rather than presenting a distinct past "event" as recorded by the field recordist, the audience is immersed in a live performance (or album audio track, depending on how the work is experienced) that glides between past and present sounds, thus destabilising the audience's perception of time and embedding the listener in an "in-between" space. Such a coalescence between past/present and here/there draws nearer the type of ecological thought that Timothy Morton calls "the mesh," or "the interconnectedness of all living and non-living things" (28).

Another way in which Leonard utilises music technology to facilitate a deeper ecological connection in *Fluxes* is by granting her audience access to sounds of otherwise inaccessible places. In addition to the extensive logistical planning and preparations undertaken by Leonard prior to her Antarctic residency, the field recordings collected required the use of highly specialised recording technology, without which many of the sounds would remain inaccessible to the naked human ear. Leonard used a hydrophone to record underwater sounds, as well as a variety of other technical devices to take field recordings of sounds from inside crevasses and other difficult-to-access areas. When considered with the aforementioned difficulties for the general public in accessing the Antarctic region, it is clear that Leonard has brought a unique listening experience to her audience. Overall, Leonard's usage of technology mediates a sounding of the natural processes that so inspired her to compose *Fluxes*.

In some ways, Leonard's usage of natural materials as musical instruments may be considered an anthropocentric practice, and counter to an ecologically attuned attitude: shells and rocks gathered and taken from Antarctica are literally transformed into musical instruments and subject to human manipulation. Jane Bennett advocates for the vitality of matter, claiming that "the image of dead or thoroughly instrumentalized matter feeds human hubris and our earth-destroying fantasies of conquest and consumption" (ix). Such practices can be harmful to contemporary ecological thought, she argues, "[and] does so by preventing us from detecting (seeing, hearing, smelling, tasting, feeling) a fuller range of the nonhuman powers circulating around and within human bodies" (ix). Whilst Leonard makes instruments out of natural materials, Bennett's conclusion that such an action categorically prevents one from a sensory awareness of the nonhuman is drawn into question: we have already described several ways in which *Fluxes* displays nuanced ecological thought. Furthermore, Leonard's own descriptions of how the natural matter is to be treated indicate a notable sensitivity towards the materials, and require great care in their handling. The performer is instructed to "brush," "rub slowly

and gently” and “bow” the materials, and there is never any indication to use an action that could damage or destroy the instruments in any way. Leonard describes the great care taken via permit and packing processes, ensuring the materials suffer no damage from collection and transit (Leonard, “Antarctic Instruments”). *Fluxes*, then, calls into question whether the “instrumentalisation of matter” may sometimes assist – rather than impede – the identification of nonhuman agency.

Conclusion

Undoubtedly, ecological issues such as rising ocean levels, extreme weather events, and mass species extinctions continue to be some of the most challenging issues that humanity faces during the Anthropocene, and they demand a fundamental shift in how human societies function and are organised, and indeed, how humanity relates itself to the rest of the world. At the start of this article, we asked, how are composers and musicians currently listening and responding creatively to the Antarctic region? And how might their contributions help to address some of the major challenges of the Anthropocene? After first highlighting the significance of Antarctica and the Southern Ocean in ecological discourse during the Anthropocene, we used examples of Leonard’s creative practice and an ecocritical analysis of her work *Fluxes* to explain how they speak to contemporary ecological issues.

Leonard has formed a creative practice that wields subtle power to connect audiences with important ecological themes. Rather than using data sonification or other compositional tools that directly connect sound with environment, Leonard’s employment of natural materials in field recordings and as musical instruments, and her usage of music technology, mediate her ecological approach to composition. Key themes that emerged during the discussion included ecological interconnectedness between living and non-living things and the breakdown of the hierarchy between the human and nonhuman. Ultimately, we conclude with the argument that the contributions made by composers such as Leonard are evidence of the type of ecological thought that interrogates and ultimately breaks down the binary distinction between nature and culture. Much work remains to be done on the role that sound, listening, and composers can take to direct the societal shifts necessary for humanity to adapt during the Anthropocene, but this article has shown that Leonard’s work makes a significant contribution to the growing body of artistic output that is demonstrative of the type of ecological thought necessary to achieve this goal.

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