WATERPROOF:
Synthetic Water Sounds in an Immersive Film Experience

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ABSTRACT

A creative response to the climate crisis, this thesis describes the design and presentation of synthetic water sounds in an immersive audiovisual experience. The project is intended as a contribution to the field of ecological sound art. This developing area within the environmentalist movement champions creative audio pieces that allude to specific ecological issues. Here, a soundscape composition with accompanying visuals depicts the geoscientific stages of a storm surge, a prevalent, destructive event caused by climate change. The sound design and videography seek to place the audience at the center of the action, rather than at a distance, as in the common case of news reports. The driving motivation is to emphasize that global warming affects everyone and must be confronted universally.

With these goals in mind, the soundtrack was produced with virtual instruments in the Digital Audio Workspace (DAW) Reason. Experimentation with synthesis techniques and precise methods in noise oscillation were implemented to create realistic water sounds. Together with musical elements, the arrangement was mixed in three dimensions using the object-based audio technology, Dolby Atmos. Visual footage was captured in collaboration with a cinematographer and the soundtrack was synchronized accordingly in post-production. In addition to images of melting glaciers and rolling ocean waves, the visuals display an apartment filling up with water, a scene that is directly relevant to the human experience of a natural disaster and the broader implications of rising sea levels. The resultant film was shown in a space with surround sound and video capacity to a panel of experts. Their critical impressions indicated that the creative and technical components of the sound design were successfully executed and that the meaning behind the piece was clear and moving. The level of immersion could be intensified with stronger spatial effects that further personalize the experience.

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I. INTRODUCTION

Water is a fundamental element of the environment that cannot be drowned out. As the world faces the realities of climate change, the necessity of water and its power as a natural force only become more striking. There are, even in this dire moment, various ways to take action. Although the scientific evidence has been clearly illustrated, there remains a gap in the awareness of what is happening and in the understanding of what is at stake. Efforts to close these gaps can be found in ecological sound art, an environmentalist movement that uses sound and music to amplify specific ecological issues. While composers and sound artists in the field approach the endeavor from different angles, many choose to incorporate sounds of natural phenomena into their work. This thesis describes an ecological sound art project that foregrounds water sounds in an immersive film experience. The respective process involves synthesizing water sounds and applying them in the composition of a three-dimensional (3D) soundscape, which acts as the soundtrack for an accompanying visual component.

In the formal Western musical tradition, recordings of water first appeared in the 1950s as manipulated sound objects in pieces of *musique concrète*. This electroacoustic technique refers to compositions containing recorded sounds that have undergone audio processing, rather than familiar instrumental notes. Later in the 1960s, as environmental activism began to gain more ground, composers started to include recognizable recorded sounds of water in soundscape compositions as a way to inspire appreciation and motivate people to protect the environment and prevent further damage. Contemporary ecological sound artists have, in addition to integrating water sounds captured in field recordings, constructed water sounds with varying types of sound synthesis, and even simulated them with the human voice. Trends in the ideology

and creative practice of ecological sound art, and in the physical audio animation of water sounds, serve as the foundation for the methods of this project.

Some sound artists have coupled their compositions with visuals that echo their ecological concerns, but there has yet to be a sharp focus on the design of a fully mixed, congruous audiovisual production. Moreover, artists have not implemented 3D audio set to visuals in this ecologically driven context. Climate change is a global crisis that requires profound attention. In much of the political and cultural discussion of this environmental emergency, there seems to be a distorted sense of distance between the projected dangers and those at risk, only to be called into question after the event of a devastating natural disaster. The problem constitutes a conceptual disconnect that must be addressed. Among the artistic responses tied to the environmentalist initiative, there are novel opportunities in music technology with potential worth realizing. This thesis project innovatively employs object-based audio as a tool to materialize the threats of climate change and stress the fact that these threats affect everyone. With this larger goal in mind, emphasis has been placed on verisimilitude in the synthesis of the water sounds and on cohesion in the immersive film experience.

II. BACKGROUND

Synthesizing water sounds in an immersive film experience that addresses the realities of climate change is an ecological sound art project calling for the use of techniques in cinematic soundtracking and 3D audio. In order to present this creative project as an innovative contribution, it is necessary to first, elucidate the meaning of the ecological sound art movement, second, hone in on water sounds specifically, and third, consider the applicable methods of

immersive sound design. There are, in addition, particular composers whose work has significantly influenced the thematic foundation for the soundtrack. It is important to note as well, that this project is interdisciplinary, not only in respect to different areas within music technology, but also in regard to inherent scientific, social, cultural, and political factors.

1. 'Ecological Sound Art'

The roots of ecological sound art lie in the second wave of the greater environmentalist movement, which took off in the late 1960s (Shabecoff, 2000). The notable introduction of sound and musical composition to the environmentalist agenda can be attributed to the composer and writer, R. Murray Schafer. First focusing on the appreciation and preservation of the environment in the creation of soundscapes, Schafer established the World Soundscape Project in 1972. He went on to formally coin 'acoustic ecology' in 1977, a discipline reinforced in 1993 by the initiation of the World Forum of Acoustic Ecology, which remains active today. Although Schafer's endeavors were ultimately influential, the coinciding movement in the domain of visual art gained more traction more quickly. All the while, the threats of climate change were intensifying. In 2006, composer Joel Chadabe joined forces with the Electronic Music Foundation to stage Ear to the Earth, "a five-day festival of ecologically-focussed sound art in New York [which now] operates as a worldwide network of sound artists addressing ecological issues" (Gilmurray, 2016). Seeking to more accurately represent the ideas behind Ear to the Earth and the associated contemporary objectives, electroacoustic composer Jonathan Gilmurray (2016) proposed the term, 'ecological sound art.'

A multifaceted movement that is still developing, ecological sound art has been assigned

somewhat differing definitions. In an article published in *Soundscape: The Journal of Acoustic Ecology*, sound artist Vanessa Tomlinson (2019) deconstructs the relationships between the concepts of sound, music, place, and environment. She explains that, in the context of music, "When performing in and with the environment, it is the composer asking the question of place," (Tomlinson, 2019, p. 21). Her discussion of the sonic role of the environment in both the act of listening and that of making sound or music, introduces the crucial idea of awareness. That is, by asking the question of place, the composer may accentuate the presence of the environment as an integral aspect of the respective composition. While awareness is essential to the practice of ecological sound art, there are certain significant distinctions that Tomlinson does not make. For instance, although both may give the environment a voice, interacting with the environment by some musical means is not the same as identifying something about the environment and making music to draw attention to it. Without indicating this dissimilarity, the use of the environment to create sound art and the use of sound art to say something about the state of the environment may be conflated.

Gilmurray (2016) emphasizes the aforementioned distinction in his *Musicological Annual* article, "Sounding the Alarm." He suggests that the production of works "which utilise the environment as the site or material, but which don't necessarily address ecological issues" may fall under the umbrella of "environmental sound art," (Gilmurray, 2016, p. 77). Ecological sound art describes works that do speak to "contemporary environmental issues such as biodiversity loss, pollution, sustain-ability, global environmental justice, and climate change" (Gilmurray, 2016, p. 77). In this particular article from 2016, Gilmurray also asserts that the ecological sound art movement has yet to be properly recognized and that the "lack of recognition as an artistic

movement in its own right means that its unique characteristics are not being engaged with, and that it is being excluded from the critical discourse surrounding the wider cultural response to contemporary ecological issues" (Gilmurray, 2016, p. 78). He takes this argument further in his chapter on ecological sound art in the Bloomsbury Handbook of Sonic Methodologies published in 2020. Seeking to set the acknowledgement and appreciation of the movement in motion, he analyzes various exemplary works and encapsulates the meaning as follows:

> Ecological sound art represents a vital and thriving contemporary field of practice, with a growing number of artists creating sound works which aim to help us to open our ears to ecological issues, to listen to and understand the warning signals, and to explore ways in which we might learn to live more harmoniously within the ecosystems of which we are a part, and upon which we all depend. (p. 458)

Gilmurray provides a clear and comprehensive definition and his informative chapter will serve as a pivotal reference in this project. His concern surrounding what he deems a deficient level of recognition of the movement, however, could prove to be unproductive or even amount to a distraction. Despite the extensive scientific evidence, ecological issues, especially climate change, are still ignored and/or unreasonably disputed. The primary purpose of ecological sound art is not to secure its place in an art history textbook; it is to foreground current ecological issues and in doing so facilitate an active response to the associated challenges.

