



Oceans sing, are you listening? Sounding out potentials for artistic audio engagements with science through the *Polar Sounds* project

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ABSTRACT

Acknowledgement of the growing crises facing our oceans has seen the increased visibility of watery spaces in policy initiatives and governance strategies. A good example is the United Nations Decade of Ocean Science for Sustainable Development (2021–2030). This international effort is designed to coordinate activities (from regional to national levels and beyond) that promote and develop knowledge of our seas and oceans to manage them for future generations. Societies everywhere, the Decade admits, are disconnected from these issues and despite the apparent growth of awareness (through popular televised documentaries and other public outputs that highlight the plight of ocean worlds) finding avenues to increase public understanding of ocean science in innovative and inspirational ways is being seen as critical for further engagement. In this article, we discuss efforts to connect society with the sea, focusing on how *sound* is a productive sensory medium for promoting ocean understanding. Drawing from a worldwide art-science collaboration, *Polar Sounds*, which united scientific acoustic data with musicians and sound artists around the globe, we make audible the potentials of embracing what is *heard* in our ocean worlds. The Ocean Decade alongside growing academic scholarship posits that ocean engagement, citizenship and connection is crucial to harness change that can improve the fate of flailing seas and that art-science collaborations can be crucial in building such bridges. We outline the *Polar Sounds* project, before arguing the need for further work that *sounds out* the potentials for engaging and inspiring alternative oceanic understandings and connections.

1. Introduction: Audible oceans

Sound and the global oceans have a unique relationship. Indeed, as [1] note, “[s]ound is the sensory cue that travels farthest through the ocean and is used by marine animals, ranging from invertebrates to great whales”. It is a crucial way in which such life is able to “explore the marine environment” and for species to interact (ibid. 2021, 1). Sound, for many organisms, is a much more effective cue for communication and gathering information than visual or olfactory cues, since these often only function over relatively short distances [2]. Sound can travel over hundreds of kilometers and provides information on distant conspecifics gathered in a feeding aggregation, it can provide insight during migration on the distance to oceanic features such as currents or the sea ice edge and can also signal to animals the presence of potential predators [3–5]. What is more, in contrast to the soundscapes that we experience on land, the scales that underwater sound travels to is significantly further creating entirely different spatial dynamics and sound environments [6]. To illustrate, Antarctic blue whale vocalizations in the Southern Ocean are estimated to range over 100 km,

remaining present in Southern Ocean waters year-round and thereby contributing an almost omnipresent background ‘hum’ in soundscapes across the Southern Ocean basins [5,7]. Although the Antarctic blue whales may be foraging in the open ocean, their hum forms the bass to the sound environment of all ocean life in this region.

For Ocean scientists too, sound is fundamental for increasing an understanding of the sea. Analysing acoustic data can provide valuable information on soundscape quality, species distribution and community compositions, especially when using other senses, such as sight, is impossible. In some cases, inferences on animal behaviour can be made, for example, when understanding calls typical for mating displays [8]. Acoustic data also provides information on cultural and social processes, such as for humpback whales, which produce population-specific songs that evolve and, in some populations, completely revolve between years (see [9]). Sound also offers scientists a way of understanding how ocean environments are transforming. Indeed

Ocean soundscapes are rapidly changing because of massive declines in the abundance of sound-producing animals, increases in

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anthropogenic noise, and altered contributions of geophysical sources, such as sea ice and storms, owing to climate change. As a result, the soundscape of the Anthropocene Ocean is fundamentally different from that of preindustrial times, with anthropogenic noise negatively impacting marine life. ([1], 1)

Sound can thus capture the very nature of anthropogenic change in the oceans and so when thinking about interacting with various publics about these changes, it makes little sense not to engage, then, with this sensory register. Indeed, sounds have the power to fascinate listeners directly and emotionally, encouraging deep and personal experiences of shared feeling [10]. Ocean sounds have for decades captured the public's imagination, and as innovations in technologies have made these sounds more accessible, so has the public's connections to various imaginaries of the deep ocean [11]. In the 1970's, for example, bio-acoustic researcher Roger Payne used naval recordings of humpback whales, sharing these with the public via a vinyl record that went multiplatinum. On its release it sold "125,000 copies, making it the most popular nature recording of all time" [12]. Later, "in 1979, an extract from the album was sent to all National Geographic's 10.5 million subscribers. This made it the largest single pressing in recording history – a record it holds to this day" (ibid. 2020). More recently sound artists such as Douglas Quin, Jana Winderen and Chris Watson, have popularised the sounds of ocean worlds, using them in various ways for their work. Ocean sounds' potential for being used as a source for inspiration and engaging with the public is therefore wide-ranging.

In this article, we further *sound out* the potentials of audio for engaging multiple audiences with both ocean worlds and the crises that human induced activity is enacting upon on them. Our title, 'Oceans sing, are you listening?' takes inspiration from [13] book, *Spaces Speak, Are You Listening?*, taking this to sea. We discuss a novel sound project that aimed to bring ordinary people and non-scientists into contact with a rarely heard space and rarely heard ocean sounds, via acting either as artists interpreting these sounds, and/or listeners engaging with them. Whilst sound has not been entirely absent from the realm of public engagement with the oceans, art-science collaborations – which are becoming an important aspect of disseminating knowledge and building (ocean) literary about environmental change – are predominantly still visually-driven [14]. This makes a lot of sense as efforts to remedy a 'sea blindness' that keeps the plight of the oceans beyond the reach of many, has taken priority (see [15-18]). But the pervasiveness of sound – the fact it may be accessed by publics 'on the go' rather than 'in the gallery', might afford other opportunities. In sum, the oceans sing, and if they sing, we might ask in which ways can people listen to them.