This core intentionality comes through in the work of the sound artist and researcher Leah Barclay. In her chapter of Sound, Media, Ecology, Barclay (2019) explains that the goal of her research is to "position acoustic ecology as a critical interdisciplinary field to inspire climate action and understand the temporal complexities of changing environments" (Barclay, 2019, p.

155). She stresses that the interdisciplinary element is not only needed in the effort to understand the field, but also for it to be put into practice successfully. Climate change is a multidimensional crisis with complex implications and it must be treated as such. In an earlier article that came out in the *Journal of Acoustic Ecology*, Barclay (2013) alludes to the behavioral shift that is required to instigate the healing and protection of the environment. She proclaims that "Sound, as a creative medium, is undoubtedly one of the most powerful means to stimulate this shift in consciousness" (Barclay, 2013, p. 32). Although the strength and validity of this statement could be debated, it indubitably demonstrates a fundamental component that drives ecological sound art: the opportunity to harness awareness and effect change.

2. Immersive Sound Design

Musicologist and avant-garde theorist Douglas Kahn (1999) posits the following in his historical book on sound in the arts, Noise, Water, Meat:

> It is the mimetic inclination of water to assume the shape of any vessel it occupies. Because of the different forms it already assumes, its powers of abstraction reach from the particularization of a drop to the atmospherics of humidity and immersion, from a brackish stagnancy to turbulence, from the pure linear figuration of waves to the chaotic mass of breaking waves. And in its relations to humans it can sustain life or destroy it. (p. 259)

Kahn's claim testifies to the breadth of possibilities present in the making of artistic representations of water and the ensuing opportunity for symbolism and potential impetus for activism. Although the technology has been developed, few ecological sound artists have chosen

to seize this opportunity using 3D audio. In 2019, sound artist Jana Winderen presented "The Art of Listening: Under Water," an eco-installation that, as related by Dave Tompkins of *ARTnews*, "encourages awareness of undersea species and how our actions might affect phytoplankton that are responsible for 50 percent of the world's oxygen" (Tomkins, 2019, p. 1). Winderen designed undersea soundscapes with hydrophone recordings, portraying spatial information of the ocean with an ambisonic speaker system. In doing so, she created a successfully immersive sonic experience. Apart from some supplementary photos of her making the recordings, Winderen's project does not have a visual component. Methods in 3D audio and techniques such as those revealed by software engineer Nuno Fonseca in his 2015 Audio Engineering Society convention paper describing the use of particle systems in a "hybrid channel-object approach for cinema post-production," allow for the creative application of immersive cinematic formats and have inspired the production of this immersive audio-visual experience, a corporeal call for awareness.

Among the various tactics called upon to achieve an immersive audio experience, an object-based approach was deemed the most fitting for this project. Object-based audio operates through the identification and arrangement of individual sound objects. Defining each object's location and motion trajectory constitutes spatial information described in metadata. This strategy allows for the creation of a 3D sound image that exists independently of a given speaker setup. In playback, since the sounds are not mapped to a particular number or layout of speakers, the metadata is presented through whichever configuration is being used. The more extensive the speaker setup is, the more accurately the object-based rendering can be portrayed. As stated by Coleman et al. in their 2018 study of an object-based audio-visual system, "In the object-based audio paradigm, the content is represented as a virtual *sound scene*…This affords new

opportunities for immersive, personalized, and interactive listening experiences" (Coleman et al., 2018, p. 1919). Here, in this thesis project, the goal of spatialization is not only to enhance the audio experience of certain sounds, but also to situate and control the literal and figurative point of view. That is, it goes beyond enveloping the audience in sound. It is not just that the listener is placed in an environment where something is happening; it is that they are in an environment where something is happening *to* them. The capabilities of object-based audio suit the intent to creatively relay the message at hand.

3. Compositional Influences

Beyond the influence of comparable sound art projects, there are several composers whose styles and processes have informed the creative decisions made surrounding this thesis. The key players are Annea Lockwood, Hildegard Westercamp, Carsten Nicolai, and Laurel Halo. An introductory overview of each of these composers is provided below. Further detailed exploration of their work will appear in the Methods section.

3.1 Annea Lockwood

Experimental composer Annea Lockwood has been making sound art, and what some have called performance art, since the 1960s. She is known best for her extensive use of field recordings and found sounds in her compositions and she has been consistently vocal about the principal role the natural environment plays in her work. The most relevant example, in the context of this thesis, is a series of installations she constructed with sounds of rivers across the world. Furthermore, she has spoken about trying to "immerse" her audiences when she performs these environmental art pieces, appealing to an inner and outer awareness (Hanson, 2020).

3.2 Hildegard Westercamp

Hildegard Westercamp began making soundscape compositions in the 1970s before they were known by that name. Not only has she composed numerous environmental pieces and worked both individually and collaboratively on many installations, she has also written widely about the art of soundscape composition and its relationship with acoustic ecology. In her words, "Cultural production can speak with a potentially powerful voice about one of the most urgent issues we face in this stage of the world's life: the ecological balance of our planet. The soundscape makes these issues audible. We simply have to learn to hear it and to speak back. The soundscape composer has the skill and the expertise to do exactly that" (Westercamp, 2002).

3.3 Carsten Nicolai

Carsten Nicolai, who records under the pseudonym, Alva Noto, is a prolific audiovisual artist acclaimed for his electronic and glitch productions in addition to his film scores. According to the composer himself, he works intensively in the "transitional area between music, art and science" (Nicolai, 2022). He frequently weaves mathematical patterns into his pieces and has led some to believe that he encodes deliberate messages in his performances. Many of his compositions contain complex musical textures made with noise. These textures are worthy of attention here because the goal of synthesizing water sounds, for instance the simulation of a rainstorm, can be achieved through the precise manipulation of noise with a virtual oscillator. Moreover, Nicolai's visual exhibitions often include experimentation with light and how it can be designed as an instrument of symbolism.

3.4. Laurel Halo

A classically trained electronic composer and performer, Laurel Halo has the kind of range that protects her from the confines of a genre. Her compositions have been presented in a concert hall and her tracks thrown on in a discotheque. Since the release of her first album in 2012, she has explored various avant-garde music scenes, making pieces with and without lyrics, playing live DJ sets, and paving new paths in ambient music. More recently, she has also taken to screen scoring. Halo often alludes to the conceptual weight behind her projects and points to poetry and visual art that guides her sonic narratives. Whatever the measure of obscurity, her creative choices are intentional and emotionally vitalized.

III. WATER SOUNDS

1. The Emergence of Water Sounds in Composition

The first documented presence of water sounds in Western art music is commonly credited with early electroacoustic composers. As is recounted by M.R. Iturbide (1995) in the *Journal of New Music Research*, the inclusion of recorded sounds, which would later come to be called ‘sound objects,’ as opposed to written notes in musical compositions was formally dubbed ‘*musique concrète*’ by the experimental composer, Pierre Schaeffer in the 1940s. In 1955, physicist and composer Hugh Le Caine presented a piece of *musique concrète* he called “Dripsody,” which was created entirely from the recording of a single drop of water falling into a trash can. Tōru Takemitsu used a similar process in his 1960 composition, “Water Music.” Although Le Caine and Takemitsu may have introduced the use of water sounds as

instrumentation, a key part of *musique concrète* is the practice of various techniques to manipulate the sound objects they have recorded and in many cases, render them unrecognizable. Gilmurray (2020) indicates that environmental sound artists seek to do the opposite. When they integrate natural sound objects, such as water sounds, into compositions and soundscapes, they intend to honor the original field recording they captured, rather than to alter the sound, in hopes of raising awareness of the environment itself. Composers take this concept a step further in ecological sound art, where the natural sound objects are not merely present and familiar; they are the driving force. Moreover, pieces of ecological sound art often accentuate sounds in reference to specific events or natural phenomena, for instance a certain body of water. In addition to working with field recordings in this pursuit, some ecological sound artists have simulated water sounds, synthesizing them or recreating them with the human voice.

2. Water and Climate Change

Many, if not most, of the threatening ecological issues tied to climate change directly involve water. Examples include melting and the loss of arctic ice, the rising sea level and the increase in the temperature of ocean water, changes in water cycle patterns and unpredictable water availability, natural disasters, such as floods, tsunamis, and extreme storms, and resultant water contamination. Ecological sound artists have come at these issues from different angles in order to spread awareness and make an impact. Each of the following projects shines light on a particular aspect of the situation and demonstrates how human actions come into play.

3. Relevant Sound Art Projects

In her description of the "Imagining Water" series, writer and artist Susan Hoffman Fishman (2019) of the Artists & Climate Change initiative presents the work of Fritz Horstman. A sound and visual artist, Horstman recorded people using their voices to make what they understood to be the sounds of water, layered these vocals, and set them as the soundtrack to a video of the Kannagawa River in Onishi, Japan. He stated that he wanted to place "human consciousness into the center of nature," asserting that "we connect to human voices in a different way than to the real sound of water rushing by" (Hoffman Fishman, p. 6). Horstman made a similar video with recordings of people making the sounds of ice behind images of the Arctic Ocean. The human connection Horstman alludes to can serve the purpose he mentioned, bringing people closer to nature and effectively weaving them into the soundscape and by extension, the landscape. The piece may also, however, relate to the question of humans' responsibility when it comes to climate change and the state of the environment. In these videos, Horstman does bring something human into the center of nature, but in doing this, he eliminates nature's own voice and replaces it with a human reproduction. Although these interpretations are somewhat antithetical, they are powerful together because they encourage a positive appreciation for the environment, as well as implicitly illustrating what is at risk.

Grant et al. (2021) sharpen the focus and concretize the role of humans in their *International Journal of Cultural Policy* paper detailing their research on artistic approaches to realizing sustainable development goals laid out by the United Nations. Instead of building on the basis of a division between people and nature the way Horstman does, the authors magnify the relevance of community in the discussion of ecological issues and how to confront them.

Barclay, a member of this creative research team, upholds her argument that ecological sound art projects are fundamentally interdisciplinary, that they require a fusion of art and science along with a thorough consideration of the cultural context. Aiming to "investigate the cultural and biological diversity of river systems through sound" and "actively engage local communities in freshwater conservation," Barclay constructed "River Listening," a study of hydrophone recordings of underwater soundscapes from the Noosa River in Queensland, Australia (Grant et al., 2021, p. 6-7). In the process of this project, Barclay consulted those with expertise in ecoacoustics and aquatic biodiversity, including First Nations' Peoples. She then paired the soundscapes with voices and stories with the intention of "immersing listeners in life above and below the surface" (Grant et al., 2021, p. 7). The press and global attention given to the launch and experience of the respective sonic installation "proved valuable in engaging communities in river conservation efforts, facilitating a stronger understanding of freshwater ecology, and drawing awareness to the effect of the climate crisis" (Grant et al., 2021, p. 7). The making of "River Listening" is an influential example not only because it accounts for the intrinsic cultural component of the ecological issue at hand, but also because it points to the efficacy of assuring a community's understanding of the issue. Barclay's project allows people to observe, to hear for themselves, making for an awareness of more than the mere fact that the environment, or freshwater specifically, is in danger.

In her contribution to composer and computer musician Frederick Bianchi's 2016 collection, *Environmental Sound Artists: In Their Own Words*, Cheryl E. Leonard explicates the ideas and practical methods she applied in her creation of the piece, "Meltwater." Much of Leonard's work is related to her research expeditions and studies of the Antarctic Peninsula.

"Meltwater" was inspired by her perception of the sounds on Amsler Island, which has been uncovered by the dramatic melting of the Marr Ice Piedmont, a glacier that, within the last fifty years, has reportedly receded more than 1500 feet. Leonard wanted to make a piece based on "the abundance of icicles" and "the sonic cataclysms of falling ice and snow" (Bianchi, 2016, p. 55). She made recordings on site, but when she listened back to them, she was not satisfied. Being an instrument builder in addition to a composer and a performer, Leonard made the decision to "re-create what had eluded [her] microphones: the ice gamelan of [her] imagination" (Bianchi, 2016, p. 55). She designed the instrumentation using plasticine clay, latex molds, pyrex beakers, petri dishes, glass, stone, and ice and carefully choreographed a performance, featuring more than one musician, during which melting and disintegration happens on stage throughout the musical composition. She has affirmed that "the effects of human-controlled air temperature on the melting icicles mirror anthropogenic influence on climate change, and highlight the shrinking of glaciers and polar icecaps" (Bianchi, 2016, p. 57).

"Meltwater" can be set apart from many other ecological sound art pieces for two reasons. First, it shows far more than it tells and second, it seems to summon the emotions of the audience members individually. Leonard has professed her belief that "sound and music can be uniquely effective in forging intimate and visceral connections and actually illicit changes and behavior" (Bianchi, 2016, p. 51). She is nonetheless critical of efforts that seek to cause panic; she does not wish to impose the gravity of her work onto those listening. She gives them more agency. In "Meltwater," she leads the audience members through the experience of appreciating the sounds and then realizing and watching as the instrumentation and the scenery lose shape and ultimately disappear. While community is, as has been shown by Barclay, crucial in the means to

confront climate change, Leonard indicates the value, and perhaps even the need, for individuals to personally discern what is at stake and arrive at the urgency of the situation. Moreover, Leonard demonstrates how compelling the point can be made using reproductions of natural sound objects in place of recordings.

IV. METHODS

1. Theoretical Framework

An application of audio technology meant to exemplify symptoms of an ailing planet, this project is not designed merely to draw attention to the environment. It has been created as a means to navigate and activate human engagement with a situation from which no one can be severed. Rather than to conduct an experiment with advanced recording apparatus and capture water sounds with hyper accuracy, the method here has been to synthesize the sounds. That is, to use artistic, technological, tools developed by humans to make something modeled on a purely environmental resource. Doing so demands an appreciation for that resource, for water, on a palpable and a philosophical level. Water has both literal and figurative weight. Synthesizing the sounds requires thinking about the texture and consistency of water and considering the sensation of hearing it, touching it and even being submerged. Moreover, water is an indication of life. Humans cannot survive without it and yet, as is made progressively clearer by extreme weather and other consequences of the global temperature increase, access to clean water is not something that can be taken for granted.

The perceptual separation of people from their physical environment is a false delineation. Validation of this statement comes from a number of directions including viewpoints

established by geophysicists and marine biologists. In a study confronting anthropogenic cacophony, Duarte et al. (2021) confirm that "Climate change is increasing the number of cyclones and marine heatwaves that degrade marine habitats" (Duarte, 2021, p. 5). As a result, "Ocean soundscapes are rapidly changing because of massive declines in the abundance of sound-producing animals, increases in anthropogenic noise, and altered contributions of geophysical sources, such as sea ice and storms" (Duarte, 2021, p. 1). The data in this study plainly illustrates that it is no longer possible to listen to the sounds in and of the ocean without the audible impact of human exploits. Efforts to instantiate a dichotomy are works of fiction.