Drawing from a worldwide art-science collaboration, *Polar Sounds*, which united scientific audio data with musicians and sound artists around the globe, we make audible the potentials of embracing what is *heard* in our ocean worlds. The Ocean Decade alongside growing academic scholarship posits that ocean engagement, citizenship and connection is crucial to harness change that can improve the fate of flailing seas and that art can be crucial in building such bridges (see [19, 20], Jung 2022). Indeed, art that has used sound has often looked to the environment for inspiration, and the Anthropocene has become a prominent feature for creative exploration in such works [21]. Thus, our intervention comes at a time when attention to the sonic is increasingly explored. In this article, we outline first the growing importance of art-science collaborations and the emphasis of global initiatives to use such creative methods to build ocean stewardship. We do so by emphasising the potential sound has for being a fundamental tool in this process. We then outline the *Polar Sounds* project and its rationale, discussing how this project was developed and the potential direction we will guide the research that will come from it. We finish by arguing for the need for further work that continues to explore the potential for engaging the ocean's soundscapes, to inspire alternative oceanic understandings and connections.

2. Art-science efforts, the Ocean Decade, and the possibilities of sound

In 2021 the United Nations (UN) launched a flagship mission to build the 'science we need, for the ocean we want' through a Decade long effort to put oceans firmly on the agenda. The UN Decade of Ocean Science for Sustainable Development (2021–2030) ('Ocean Decade', or 'Decade' for short), represents a coordinated global push through top-down and bottom-up actions to create and share ocean knowledge ([22], see also [23]). Part of this attempt focuses on the need for ocean engagement, citizenship and connection by the public as a necessity for harnessing change. There are various kinds of creative exchanges that have developed (and are continuing to develop) under the Decade's aim towards "an inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development". One way this is being enacted is through art-science projects.

As of 2023, there have been no less than 10 specific art-science programmes listed as 'Decade Actions' – including critical cartography projects, artist in residence schemes at ocean institutes, collaborations with the Royal College of Art, UK as well as an Ocean Science Jam endorsed by the UN Decade and developed by the first author of this paper which brings musicians, artists, dancers, performers and marine biodiversity scientists together to respond creatively in real time to visual and audio cues based on a theme related to marine scientists' work.¹ Focus for these projects tends to be about making the hidden, distanced, deep and marginal oceans visible through creative pieces – from music, painting, collage, mapping, photography, to film, cartoons and comics.

Yet knowing the oceans and sharing knowledge of them can prove challenging. Vision has tended to dominate ([24]; Wissmann 2014). As Stokes contends, "social experience insistently privileges the visual" and academic disciplines "unerringly continue to reproduce this fact" (1997, 673). In a TED talk given by Rose George in 2013, the journalist discussed a phenomenon known as sea blindness, a condition prevailing across our largely landed society [25]. As she noted,

...a few years ago, the first sea lord of the British admiralty... said that we, and he meant in the industrialized nations in the West... suffer from sea blindness. We are blind to the sea as a place... It's just something we fly over, a patch of blue on an airline map. Nothing to see, move along... (TED, 2013)

George was to attend to her own sea blindness by joining a container vessel, the *Maersk Kendal*, and setting sail with its crew from Felixstowe, UK to Singapore. The journey is mapped in detail in the book *Ninety Percent of Everything*, where George makes visible hidden worlds at sea (2013). She is not the only author and journalist who has aimed to make seen, our hidden ocean worlds. In 2004, the writer William Langewiesche was to write in the opening pages of his book *The Outlaw Sea*, "since we live on land and are usually beyond the sight of the sea, it is easy to forget that our world is an ocean world" (2004:3). Moreover, the popular commentator Ian Urbina stresses that not only is the public sea blind, but there is also a looming intellectual sea blindness too, with less known of the deep seas than other planetary (and extra planetary spaces) [18]. Nonetheless, beginning with the deep-sea images filmed by Jacques Cousteau [26], to the globally significant impact of David Attenborough's 'Blue Planet' documentaries ([27,28]), efforts have attempted to make oceans *visible* – from their spectacular difference to their fate through manifold, simultaneous environmental crises (see [15]). This visibility is often deemed as a vital step in building oceanic connections, and therefore stewardship in contemporary climate-change impacted society. Indeed, alongside visually impactful documentaries, art-science projects have been heralded as ways to engage multiple

¹ For information, see here: <https://hifmb.de/transfer/art-science/ocean-jam-night/>

publics with oceans (see [20] for a review, also [14,29]). Much hinges on making invisible ocean worlds *seen*.

However, whilst vision has been a primary sense for unveiling ocean knowledges and has been dominant in oceanic art-science collaborations to date, it is *sound* that has a special place when understanding marine environments, and which has special capacities for engaging publics (as Payne's records of the 1970s revealed). Of all the sensory impressions, sound is the one that travels the farthest in the oceans and acoustic methods are an important tool that researchers use to better understand the polar oceans and the biodiversity that exists within them. This is because the depth of the oceans alone, or ice cover, *pushes optical observations to their limits*.