This audiovisual experience employs surround sound and video formats in a way that, at several moments, intentionally engenders a sense of disorientation. The purpose of this unsettling characteristic is not only to accentuate the disturbing gravity of the issue at hand, but also to represent the need for a response, to emphasize that there are questions to be addressed. These are troubling unknowns that call for investigation. What is certain is that the answers must account for the complexity of the problem; actions taken have to be interdisciplinary in order to be effective. The task cannot rest on one sector. It is a matter of science and policy and community and art. It is relevant to society and to the individual. In this film, manipulation of familiar sounds and scenery seek to concretize the universal magnitude of what is taking place on Earth right now, and thus serve as one artistic constituent of the aforementioned response.

2. Influences in Practice

The creative and technological process of making this soundscape composition has been influenced by the work of multiple artists, including, but not limited to, that of the four

introduced in the Background (Section II, part 3): Annea Lockwood, Hidegard Westercamp, Carsten Nicolai, and Laurel Halo. To be more specific, ideas for the conceptual impetus have come most notably from projects by Annea Lockwood and Hildegard Westercamp, while inspiration for the stylistic choices can be found in the electronic music made and performed by Carsten Nicolai and Laurel Halo.

In 1982, Annea Lockwood presented the composition, "A Sound Map of the Hudson River," the first in a series of installations constructed from sounds of rivers across the world. As described by Professor of Philosophy and curator of sound art, Christopher Cox in Sonic Flux: Sound, Art, and Metaphysics, the piece involves an extensive "catalog of noise textures drawn from the entire length of the [Hudson] river" (Cox, 2018, p. 134). He goes on to explain that "auditory volume is linked to the volume and rate of the river's flow as it widens and accelerates downstream. The piece ends in the thunderous pulse of surf as it crashes on the shore of Staten Island" (Cox, 2018, p. 134). Of the series as a whole, Cox claims that each of Lockwood's recorded river samples "is not merely a unique particular, but a microcosmic portal– a sort of Leibnizian monad– that opens out onto a vast geological and biological history" (Cox, 2018, p. 134). In the later installations, such as, "A Sound Map of the Danube" and "Bayou Born (For Pauline)," Lockwood has approached the creative work in what *The Wire*'s environmental journalist Louise Gray calls, "a very geological way of representing the sound envelope- the attack, the sustain and then the decay. It's a way of short circuiting the expectation built into so much music, a way of working with minimal material for maximal results" (Gray, 2018, p. 28). Although this thesis concerns synthesized water sounds, rather than samples obtained through field recordings, Lockwood's river series remains decidedly relevant. The soundscape presented

here is shaped dramatically by noise textures and seeks to maximize the immersive experience with minimal material, both in terms of the sounds and the visuals. Even more directly, the narrative progression in "A Sound Map of the Hudson River," the deliberate variation in the volume and the culminating crash, serves as the basis for the development of the narrative staged in this audiovisual project.

Hildegard Westerkamp (2002) states that "each soundscape composition emerges out of its own context in place and time, culturally, politically, socially, [and] environmentally" (Westerkamp, 2002, p. 52). She writes on the conceptual foundation that supports the soundscape composition and its relationship to acoustic ecology. While she does not insist that soundscape compositions must, in all cases, be rooted in environmental activism, she does point to the breadth of opportunity in this particular medium to "awaken our curiosity and to create a desire for deeper knowledge" (Westerkamp, 2002, p. 52). The soundscape composition has the power, Westerkamp contends, to be used as "an ecologically meaningful language" (Westerkamp, 2002, p. 53). Out of Westerkamp's many works, the two that can be clearly identified as sonic references for this project are the composition *Talking Rain* and the multimedia installation *Seascapes*. Along with their common emphasis on water sounds, these pieces are audibly strengthened by the attention given to spatial elements. Westerkamp's sense of movement in these pieces is emulated and magnified in that of the production and mixing of this soundscape. It is therefore both the decisions she makes in regard to sound design and the ideological bedrock upon which she makes them that actively inform the different layers of this thesis.

Much of the creation of this soundscape is the result of noise oscillation. Carsten Nicolai uses noise in his electronic compositions in various ways, experimentally manipulating the

collections of frequencies to different effects. In the article, "Sounds of the system: the emancipation of noise in the music of Carsten Nicolai," Adam Collis (2008) thoroughly deconstructs the solo album *Autorec*, which Nicolai released under the pseudonym, "noto" in 2002. Collis argues that on *Autorec* and other records, "Nicolai has introduced noise not just at the source of composing, but at the point of consumption; background noise of the audio system has been brought into the foreground, shaped and structured" (Collis, 2008, p. 37). *Autorec* demonstrates how meticulously and innovatively noise can be curated in a musical context. In addition to the exemplary noise-based sounds in the tracks, the album leans into the theoretical side of immersion that is crucial to this thesis. Collis indicates that "the noise encourages the listener to become, not just a destination, but a component in and observer of the communication system" (Collis, 2008, p. 38). That notion is essential to the design of this audiovisual production in regard to the role and the abstract positioning of the audience.

Strictly speaking, this thesis seeks to convey a compelling sense of space and a coherently immersive audiovisual experience. A description of the intricate psychoacoustics at play in the minds of the listeners/viewers goes beyond the scope of this project. The creative process does, however, reckon with the force of emotional response. Laurel Halo's music is a chosen model for the sonic emotional aesthetic intended to run through the soundtrack for the film. Paula Mejia (2013) of *Interview Magazine*, characterized Halo's work as "emotive, disturbing, and engaging," calling it a kind of music that "stirs movement both in your limbs and in your brain" (Mejia, 2013, p. 1). Halo has expressed that given the chance to score films, she would gravitate towards those "that require an undercurrent of musical urgency that's not on the sleeve, that's more atmospheric. Where shots of desolate landscape unfold over the course of

minutes and seismic decay requires some melted percussion" (Mejia, 2013, p. 4). This vision, along with her published electronic compositions, have contributed to the overall aura of the soundscape composition.

3. Composition Process

3.1 Narrative and Structure

The glaring evidence of climate change is visible in a vast variety of natural events, the greater part of which are directly related to water. Within the aquatic realm itself, there is a range of consequences that can be seen in everything from unusual trends in marine animal behavior to more frequent occurrences of drought. The synthesis of water sounds and the corresponding soundscape composition, the core elements of this project, do serve to represent the perilous situation as a whole, but the sounds and images have also been created with specific ecological issues in mind. It is worth noting here that the objective in this project is not to fabricate some sort of natural disaster that has yet to happen on Earth; it is to present a cogent production of what is, in fact, already happening.

The film experience will revolve around rising global sea level and the resultant danger of storm surges. The audiovisual formulation of the storm surge is based on the actual scientific sequence of incidents that causes this particular kind of event. According to the United States National Oceanic and Atmospheric Administration, a storm surge is defined as "an abnormal rise of water generated by a storm, over and above, the predicted astronomical tides…[It is] produced by water being pushed toward the shore by the force of the winds moving cyclonically around the storm" (NOAA, 2022). Though the geo- and hydrospheric origin is not the same, the event of

a storm surge resembles that of a tsunami or a tidal wave. Weighing about 1000 kilograms per cubic meter, water has the capacity to be tremendously destructive. Much of the horrific damage done in the course of recent hurricanes, such as Katrina, Ike, and Sandy, can be traced back to an associated storm surge and the ensuing floods. In the footage of these storms that is shown by the media, the scenes tend to be captured with both a literal and figurative degree of distance. This project aims to come at the issue from a different perspective, moving away from a news report and towards an experiential reality.

The narrative progression of the film experience has been developed in collaboration with a cinematographer. While her responsibility centered around capturing and compiling the footage, one of the central objectives in this project is to assure that the audio and the visual components are cohesive, that they fit together and communicate a consistent message, even if that message is multifaceted. The audio component contains accurate allusions to realistic sounds of water supported by a musical underpinning. Similarly, the visual component contains representative images, as well as abstraction. Though it is not an entirely literal presentation and allows much room for interpretation, the piece maps out implications of the global increase in temperature, beginning with melting ice in arctic regions, building up to the event of a severe storm surge, and ending in the aftermath. Apart from the opening photographs of ice caps, the film takes on its own means of designing a personal perspective, placing the viewer in the familiar setting of a bedroom. The audiovisual work has been adapted for an immersive space that is set up with a multi-speaker system and surround video capacity. The project has, however, been made accessible in more limited formats, by way of downmixing and reverting to a single screen.

In more detail, the soundscape can be broken down into five conceptual parts: First, the composition leads in with sounds that resemble that of rupturing glacial ice and corresponding avalanches. Second, there is a transitional sonic depiction of the ocean, which initially simulates movement only from side-to-side, along the azimuth. Soon after, the movement heads upward, suggesting a rise in sea level. Third, as the surface of the water continues to gain elevation, intimations of a traveling storm are introduced and gradually brought to the forefront. Fourth, the storm surge occurs, crashing violently across the hypothetical shoreline. Fifth, the flood overtakes the space, leaving every sound and visual object underwater. As these parts take place sequentially, the scale of immersion intensifies, making the sonic occurrences feel as though they are getting closer, escalating in the sense of proximity and danger. This effect is achieved sonically starting with the production of the soundscape, but more distinctively in the mixing process with the application of object-based audio techniques rendered through Dolby Atmos. Rather than mirroring the sounds with predictable oceanic scenery, the visuals illustrate the inundation of an apartment, a common consequence of storm surges. Moreover, instead of showing a home drowning from above, a typical image associated with newstories, the visuals leave the audience inside as the water fills the room and rolling waves finally usurp the surroundings.

3.2 Music

A professor of anthropology at MIT, Dr. Stefan Helmreich makes the following claim in "Tuning Composition to the Sounds of Science," a chapter of The Routledge Companion to Biology in Art and Architecture:

> We can track how technologies of underwater audition are often adjusted to deliver aesthetic experiences in line with the way composers imagine submerged sound should sound; how, to take one example, the notion of water as sublimely immersive can be reinforced in compositions that make use of hydrophonic listening and playback. We can also sometimes discern a querying of dominant thinking about the symbolism of underwater sound. (p. 347)

In addition to sounds emulating those of water and other environmental phenomena, such as wind and thunder, this soundscape composition contains musical elements. The decision to introduce and integrate tonal segments and measurable rhythms aligns in part with Helmreich's claim quoted above. They are catalysts in delivering a certain aesthetic experience and they can be interpreted symbolically. Synth lines predominantly built with sine waves suggest opposing impressions, pinning fear against beauty and depth against vulnerability. Beats signify a way of grasping the passage of time, only to ultimately obscure its regularity. The music melds into the larger soundtrack, a collective means of stimulating reflection. Venturing into the cavernous reach of the imagination, the music also assists in framing the character of the sounds, for instance, casting the traveling storm in the role of a monster. Tonality fitting into sonic tropes of tension provides balance in enigmatic moments.

Later in the chapter, Helmreich continues, stating, "The aesthetic aim in pieces that *evoke* and *invoke* water is a sense of immersion…If the sounds of science saturate underwater music, these sounds are multiply mediated and manipulated" (Helmreich, 2016, p. 349). The potential effect of the music in this piece is also a product of its spatial content. The motion and variation in breadth of the tonal and rhythmic fragments relative to the listener inform more than location.

They help to tell an immersive story. As Helmreich affirms, the sounds have been extensively manipulated, which, in this case, is true for the representations of environmental sounds as well as for the music and how these elements interact. Furthermore, immersion is not the kind of sense that can be described by one emotion or physical sensation. It summons the compound meaning of presence. It is externalizing and concurrently visceral. Music is a discipline that can communicate the kaleidoscopic quality of the experience. When honing in on the underwater design here in particular, the immersion is meant to achieve ubiquity, but rather than appealing to the glory that may be discovered in a spiritual sound bath, it leads the listener to realize there is no way out. Musical phrases guide the experiential intent of the piece. The subject of climate change is often portrayed in extremes; the conversation seems to exist in an aura of doom or a rush of optimism. In a pursuit of realism, the composition fades out on a note of uncertainty and opportunity.

3.3 Synthesis Techniques

The procedure for this project entails the utilization of multiple tools. The first phase of production concerns the synthesis of the water sounds. This task has been carried out in two virtual synthesizers in the Digital Audio Workspace (DAW), Reason. The first is the "Malström Graintable Synthesizer," a virtual instrument that blends attributes of granular synthesis with those of wavetable synthesis. The most useful features for the purpose of this project are its two oscillators, which operate on granulated waveform samples, and its shaper function, which allows for the introduction and modification of distortion. These functions have facilitated the construction of sounds that symbolize the approach and arrival of a storm. The second is the

"Thor Polyphonic Synthesizer," a semi-modular synth with an expansive array of filters and oscillators. It has a distinct noise operator that wields the capabilities of both a noise oscillator and a noise generator that can be applied to several different types of noise. The two with the prominent roles in this soundscape composition are manipulated white noise and pink noise. (Images of these instruments can be found in the Appendix section, Figures 1-3.)

A preliminary soundscape was produced in stereo with the instruments described above and the addition of audio effects in both Reason and Pro Tools. Although the final output is a result of synthesis as opposed to field recordings, production audio was captured on site with the cinematographer. These recordings were used as references to optimize likeness and/or the quality of realism, when needed. While the 3D soundscape composition came together in parts, one of the central intentions of the project was to assure a symbiotic connection between the soundtrack and the visuals. For that reason, close attention has been given to the visual scenes and the design of the corresponding audio segments, as well as to the transitions between them. The 3D mixing process began after the consolidation of the soundtrack. Along with the broader goal of spatializing the composition, Dolby Atmos technology has been employed to drive the simulation of motion in particular, a fundamental theme of the experience. Although the soundtrack was created in the contextual frame of the visuals, the pairing of the components is of the utmost importance. On that account, additional steps were taken after the soundtrack was mixed in Dolby Atmos in the interest of closely aligning the audio with the visuals and thereby discerning whether any of the audio elements had cause to be altered.

Taking a more thorough look, the main technical steps that equipped the precise production of this piece are as follows: As has been mentioned above and alluded to in the

Background, one creative strategy is noise oscillation. Although varying levels of noise pervade much of the composition, there are specific instances in which noise carries the bulk of the audio narrative. The opening of the film places the audience in glacial territory. This distinctive soundscape calls for consistently confrontational gusts of wind, splintering ice, and resounding signs of an imminent avalanche. In order to represent these features, noise was generated, oscillated, modulated, equalized and layered. Curated deviations in the frequency, pitch, resonance, and intensity of the noise intimate active surroundings and follow the theoretical implication of movement. Noise is also central to the climactic storm sequence. Along with denoting the high winds, the noise adds density to the deluge, embodying the surging aspect of the water and thickening the comprehensive texture of the sound in that scene.

The composition has been built on the foundational operation of wave manipulation. With the exception of the programmed drums, which will be addressed in more detail later in this section, every sound in the piece has been produced by means of manipulating the distinguishing features of waveforms. The raw material that served as the source for the water sounds changed depending on the desired state and activity of the water. Individual droplets were created with varying techniques and effects to ensure contrasts in timbre and to thus avoid unintendedly repetitive content. Starting with a sine wave made for sounds with sharper, heavier impacts and was especially useful in the effort to produce bubble sounds. Starting with noise allowed for a softer, more fluid texture to emerge. The tonal segments were predominantly based on sine and triangle waves, though some of the musical backdrop that accompanies the underwater sounds is a product of phase modulation between a square and a sawtooth wave.