Indeed, whilst Jacques Cousteau's travels to the deep ocean unlocked a 'silent world' (1956) it is very much acknowledged the oceans are far from quiet. Waves lap on the shore, or crash against cliffs. Life within the ocean rely on sound, as a mode and method of communication – as a vital device of survival, for breeding, feeding, migrating and so on (see [1]). Human activities at sea are ever-present and often dominate in many of the world's oceans [30], in most cases producing underwater sound deliberately or as a by-product. Beneath the waterline the sound of ships' engines rumble creating vibrations that travel through the seas over vast distances. Seismic exploration, pile driving, the installation and operation of windfarms at sea all add their own acoustic signature to local underwater sound environments, in some cases acoustically deterring marine life from their habitats. The impacts of changing ocean soundscapes on marine animals have received relatively limited attention. Thus, making sounds more audible – listening to the ocean sing – may have broader impacts making known the plight of the oceans, and perhaps even bringing about change. As Duarte et al. have written:

of global change in the ocean, as well as scientific assessments and policy frameworks [United Nations Convention on Biological Diversity (UNCBD), UN Convention for the Law of the Sea (UNCLOS), UN Sustainable Development Goals (UN SDGs)] aimed at improving ocean conservation and sustainability. Given the rapid pace of change in ocean soundscapes, we argue that there is an urgent need to assess the evidence for impacts of anthropogenic noise on marine life, which will enable policy frameworks to mitigate human impacts on ocean soundscapes as a necessary foundation for a healthy ocean ([1], 1)

Given the power of sound to flow through listeners then [31], we aim to explore how oceanic soundscapes can create an alternative and improved understanding of underwater worlds beyond scientific audiences. Art-science sound projects offer the potential to work with ocean soundscapes in multiple ways – to make audible the worlds that are so far largely unheard beyond specialist labs. In the next section we provide one response which tries to at least partially contribute towards this, by explaining the rationale and process behind a worldwide art-science initiative, *Polar Sounds*, a collaboration between two marine science institutes and a sound art project: the Helmholtz Institute for Functional Marine Biodiversity (HIFMB), a centre for interdisciplinary ocean studies (which employs staff from ecological, biological, geochemical sciences alongside data modellers, critical political ecologists, geographers and artists), the Alfred Wegener Institute for Marine and Polar Science (AWI), a centre of expertise on marine and polar climate- and ecosystems and soundscapes, holding unique underwater audio data from the Arctic and Southern oceans and *Cities and Memory*, a collaborative sound art and field recording program for artists around the world. The project united acoustic scientists and artists around the globe through the sharing of scientific acoustic data from the polar seas (the Arctic and Southern Oceans) and their translation into compositions. In what follows we introduce *Polar Sounds* to make audible the potentials of embracing what is *heard* in our ocean worlds.

3. Developing an art-science project: A portal to the polar seas

3.1. *Sounding out a rationale, and showing why it matters*

In 2022, Geraint Rhys Whittaker artist and researcher joined the HIFMB for a fellowship to examine how sound could be harnessed in art-science collaborations for creating new oceanic knowledges and exploring how this might be shared with wider public audiences. Unlike pre-determined fellowships with a clearly defined project, or short-term art-science residencies, his position very much relied (and continues to rely) on experimentation and flexibility, where open and free discussions generate possible creative projects to pursue over time. The only pre-determined focus of the project was that Geraint's work would focus specifically on *sound*.

Working closely with Ilse van Opzeeland of the AWI Ocean Acoustics lab, and with input from Kimberley Peters in the Marine Governance Group, it was to be a collaboration that spanned (and continues to span) differing creative capabilities, academic disciplines and technical skills but with a shared passion by all for art, communication, science and the environment. For us, by bringing our diverse expertise together we were (and are) free to experiment with the various ways that art and creativity can offer alternative interpretations of scientific data and by doing so, generate new approaches to forming oceanic knowledges. How art-science collaborations develop, depends as much on the 'situation, personalities, and organizational cultures involved' ([32]:4), and so for the three of us, meetings are often exploratory, with the time to think, experiment and discuss not only what we want to achieve but why. This is fundamental and something that isn't often afforded to art-science collaborations, the time to allow such interventions to develop beyond short-term or temporary interventions [20]. Having the freedom to do this, and also the *choice* to allow ideas to develop organically has become a fundamental part of our fruitful collaboration and is typical of other successful trans-disciplinary collaborations as highlighted by Carnac [33]. As conversations developed, numerous ideas emerged (see HIFMB Art-science page for other projects which include a sound installation as well as an Ocean Science Jam²), one however was focused on wanting to increase the accessibility of the sounds from the Ocean Acoustic Group to a wider artistic audience. He (and we together) were interested especially in the potential of sound to go against the grain of visual art-science projects that tend to dominate. What is more, sound has a special place in the scientific work of the HIFMB and AWI with dedicated working groups in this area. This provided an array of data, as well as equipment, and expertise to engage in the process. Because the focus of the Ocean Acoustic Groups research is mainly conducted in the polar regions, soon after beginning the fellowship, the importance of sound in these seas began to emerge as a critical space to build a project. Before detailing the project then it is worth exploring the appeal of sound data and research in these parts of the world.

In many polar regions, sound is a fundamental way to collect data, not least in winter and often this is done in the absence of people, where equipment is set up and later retrieved. Indeed, this is not to say capturing sound data is without difficulties. Due to the relative remoteness, extreme weather conditions, and logistical and financial challenges in reaching the poles, as well as the physical and psychological toll expeditions can have on the human body when equipment set up and collection happens ([34]), we know less about the seas – and polar seas particularly – than of terrestrial spaces [35,36]. There are specific considerations of capturing data in such 'harsh' seas, but great potential of harnessing these sounds for environmental understanding (see [3]). Indeed, making known changes in the polar seas is crucial to understanding the state of the planet more broadly. What happens in the polar regions has important consequences for the health of the oceans worldwide, and so understanding how knowledge is created about them