Next, much of the achievement of the likeness of these sounds to those of water can be attributed to the audio effects and their resultant transformation of the noise. Equalization (EQ) and the associated filter settings were implemented in the task of initially isolating fractions of the noise signals to best fit the kind of water sound needed. After securing the EQ measures, the sounds were run through Reason's "BV512 Vocoder." Adjustments made to the number of filter bands functioning through the vocoder altered the degree of intelligibility when it came to distinct droplets as opposed to a collective downpour or underwater submersion. The vocoder also shaped the progression of rainfall into tempestuous streams. This device additionally features the option to enter Fast Fourier Transform (FFT) mode for optimal clarity. The combination of working in FFT mode and devoting close attention to the attack and decay proportions created a range of energy and fluidity in the sounds, influencing the mood of the given scene. These parameters, along with that of the shift knob, which controls the frequency levels of the underlying filters, affect the listener's impression of the sounds' proximity as well, though the bulk of the spatial information presented has been assembled in the mixing process.

One of the most significant issues alluded to in this film is that of rising global sea levels. It is a pressing oceanographic problem that directly causes destruction in the context of human lives. In order to represent the issue with sound, there were choices to be made regarding the degree of accuracy and the question of what would be most creatively effective. These choices came up at multiple points throughout the composition process. Making the decisions was a somewhat delicate matter because the accuracy of the sounds does not ensure experiential efficacy. The narrative and motivation behind the film had to be considered along with the literal nature of the synthetic model. With these principles in mind, the rising sea level segments were

characterized by bubbling sounds layered on top of a low frequency drone made with a sine wave. The formative audio effects at play were expansive reverberation and a parametric EQ that was automated to move between radically dissimilar settings. The combination derived pronounced pops happening at different frequencies with trailing delay tails that overlapped. Sparse additions of pitched noise and musical elements strengthened the atmospheric tension. This method prevented the monotony that could have come with a more authentic sonic reproduction of rising water. It also echoed the intent for events to sound as though they were occurring in very close proximity to the listener.

The remaining compositional tool used is the Reason "Redrum Drum Computer," a virtual matrix drum sequencer with which beats, a distinctive part of the piece, were programmed. As is touched on in the earlier analysis of the musical elements (Section IV, part 3.2), the minimal rhythmic lines facilitated control over the theoretical passing of time. They also strengthen the dimensions of the low end. Finally, the beats serve as valuable material to be spatialized in the mixing process, contributing to descriptions of both location and motion.

3.4 Mixing Techniques and Object-Based Immersion in Dolby Atmos

The method of spatialization in this project is object-based. A breakdown explaining how object-based audio works can be found in the discussion of immersive sound design that appears in the Background (Section II, part 2). The implementation of this method was carried out with the Dolby Atmos renderer. In the mixing process, metadata was assigned to 37 sound objects. The content of the metadata was defined by choices made in the Dolby Atmos software system accessed through a connection to Pro Tools Ultimate and a mixing console with 3D panning

capabilities. These tools made it possible to both place the sound objects in distinct locations and to orchestrate motion. In addition to monitoring the dynamic levels and positions, particular attention was dedicated to adjusting the elevation and width of certain objects, not only to manifest rising water, but also to intensify immersion gradually throughout the film. While opening occurrences come from discernable directions and go on to make sharp turns, the final scene fills the space, extending the breadth and the reach of the sounds. The intended idea associated with this progression is less about conveying a defeatist sense of having drowned and more about indicating to the audience that they are at the center of the event, that the situation is relevant to them, and that to prevent an irreversible descent, they have to find a way to swim.

3.5 Visuals and Audio-to-Video Synchronization

The visuals for this project were constructed collaboratively, involving the input of two NYU Tisch graduate students: a cinematographer studying film and a set designer in the Interactive Telecommunications (ITP) program. Beginning with in-depth storyboarding sessions, the cinematographer, set designer, and sound designer realized a production plan. The shoot entailed filming through a 75cm x 15cm x 20cm glass aquarium to carry out the effect of water flooding a bedroom. Footage was captured with a Sony A7iii camera and a Sigma 14-24mm lens from the angle of each wall in order to visually place the audience in the middle of the action. (Please see associated images below and in the Appendix section.) An Aputure 300d Mark ll LED light was used to simulate the lightning in the storm sequence. The final scene unveils a projected video of rolling waves superimposed on a shot framing a window. Sourced images of glaciers were also added in post-production.

The audio and visual media were created in correspondence with each other and edited after the fact. While it does not simply provide an aural report of what is happening on screen, the soundtrack was still mapped accordingly in the composition process, and precisely synchronized with the video in Pro Tools, before it was mixed. The water sounds and the musical elements were positioned specifically in time, as well as in space, to follow and to optimize the audiovisual narrative.

V. FINDINGS AND DISCUSSION

1. Symbiosis

Creating distinct water sounds and making a symbiotic piece presented divergent challenges. In the production process, there was a constant consideration of the realistic quality of the synthesized sounds against their compatibility, first with one another, and next with the musical elements. Repetition of the water sounds had the potential to strengthen or weaken the

desired effects depending on the pursuit at hand. For instance, the extended segments of flowing water needed to feature fluctuation, but only back and forth within a limited range of frequencies and textures. Recurrence of the droplets, however, had to be dispersed deliberately and sparingly in order to elude conspicuous patterns. Moreover, any variation in pitch had to be engineered in the context of the given tonal backdrop. There were, evidently, numerous factors at play with the propensity to clash. While the production eschewed unwelcome, intrusive dissonance, the sounds tended to retain their resonance as individual objects. Introducing motion in the mixing process established a separation in space, which only further accentuated the contrast between the sounds. The disparate nature of the objects did complicate the task of melding the sounds together into a cohesive composition, but it also facilitated the rendition of the narrative and the transitions between thematic developments. These findings are undoubtedly related to the expansive use of white noise in the piece as there is inherent difficulty in consolidating sounds that include random signals as well as calculated harmonies. One response to this issue was to group certain sounds and isolate others when it came to spatial choices and dynamics. This way, each of the scenes could have particular sound objects in leading roles that were, so to speak, backed by supporting characters.

Synchronizing the audio with the visuals summoned questions about pacing and the resultant experiential impact. The degree of tension had to be regulated in a way that would hold the audience's interest while steering clear of both chaos and tedium. In order to do so, the audio and video events were aligned more on the basis of the narrative and the creative framework than on exactly what is portrayed visually. The main objective in the process of synchronization was to make a compelling and cohesive film as opposed to directly matching one medium with the

other. It was, in turn, also imperative to ensure that the sounds and the visuals were working together, rather than competing or causing a sense of distraction. This concern was, at least in part, alleviated by the complementary approaches to the use of motion and stillness in the different components. That is, the sound objects fly dramatically throughout the space, as defined by their multidirectional metadata. The visuals ground the audience in a set location and motion is purposely depicted only in the water and the sporadic lightning that strikes during the storm. As such, wielding the immersive tools was a sensitive matter of balance.

Producing with specific influential artists in mind led to decisions that made the musical elements a more prominent part of the piece than originally imagined. As is true for many of his records, on his album, "HYbr:ID I," released in 2021, Carsten Nicolai exemplifies his dexterous ability to give noise rhythmic, and even melodic, attributes. Taking cues from Nicolai's work and putting them in conversation with Laurel Halo's minimalist techno tracks inspired a strong accentuation of beats throughout this composition. In early drafts of the soundscape, the beats were hidden behind everything else. The choice to reveal them more clearly helped to fortify the narrative and enliven the piece all around. It also enhanced the presence of the tonal synth lines, which initially seemed to stand out in a somewhat cumbersome way. The interrelation between the beats and the predominantly sinusoidal wave sounds provided a continuous musical means by which to blend and cushion the water sounds and transform the streams of noise.