² See art-science collaborations here: <https://hifmb.de/transfer/art-science/>

is critical for ocean science and marine management. Although in many instances these regions are ‘poles apart’ with regards to their proximity to coastal states, permanent residential populations, and in view of how they are governed ([37]: 1), they both drive heat distribution, influence sea level rise, control carbon and nutrient levels, and are fundamental for understanding marine ecosystems [38]. They are also ‘lived spaces’ ([39], 582). They are sites of research interest across disciplines in the natural and social sciences ([40], Richardson 2014, [41]). They are places of geo-political contestation over resource exploitation, trade, and security where coastal, non-coastal and indigenous states claim territorial sovereignty over their control [42,39,43,44]. They are also places of increasing tourist activity [45,46], hold vast marine biodiversity [47], are integral in influencing the earth’s climate [48] and in the case of the Arctic, are home to around 4 million humans (Arctic Review).³

The polar regions are also alive in the consciousness of publics who live far from these places, who are likely to never physically visit them but whose actions no doubt impact them. Through books [49–52], film [53,54], photography [55,56], the news [57] and social media [58], audiences around the world have been given access to these places to be inspired and challenged, contributing to how polar imaginaries develop. Whether they have been depicted as places of conflict [59,60], of climate panic [61], as a tranquil place for humans to experience silence away from everyday life [62], as heroic, futile, predominantly male and otherworldly [50] or illustrated as ‘empty’ places which erases the lives of those people who live and work in them [63], how imaginaries of the polar seas are created very much depends on the way they are framed, and who gets access to the information. Thus, our understanding of the polar oceans develop from the stories told about them [39] which asks us to address an important question posed by [49], that is, “what communication medium, emerges from and is demanded by the Anthropocene?”. The Polar Sounds project would thus develop from us pondering this question in relation to the sounds of the polar seas.

3.2. Sounding out a project, and making it real

From an artistic perspective, sound is like other materials in that it is something that can be moulded and shaped [64]. We therefore wanted to understand what sound can offer to how imaginaries of the polar seas are constructed and reconstructed through creativity, and to explore how art reveals innovative and marginalized perspectives about the polar oceans that would otherwise remain unexplored. By doing so, we hoped to open new dialogues between artists and scientific data – moving beyond the idea that *sound* too is *only* data. In sum: could we build a collaboration to share some of the sounds from the Ocean Acoustics lab? Could we discover how familiar non-scientists are with the soundscapes of the polar seas? Could we understand not only how artists interpret these sounds but also what *they do with them and produce from them*? Could we use that as a basis to both shift the sounds from the lab to the wider world, and to allow different publics to engage those sounds not just through listening, but *creating*? What might these endeavours in creativity tell us about how people understood and understand the ocean, before and after the creative process? This, in essence, was the basis of *Polar Sounds*.

But how to make it happen? We needed to find a partner with a similar love and desire for combining the sounds of the world with creativity. We contacted one of the world’s largest sound art projects *Cities and Memory*, and asked if they would be interested in collaborating with us. *Cities and Memory* is “a collaborative sound art and field recording programme with the aim of remixing the world, one sound at a time” (*Cities and Memory*, 2023). On their much-visited platform, they

have featured projects that have covered themes from ‘sacred sounds’, ‘obsolete sounds’, ‘sounds of sleep’ and ‘prison songs’. Soon, they would feature ‘polar sounds’. After contacting Stuart Fowkes, founder of *Cities and Memory*, and establishing how the project would work, the next step would involve picking appropriate sound clips to offer to a broad public of artists – amateur and professional.

This involved Geraint (with assistance from doctoral student Soli Levi) listening to the Open Portal to Underwater Soundscapes (OPUS, www.opus.aq), which is an online sound portal developed by the Ocean Acoustics Group at AWI. This gives access to spectrograms so that a user can scroll through yearlong acoustic data and listen to the recordings. Due to the vast amount of data (for example 1 spectrogram is typically a year’s worth of sound recordings), this process lasted a few weeks and involved listening to and identifying sounds that were deemed interesting enough for artistic interpretation. This was very much a subjective decision made by Geraint based on his previous artistic experiences of working with sound, but the general rule was that the clips would last around 1–2 minutes, enough to give contributors to the project something solid to work with, not so much as to be overwhelming. Enough to get to know and feel the sound, but not to be unwieldy. The sounds were the ocean, and the life within it. They included biological sounds: Humpback, Bowhead, Killer and Sperm whales, Ross and Weddell seals, as well as Leopard and Crabeater seals. They included geological sounds: such as collapsing and colliding ice shelves. They also included anthropogenic sounds: seismic air guns and ship noise.

At this point, Geraint was unfamiliar with many of the sounds, and so after picking 50 clips of interest the next step was to sit with Ilse, as the scientific expert, to find out what each sound was. This was itself a process of discovery and discussion which was critical in establishing early relationships between Geraint and Ilse, and for Geraint to further understand the science of ocean acoustics. It is these early moments of transdisciplinary dialogue which make art-science collaborations unique interventions and helped to develop what [65]:45–46 call ‘deep collaboration’, those important moments in communication between colleagues which relies on “genuine excitement experienced in maintaining the required openness and lack of possessiveness around skills and materials”. Once the sounds were selected, we sent them to Stuart to curate and create the Polar sounds page on the *Cities and Memory* website and to begin creating the call to artists around the world. We utilised the long-established reputation and contacts of *Cities and Memory* as well as sending out press releases via the AWI and HIFMB channels and circulating amongst our own contacts and social media channels.

On closing the call, we received over 300 applications from 45 different countries, a testament to the broad interest in the project. The selection criteria for choosing participants was agreed upon between us and *Cities and Memory* and involved examples of previous work provided by the applicants. Preference was given to people who had not taken part in *Cities and Memory* projects before (to ensure a wide remit of artists), also eliminating anyone who was already taking part in other concurrent projects that *Cities and Memory* was involved in. We also omitted anyone unwilling to, in principle, be open to a follow up interview which was a core part of our strategy to learn about how the artists engaged with these sounds of the seas through creative practice. A number of diversity and inclusion criteria were included to ensure representation across genders and locations.

Once they were selected each artist chose one sound clip which they could do anything they wanted with. Artists were given 3 months to complete a composition. We did not want to limit the participants to only creating what is traditionally seen as sound art, but wanted to give them the freedom to create anything they wanted as long as it used the audio clip from the polar seas in some form (for an analysis of the history of sound art see [66,67]). The completed compositions were a diverse mixture ranging from songs (with lyrics), avant-garde pieces, fictional pieces, narratives and more. We received 103 compositions from 31 countries. The compositions (and original sounds) are permanently hosted on the *Cities and Memory* site, and we are also developing a

³ <https://arctic.review/people/population/#:~:text=With%20a%20population%20of%20about,diverse%2C%20both%20culturally%20and%20linguistically.>

physical phone booth installation which will allow audiences to listen to the project in a physical space. The launch of the project in February 2023 garnered significant media attention across the world. So far over 40 online articles have been identified that were written on the project, the team have participated in over 20 Radio and Podcast interviews as well as interviews on TV and online platforms such as Instagram and Twitter. The *Cities and Memory* Polar sounds page has had 21,000 hits so far and combined with the media interest has meant the project has been exposed to a potential audience of millions globally, enlivening interest in the sounds of the Polar seas.

So where do we go from here? What is the future of the Polar sounds Project? The project reached a large audience, caught the attention of worldwide media, brought the public into direct contact with scientific data and the creation of such diverse compositions are a contribution towards new oceanic knowledge. As such, we could already say that it has fulfilled the UN Ocean Decade's goals of creating a project which encourages an 'engaging' and 'inspiring' ocean for the public. However, what is often missing with art-science collaborations in general, is thorough academic exploration and reflection into what a project means beyond its creation. In other words, there is a lack of reflection on process, including "what worked, what didn't, how the relationship developed" and also what a project means to various audiences ([20]:4). As part of our ongoing efforts then to further understand Polar Sounds, we are developing various research avenues which will build further knowledge on this project.

One avenue is exploring what the project meant to the artists. Since launching, 63 interviews have been conducted with the artists involved, following not just their creative journey with the sounds, but an exploration of what they made of the sounds they were given including questions such as: how did the sounds meet their expectations of what the polar seas would sound like? How did these ideas shape their compositions? How did hearing the sounds re-shape any previously held beliefs? How has participation in the project changed, if at all, their relationship to the environment, and a climate-impacted planet? Further research will also involve conducting focus groups with different combinations of listeners to the original sounds and compositions asking what does an artistic interpretation do? Can it make distant seas more accessible? We are also in the process of discovering what the scientists who collect and use this acoustic data think of the compositions and project, asking in what ways do these new interpretations of the acoustic data that they use every day, offer alternative insights into the work that they do. A final avenue we are pursuing will also follow the media trail of the project to ask, 'what does online, and media engagement mean for an art-science project?'. These, therefore, are some ways that the project lives on in numerous guises beyond the artistic output, allowing the sounds of the polar seas to reverberate in various new forms.

4. Sounding out a future of potentials: Conclusions

In this article, we have made the case for taking seriously attentive listening when analysing spatial understandings of the oceans [13,68,69]. *Sound* is as important as vision. Acoustic data can provide invaluable information about reproductive habits, migration patterns, and the negative impact of human-caused noise on the marine environment. Studying the soundscape of the seas thus reveals a lot about the state of the oceans. Sound is under-examined compared to other elements of ocean worlds and art-science sound projects offer the potential to work with ocean soundscapes in multiple ways – to make audible the worlds that are so far largely unheard beyond specialist labs. Sound data, we have found, is particularly evocative and enchanting and this drove our desire to work with sound 'differently'. As such, we have introduced a unique, oceanic, global art-science project centred on sound: embracing the soundscapes of the polar seas to sound out the potential for embracing this medium and *make sense* of changing ocean worlds for a broad public audience, to show how when in the hands of artists sounds collected by scientists become *more than just data*.

With increasing acknowledgement of the value of art-science collaborations for communicating ocean knowledge [14,20] – sound, or even (as future projects could explore smell, taste or touch/haptic experience) can be vital sensory modes to building ocean citizenship, engagement and stewardship ([70-72,19]). It is our contention then, that art-science collaborations can be a productive way to bring societies, communities and individuals into touch with the seas and oceans. This is due to the linkages of sound and the ocean but also the pervasiveness of sound (Polar Sounds can be listened to, 'on the go', as an audio accompaniment to a train journey, or backdrop to life at home on the stereo). Likewise, when presenting sound data (either at conferences or public engagement events), we have each found it has had profound stilling effects on those engaging it specifically, perhaps because there are fewer pre-held assumptions about it than visual ocean cues. The huge uptake of interest in *Polar Sounds* by artists worldwide signals to the wonder that sound can elicit, and its creative potentials. What is more, the wider interest of the listening public (through media engagement, 'likes', downloads and so on), demonstrates further that sound captures the imagination in ways vision alone cannot. Sound may allow for entering an ocean world as ears are enveloped in headphones, or sounds vibrate through everyday spaces – homes, schools and workplaces (all sites where *Polar Sounds* has been listened to and engaged with which will be the focus of further papers to come).