2. The Place for this Project in the Field of Ecological Sound Art

As a whole, this project made significant moves away from established trends in environmental art and historical approaches taken to soundscape composition. The context of

climate change is a common thread, but the methods applied to creatively address the situation are fundamentally different, in terms of both music and technology. Pioneers of soundscape composition including Annea Lockwood and Hildegard Westercamp made pieces that revolved around the method of field recording. Capturing these live sounds of environmental phenomena was not simply a procedural activity; it was a core element of the compositions and of the communication of the environmentalist message. Making the field recordings was in itself an exercise in devoting attention to the earth and sharing them was an invitation for the listener to do the same. While this thesis is intended to spread awareness, it is also meant to stress the need for action and to concretize the threatening realities and consequences of global warming. The ailing state of the planet today is indisputably more serious and alarming than it ever has been in the current geological age. This audiovisual experience is set in the present day crisis where the endeavor of protecting the environment has to take what is happening to *people* into account, as well as illustrating what is happening to natural resources. Synthesizing the water sounds and engaging with techniques and styles of electronic music brought social and creative human practice into the discourse, expanding upon the concepts in Fritz Horstman's piece in the "Imagining Water" series detailed in Section III, part 3. Implementing object-based audio placed humans in the middle of the issue. There is effectively no distance or dichotomy between the fate of the environment and that of its inhabitants.

3. Expert Opinions

The completed film was shown to a panel of professors and Ph.D. students, all of whom have expertise in both audio technology and music composition. After the screening, they offered

their first impressions and went on to critique specific elements of the piece. Their responses were almost entirely positive and the overall project was unanimously deemed successful. More specifically, the experts indicated that the structure, pace, and length of the composition worked well. They were able to "get lost" in the experience without distracting thoughts about the duration. They found the water sounds to be realistic and confirmed that the sound design and the musical components were seamlessly symbiotic. Furthermore, the audio segments clearly complemented each visual scene. There were conflicting opinions about the ending, some saying that it meandered and others suggesting that the sounds in the final sequence helped to "bring [the audience] back down" after the storm.

On the subject of immersion, some thought the piece could have benefited from more spatial effects that changed the perspective of the audio in different parts of the room. The panelists discovered that they preferred the experience when they were sitting and turning their heads, as opposed to walking around the space. In this particular presentation of the film, the visuals were wide and short, filling the projector screens horizontally and taking up a narrow, centered section vertically. Although this display may have curtailed the factor of immersion, one professor reported that this format made the audience focus. Another proposed that it allowed them to see what was happening through a window, rather than potentially being overwhelmed by floor-to-ceiling imagery. With these comments in mind, the immersive quality of the piece is an area that can be developed and improved both in terms of the audio and the visuals. Future iterations could call for more in-depth experimentation based on the characteristics of the performance space to invigorate the experience.

In regard to the meaning of the project, the experts explained that while other films related to global warming induce climate distress, and abandon the audience in a sense of doom, this film relays a slow shock, “a call to action, but not a terrifying one.” Moreover, the choice of having scenes precede and follow the storm communicated the idea that climate change is “a continual thing we have to pay attention to all the time, not just when it really goes out of hand.” It leaves the audience concerned, but not scared, ultimately wondering, “What can I do?”

VI. CONCLUSION

This creative project applied techniques in electronic music composition and immersive audio to address threats of climate change. Among the consequences of global warming, issues related to water are manifold. Water is a natural resource that is both indispensable to life and capable of causing disastrous damage. With these realities in mind, this audiovisual piece was designed with a focus on water sounds and accompanying videography. Virtually synthesized water sounds and musical elements were rendered as sound-objects with Dolby Atmos technology to create an immersive experience. Experimenting with different approaches to synthesis allowed for a diverse collection of water sounds and object-based audio provided the means to position these sounds in space and physically move them around dramatically. Together with the visuals, the soundtrack follows the narrative of a storm surge, a manifestation of the climate crisis that has become disturbingly common. Rising temperature melts ice, elevating global sea level and increasing the prevalence of cyclones, which can culminate in tidal surges. These events violently destroy property and harm communities. When such an occurrence is covered on the news, there is a comprehensive separation between those watching and those

suffering. The goal of this thesis has been to accentuate the gravity of the situation and more importantly, to illustrate that the risk factor is universal. Climate action will be most effective if taken on a unified front with interdisciplinary support.

The film and the respective composition process do fit into the specified description of Ecological Sound Art. There are, however, few, if any, directly comparable productions. The principal innovative characteristics include the immersive sound design rendered in Dolby Atmos, the accompanying narrative visuals, and the musical structure and presentation. It is also relevant to recognize that this project is an adaptable installation. It has been designed in a way that allows it to be reconfigured and shown in various spaces. This aspect provides the potential to reach larger audiences and to procure unique effects, similar to the allure of live performances. Immersive audio and film are media that auspiciously lend themselves to this kind of ecologically-conscious application. The condition of the environment is something of a stature that can be hard to fathom. It is bigger than political administrations and international alliances and it is a constant concern. With these attributes and the fact that there are no simple answers, the issue gets avoided. Immersive audio and film experiences can be harnessed as visceral reminders, not only of the climate crisis itself, but of the profound human connection to and dependence on the earth. They can create a corporeal space where the cries of the climate can be heard and understood instead of muffled and presumably ignored.

In the past six months, drought and heatwaves plagued Europe, floods inundated Pakistan, and Hurricane Ian struck Florida. The combined death toll was at least 28,178[1] people. These fatal occurrences cannot continue to be transitory headlines. The only response to extreme

[1] This statistic was a summation of numbers reported by *Le Monde*, the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), and the *New York Times.*

weather and the prohibitive demands of relief efforts can be the will to prepare for the effects of climate change and to prevent further loss of life. This thesis offers evidence that methods in music technology constitute an opportunity to contribute and to do it creatively.

VII. APPENDIX

Figure 1.
This image displays a patch made with the "Thor Polyphonic Synthesizer" in Reason. The noise oscillation features appear on the left side; in this patch, white noise has been selected. The filters are applied with a sinusoidal waveform. Below this synthesizer is the "BV512 Vocoder," which is modulating the signals produced by the synth in FFT Mode.

Figure 2.
The following image shows a patch created with the "Malström Graintable Synthesizer," which produces sounds using features of both granular and wavetable synthesis.