Whilst we continue to analyse exactly how publics have engaged the seas, and what they have learned of ocean environments through creating and listening to the array of polar sounds offered, for now we hope to have inspired readers to visit the project – to listen to the original sounds and their interpretations and to consider whether there may be other ways to communicate science beyond often 'tried and tested' methods. On top of our increasing acoustic dominance in underwater environments, overfishing, invasive species, coastal development and climate change are just a few further human impacts that are changing and affecting the world's oceans. The public unawareness of the virtual code red for humanity that was declared by the [73]) sharpens the contrast between our role (or responsibility) and perception of the crises in the sea even further. In sum, in this article we have advocated for a sea change in art-science and science communication work and to make our oceans heard. As Ilse notes in comments included in the press release for the Polar Sounds project

...the soundscapes we are recording in the polar oceans are breathtaking in terms of the new scientific insights they provide since we started our passive acoustic monitoring. A 'translation' through art breathes new life into our scientific data that goes beyond a traditional publication or policy paper by making it accessible to non-scientists. We must make the greatest effort to protect, conserve, and restore our planet's endangered habitats. The interaction of art and science can help by creating awareness and attention to this (author 2, press release, 2023).

Author statement

We certify that we have participated sufficiently in the intellectual content, conception, and design of this research as well as the writing of the manuscript, to take public responsibility for it and have agreed to have our names listed as contributors.

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Yours

Geraint Rhys Whittaker, Kimberley Peters and Ilse van Opzeeland

CRediT authorship contribution statement

Geraint Rhys Whittaker: Writing – original draft. **Kimberley Peters:** Writing – original draft. **Ilse van Opzeeland:** Writing – original

draft.

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References

- [1] C.M. Duarte, L. Chapuis, S. Collin, D.P. Costa, R. Devassy, V. Equiluz, C. Erbe, T. Gordon, B.S. Halpern, H. Harding, M. Havlik, M. Meekan, N. Merchant, J. Miksis-Olds, M. Parsons, M. Predragovic, A. Radford, C.A. Radford, S. Simpson, H. Slabbekoorn, E. Staaterman, I. Van Opzeeland, J. Winderen, X. Zhang, F. Juanes, The soundscape of the Anthropocene ocean, *Science* 371 (6529) (2021).
- [2] S.M. Van Parijs, C.W. Clark, R.S. Sousa-Lima, S.E. Parks, S. Rankin, D. Risch, I. C. Van Opzeeland, Management and research applications of real-time and archival passive acoustic sensors over varying temporal and spatial scales, *Mar. Ecol. Prog. Ser.* 395 (2009) 21–36.
- [3] I. Van Opzeeland, L. Kindermann, O. Boebel, S.M. Van Parijs, Insights into the acoustic behaviour of polar pinnipeds: current knowledge and emerging techniques of study. *Animal Behaviour: New Research*. EA Weber, LH Krause, Nova Science Publishers. Hauppauge, NY, 2008.
- [4] I. Van Opzeeland, H. Slabbekoorn, Importance of underwater sounds for migration of fish and aquatic mammals, *Adv. Exp. Med. Biol.* 730 (2012) 357–359.
- [5] I. Van Opzeeland, F. Samaran, K. Stafford, K. Findlay, J. Gedamke, D. Harris, B. S. Miller, Towards collective circum-Antarctic passive acoustic monitoring: The Southern Ocean hydrophone network (SOHN), *Polarforschung* 83 (2) (2013) 47–61.
- [6] C.W. Clark, W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, D. Ponirakis, Acoustic masking in marine ecosystems: intuitions, analysis, and implication, *Mar. Ecol. Prog. Ser.* 395 (2009) 201–222.
- [7] K. Thomisch, O. Boebel, C.W. Clark, W. Hagen, S. Spiessacke, D.P. Zitterbart, I. Van Opzeeland, Spatio-temporal patterns in acoustic presence and distribution of Antarctic blue whales *Balaenoptera musculus intermedia* in the Weddell Sea, *Endanger. Species Res.* 30 (2016) 239–253.
- [8] S.M. Van Parijs, C. Lydersen, K.M. Kovacs, Vocalizations and movements suggest alternative mating tactics in male bearded seals, *Anim. Behav.* 65 (2) (2003) 273–283.
- [9] J.A. Allen, E.C. Garland, R.A. Dunlop, M.J. Noad, Cultural revolutions reduce complexity in the songs of humpback whales, *Proc. R. Soc. B* 285 (1891) (2018) 20182088.
- [10] G. Revill, How is space made in sound? Spatial mediation, critical phenomenology and the political agency of sound, *Prog. Hum. Geogr.* 40 (2) (2016) 240–256, <https://doi.org/10.1177/0309132515572271>.
- [11] M. Cohen, *Adventures in Toxic Atmosphere*, in: W. Abberley (Ed.), (2018) Introduction, *Underwater Worlds: Submerged Visions in Science and Culture*, Cambridge: Cambridge Scholars Publishing, 2018, pp. 72–89.
- [12] Lewis, T. (2020) 'It always hits me hard': how a haunting album helped save the whales, *The Guardian*, Available at <https://www.theguardian.com/environment/2020/dec/06/the-songs-that-saved-the-whales>.
- [13] B. Blesser, L.R. Salter, *Spaces Speak, Are You Listening? Experiencing Aural Architecture*, Cambridge, Massachusetts, The MIT Press, 2006.
- [14] J. Jung, D. Gupa, C. Hash, J. Thoms, D. Owens, J. Threlfall, S.K. Juniper, Doubling down on wicked problems: ocean artscience collaborations for a sustainable future, *Front. Mar. Sci.* 9 (2022) 873990.
- [15] G. Crawley, E. Critchley, M. Neudecker, in: K. Peters, J. Anderson, A. Davies, P. Steinberg (Eds.), 'Art, film, and the scenography of oceanic worlds', *The Routledge Handbook of Ocean Space*. (Abingdon: Routledge), 2022, pp. 277–297.
- [16] R. George, *Deep Sea and Foreign Going: Inside Shipping, the Invisible Industry that brings you 90% of Everything*, Portobello Books, London, 2013.
- [17] W. Langewiesche, *The Outlaw Sea: A World of Freedom, Chaos, and Crime*, North Point Press, US, 2004.
- [18] I. Urbina, *The Outlaw Ocean: Crime and Survival in the Last Untamed Frontier*, Random House, London, 2019.
- [19] E. McKinley, D. Burdon, R.J. Shellock, The evolution of ocean literacy: a new framework for the United Nations Ocean Decade and beyond, *Mar. Pollut. Bull.* 186, Artic. Number (2023) 114467.
- [20] G.R. Whittaker, Creatively connecting science, society and the sea: a mini-review of academic literature focusing on art-science collaborations and the ocean, *Front. Mar. Sci.* 10 (2023) 1234776.
- [21] Vandsø, in: S.K. Groth, H. Schulze (Eds.), *The sonic aftermath: anthropocene and transdisciplinarity after the apocalypse*, *The Bloomsbury Handbook of Sound Art* (New York: Bloomsbury, 2020, pp. 21–40.
- [22] Ocean Decade (2021) Vision and Mission. Available here: <https://oceandecade.org/vision-mission/> (Accessed 20.09.2023).
- [23] Franke, A., Peters, K., Hinkel, J., Hornidge, A.K., Schlüter, A., Zielinski, O., ... & Hillebrand, H. (2023). Making the UN Ocean Decade work? The potential for, and challenges of, transdisciplinary research and real-world laboratories for building towards ocean solutions. *People and Nature*, 5(1), 21–33.
- [24] M.T. Swanson, N.J. Wade, *Visual Perception: An Introduction*, Psychology Press: East Sussex, 2013.
- [25] TED Talk (2013) 'Rose George: Inside the secret shipping industry'. Available here: https://www.ted.com/talks/rose_george_inside_the_secret_shipping_industry/transcript (Accessed 20.09.2023).
- [26] Cousteau, J.Y. (1956) *The Silent World*. New York and London.
- [27] Blue Planet (2001) Series I. BBC Productions.
- [28] Blue Planet (2017) Series II. BBC Productions.
- [29] R.E. Brennan, *Re-storying marine conservation: integrating art and science to explore and articulate ideas, visions and expressions of marine space*. *Ocean & Coast. Manag.* 162 (2018) 110–126.
- [30] C.C. O'Hara, B.S. Halpern, Anticipating the future of the world's ocean, *Annu. Rev. Environ. Resour.* 47 (2022) 291–315.
- [31] C. Cox, Beyond representation and signification: toward a sonic materialism, *J. Vis. Cult.* 10 (2) (2011) 145–161.
- [32] C. Schnugg, *Creating ArtScience Collaboration. Bringing Value to Organizations*, (Palgrave Macmillan: Switzerland), 2019.
- [33] H. Carnac, *Moving Things around...Collaboration and Dynamic Change*, in: A. Ravetz, A. Kettle, H. Felcey (Eds.), *Collaboration Through Craft*, Bloomsbury, New York, 2017, pp. 31–44.
- [34] G.M. Sandal, G.R. Leon, L. Palinkas, Human challenges in polar and space environments, *Rev. Environ. Sci. Bio/Technol.* 5 (2-3) (2006) 281–296.
- [35] K. Peters, Future promises for contemporary social and cultural geographies of the sea, *Geogr. Compass* 4 (9) (2010) 1260–1272.
- [36] P. Steinberg, *The Social Construction of the Ocean*, Cambridge University Press, Cambridge, 2001.
- [37] T. Stephens, D.L. VanderZwaag, Polar oceans governance: shifting seascapes, hazy horizons, in: T. Stephens, D.L. VanderZwaag (Eds.), *Polar Oceans Governance in an Era of Environmental Change* (Cheltenham and Camberley, Edward Elgar Publishing, 2014, pp. 1–17.
- [38] D.K.A. Barnes, G.A. Tarling, Polar oceans in a changing climate, *Curr. Biol.* 27 (11) (2017) R454–R460.
- [39] A. Dodds, K. Hemmings, 'Polar Oceans: Sovereignty and the contestation of territorial and resource rights', in: H. Mith, J. Suárez de Vivero, T. Agardy (Eds.), *Routledge Handbook of Ocean Resources and Management*, Abingdon: Routledge, 2015, pp. 576–591.
- [40] A. Howkins, P. Roberts, Cambridge. *The Cambridge History of the Polar Regions*, Cambridge University Press, 2023.
- [41] M. Nuttall, T. Christensen, London. *The Routledge Handbook of the Polar Regions*, Routledge, 2018.
- [42] S. Chaturvedi, The future of Antarctica: Minerals, bioprospecting, and fisheries, in: M. Nuttall, T. Christensen, M. Siegert (Eds.), (2018) *The Routledge Handbook of the Polar Regions*, London: Routledge, 2018, pp. 403–415.
- [43] K. Dodds, Geopolitics and ice humanities: elemental, metaphorical and volumetric reverberations, *Geopolitics* 26 (4) (2019) 1121–1149.
- [44] A. Østhagen, Geopolitics and security in the Arctic, in: M. Nuttall, T. Christensen, M. Siegert (Eds.), (2018) *The Routledge Handbook of the Polar Regions*, Routledge, London, 2018, pp. 348–356.
- [45] W. Cheung, T. Bauer, J. Deng, The growth of Chinese tourism to Antarctica: a profile of their connectedness to nature, motivations, and perceptions, *Polar J.* 9 (1) (2019) 197–213.
- [46] B. Frame, D. Liggett, K. Lindström, R. Roura, L.M. van der Wat, Tourism and heritage in Antarctica: exploring cultural, natural and subliminal experiences, *Polar Geogr.* 45, NO 1 (2022) 37–57.
- [47] H. Meltofte, Biodiversity in the Polar Regions in a warming world, in: M. Nuttall, T. Christensen, M. Siegert (Eds.), *The Routledge Handbook of the Polar Regions*, Routledge, London, 2018, pp. 137–148.
- [48] R. Bingham, in: M. Nuttall, T. Christensen, M. Siegert (Eds.), 'Polar oceans and their global significance', *The Routledge Handbook of the Polar Regions*, (London: Routledge, 2018, pp. 158–175.
- [49] H. Blum, *The News at the Ends of the Earth: The Print Culture of Polar Exploration*, Duke University Press, 2019.
- [50] H. Hansson, 'The Arctic in literature and the popular imagination', in: M. Nuttall, T. Christensen, M. Siegert (Eds.), *The Routledge Handbook of the Polar Regions*, Routledge, London, 2018, pp. 45–56.
- [51] P. Krapp, *Polar Media, Inf., Commun. Soc.* 11 (6) (2008) 831–845.
- [52] E. Leane, The Antarctic in literature and the popular imagination, in: M. Nuttall, T. Christensen, M. Siegert (Eds.), *The Routledge Handbook of the Polar Regions*, Routledge, London, 2018, pp. 57–66.