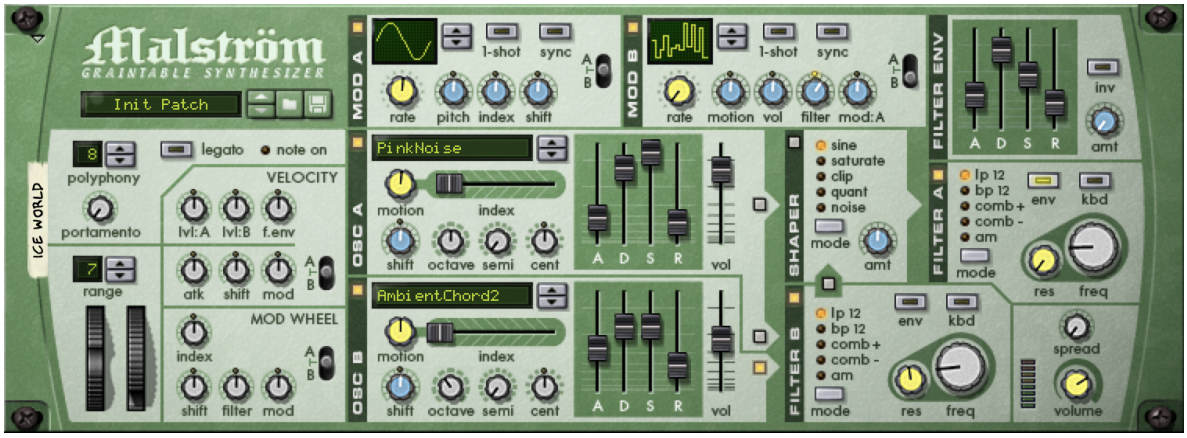
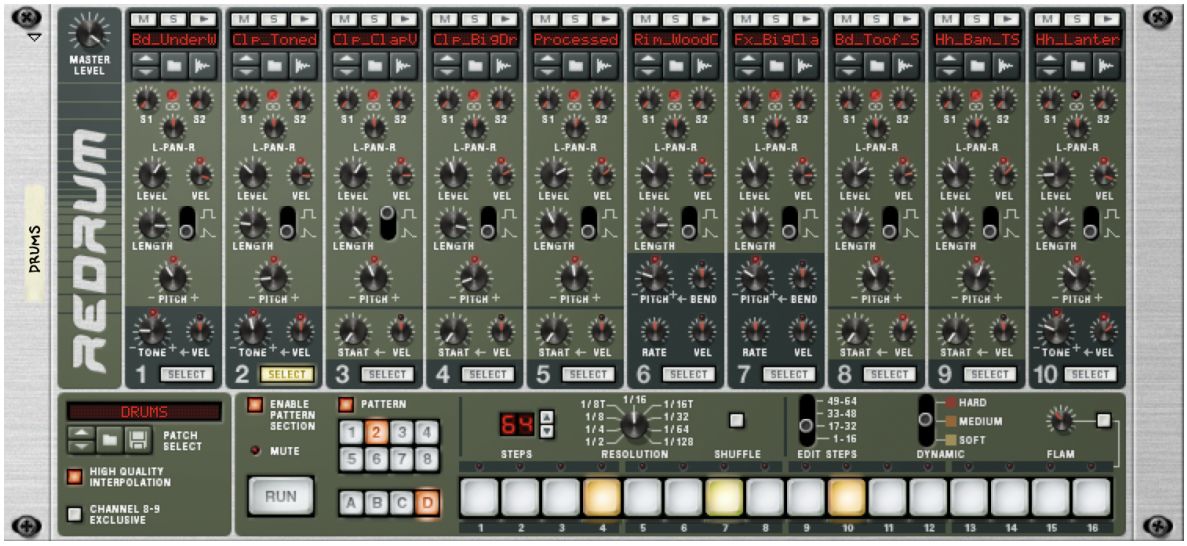


Figure 3.
Drums were programmed with a Reason matrix sequencer, the "Redrum Drum Computer," pictured here.



Figures 4. and 5.

As shown below, video footage was captured through a 75cm x 15cm x 20cm glass aquarium with a Sony A7iii camera and a Sigma 14-24mm lens from the angle of each wall of a bedroom.

Figure 6.
Sounds were spatialized in the Dolby Atmos Renderer. The circles outlined in blue on the left side represent the 37 sound-objects that make up the composition.

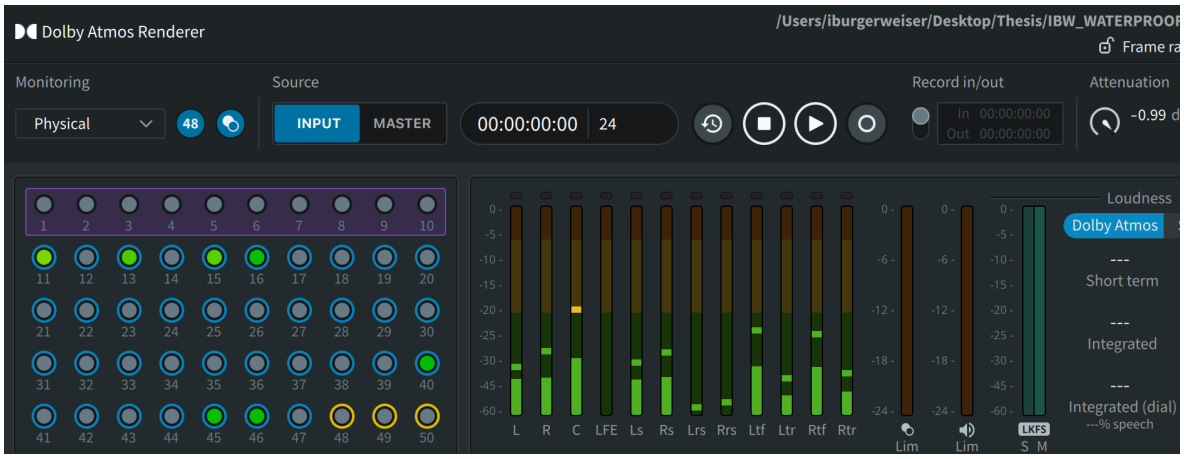


Figure 7.
As can be seen on the left side of this image, in this instance, all of the speakers, apart from the LFE, are active. The positions of the sound-objects are visually represented in the renderer as green spheres on the right side. The size of the ring around the spheres depends on the width of the sounds.

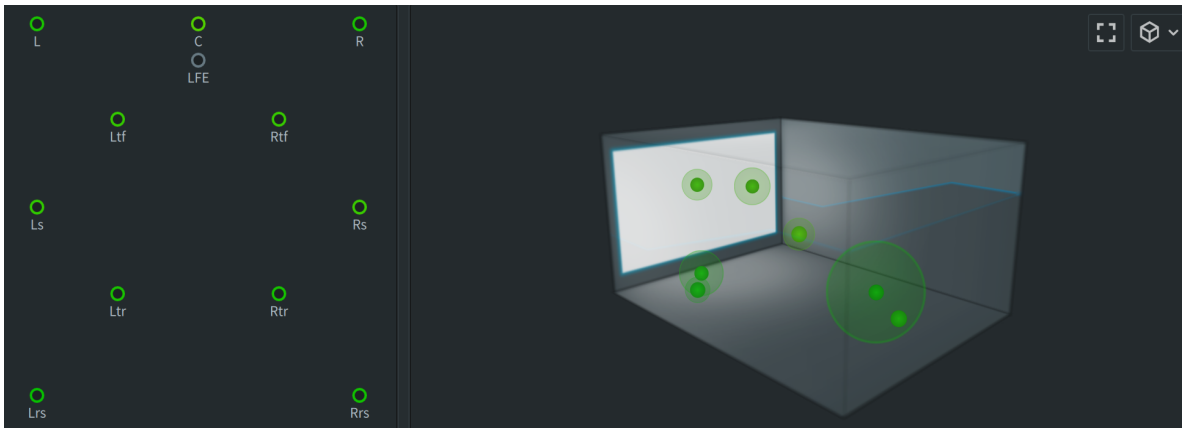


Figure 8.

The mix was processed using the object-based channel settings in Pro Tools Ultimate. The orange circles above the faders represent the panning automation defined for each sound-object. This image of the mix window shows 15 of the 37 tracks in the session.

Figures 9. and 10.
The opening scene of the film is a sequence of images depicting glaciers representative of melting ice caps.

Figures 11. and 12.
The second scene depicts a bedroom that is filling up with water. In addition to illustrating severe flooding, this scene alludes to the issue of rising sea level.

Figures 13. and 14.
An Aputure 300d Mark ll LED light was used to simulate lightning striking in the storm sequence. This scene was shot at night to accentuate the effect.

Figure 15.
The final scene is a shot of a window in an apartment that was superimposed on top of a projected video of rolling waves. The idea behind this shot is that everything, including the world outside of the window, is now at the mercy of the water.

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