- [53] H. Nielsen, Identifying with Antarctica in the ecocultural imaginary, in: T. Milstein, J. Castro-Sotomayor (Eds.), *Routledge Handbook of Ecocultural Identity*, Routledge, London, 2020, pp. 225–239.
- [54] M. Schillat, Images of Antarctica as Transmitted by Literature, in: M. Schillat, M. Jensen, M. Vereda, R. Sánchez, R. Roura (Eds.), *Tourism in Antarctica A Multidisciplinary View of New Activities Carried Out on the White Continent*, New York: Springer, 2016, pp. 21–39.
- [55] M. Fjellestad, Picturing the Arctic, *Polar Geogr.* 39 (4) (2016) 228–238.
- [56] M. Poliza, *Antarctic: A Tribute to Life in the Polar Regions*, TeNeues, Krefeld, 2011.
- [57] D. Wehrmann, *Critical Geopolitics of the Polar Regions An Inter-American Perspective*, London Routledge, 2018.
- [58] C. Runge, V. Hausner, R. Daigle, C. Monz, Pan-Arctic analysis of cultural ecosystem services using social media and automated content analysis, *Environ. Res. Commun.* 2 (7) (2020) 075001, <https://doi.org/10.1088/2515-7620/ab9c33>.
- [59] R. Pincus, S.H. Ali, *Diplomacy on ice: Energy and the environment in the Arctic and Antarctic* (Eds.), Yale University Press, New Haven, CT, 2015.
- [60] E.W. Rowe, A dangerous space? Unpacking state and media discourses on the Arctic, *Polar Geogr.* 36 (3) (2013), 232–24.
- [61] E. Glasberg, Living ice': rediscovery of the poles in an era of climate crisis, *Women'S. Stud. Q.* Vol. 39 (No. 3/4) (2011) 221–246.
- [62] H. Mamzer, The attractiveness of polar regions as the zones of silence, *Oceanologia* 62 (4) (2020) 557–564 (B).
- [63] K. Dodds, J. Smith, Against decline? The geographies and temporalities of the Arctic cryosphere, *Geogr. J.* 189 (3) (2022) 388–397.
- [64] T. Holmes, *Sound Art Concepts and Practices*, (London, Routledge, 2022).
- [65] D. Gates, A. Kettle, J. Webb, *Triangulation: Working towards a Practice of Collaboration*, in: A. Ravetz, A. Kettle, H. Felcey (Eds.), *Collaboration Through Craft*, Bloomsbury, New York, 2017, pp. 45–58.
- [66] Groth, S.K. and Schulze, H. (2020) *The Bloomsbury Handbook of Sound Art* (New York: Bloomsbury).
- [67] A. Licht, *New York. Sound Art Revisited*, Bloomsbury, 2019.
- [68] Helmreich, S. (2016).
- [69] G.R. Whittaker, K. Peters, 'Research with Sound: An Audio Guide', in: N. von Benzon, M. Holton, C. Wilkinson, S. Wilkinson (Eds.), *Creative Methodologies*, Sage, London, 2021, pp. 129–140.
- [70] S. Helmreich, C. Jones, Science/art/culture through an oceanic lens, *Annu. Rev. Anthropol.* 47 (1) (2018) 97–115, <https://doi.org/10.1146/annurev-anthro-102317-050147>.
- [71] E. McKinley, S. Fletcher, Individual responsibility for the oceans? An evaluation of marine citizenship by UK marine practitioners, *Ocean Coast. Manag.* 53 (7) (2010) 379–384.
- [72] E. McKinley, S. Fletcher, Improving marine environmental health through marine citizenship: a call for debate, *Mar. Policy* 36 (3) (2012) 839–843.
- [73] IPCC (Intergov. Panel Clim. Change), in: V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan (Eds.), *Summary for Policymakers. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, et al. Cambridge, UK: Cambridge Univ. Press, 2021.