WHALES, AI, AND THE RIGHT TO OPACITY

DECOLONISING INTERSPECIES COMMUNICATION IN THE WORK OF ARIEL GUZIK

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Can artificial intelligence allow us to talk to whales? If so, will deciphering the sounds of the world around us help us protect it better? Building on recent advances in Natural Language Processing (NLP) and machine learning (ML) — the technology behind ChatGPT — a group of scientists are now trying to translate sperm whale language. They are part of an interdisciplinary project of unprecedented scale, in which marine biologists, roboticists, linguists and ML experts hope AI will eventually speak to the whales: the Cetacean Translation Initiative or "Project CETI."[1]

Project CETI explains that speaking with the whales will provide insight into their highly sound-based experience, allowing researchers to better understand the impact of underwater noise pollution.[2] It operates on the expectation that this understanding

"can be built further upon as a template to decipher other forms of animal and non-human communication. Sperm whales, with their highly developed neuroanatomical features, cognitive abilities, social structures, and discrete click-based encoding make for an excellent model for advanced tools that can be applied to other animals in the future."[3]

In other words, the project can potentially break the language barrier between humans and animals, while providing opportunities for technological development. To collect the immense amount of data required, Project CETI uses an extensive observation system launched in 2023 in Dominica. It will be in place for several years: in addition to scientists out on the water, there will be hydrophones and cameras attached to buoys, especially designed robotic fish following the whales, suction-attached temporary whale tags and aerial drones.[4] In theory, when enough data is available to train the computers — researchers estimate needing continuous observation of 50 to 400 whales for multiple years — they could learn to recognise the structures of sperm whale vocalisations, or "codas" which consist of a series of individual "clicks," and extract their meaning from mapping patterns and cross-referencing with observed behaviour.[5] If all goes well a chatbot can speak back to the whales to test the project's achievements, which should then be "translated" to human language.

But what exactly is "interspecies communication" in this context? The quote above shows that the rhetoric of "decoding" whale language casts sperm whales in a particular light: as efficient encoders that are naturally

1
Other similar but smaller initiatives using AI to attempt to translate animal languages are DeepSqueak and the Earth Species Project. See Emily Anthes, "The Animal Translators," *The New York Times*, August 30, 2022, https://www.nytimes.com/2022/08/30/science/translators-animals-naked-mole-rats.html.

2
Jacob Andreas et al., "Toward Understanding the Communication in Sperm Whales," *iScience* 6, no. 25 (June 2022), 13.

3
Andreas, "Toward Understanding," 1.

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Project CETI especially develops minimally invasive technology, but this does not take away the ethical question of consent to intensive observation. It is not explained whether the communication between robotic fish or drones and their operating systems might interfere with whale communication.

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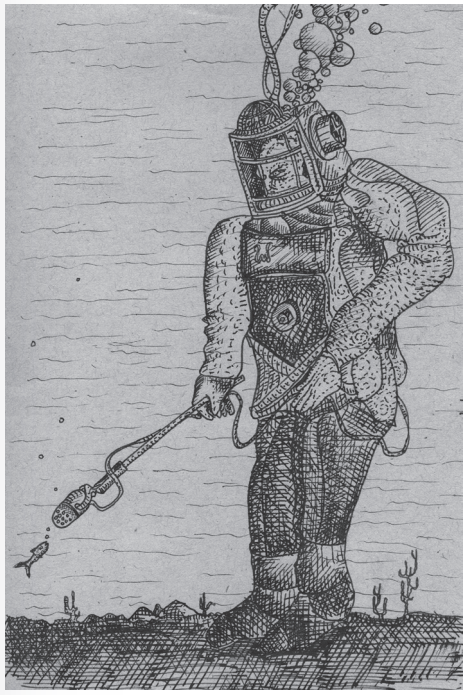
Andreas, "Toward Understanding," 7.



↑fig.1 Ariel Guzik, *Interview*, 2010, ink on paper, courtesy of Ariel Guzik.

compatible with the code compiled by computers and can serve as testing models for speculative investment in robotics and ML that offers likely future returns. It aligns with the "speculation" historically found in natural sciences, aiming at scientific progress as well as exploring new resources.[6] Though revolutionary and potentially transformative of our relation animals and ecosystems, I contend that from a postcolonial perspective, undertakings like Project CETI fit into a specific type of knowing and making knowable that is not that different from historical exploitation of whales in the service of technological progress, originating in the imperial whaling industry.

Here I ask how we can conceive of listening practices that inspire more poetic and empathetic forms of interspecies communication and ecological relations. How can they teach us to *think with* whales? For this, I turn towards the work of sound artist Ariel Guzik, to analyse his acoustic encounters with cetaceans as enabling *decolonial* ways of relating to whales and, by extension, the marine environment. Under imperialism, politics, culture, and science worked together to produce a reality in which racialised humans and the natural environment were there for the coloniser to discover and exploit.[7] This power relation continues to exist, even after 'the end' of colonialism. Decolonial practices, therefore, aim to challenge this dynamic and develop alternative options.[8] Through a comparison of the two projects, based on conversations with Guzik, I delve into the value of artistic research for thinking about the politics of listening to nature.

Project CETI: rendering whales transparent

First, I will describe the historical relation between whales and colonialism. I focus on the shift from vision to sound and how different techniques of engaging with whales entail different ways of imagining them. A backdrop to this consideration is environmental theory scholar Antoine Traisnel's analysis of the biopolitical history of animal science in *Capture: American Pursuits and the Making of a New Animal Condition*. He traces how apparatuses for "capturing" animals, from hunting to photography and environmental conservation, changed how they and their environment are perceived.[9] If the imagination of animals, in this case

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Antoine Traisnel, *Capture: American Pursuits and the Making of a New Animal Condition* (Minneapolis: University of Minnesota Press, 2020), 64.

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It is well established that colonialism and capitalism worked in a double bind, with the European economy being able to develop itself due to its colonial profits and in turn, the capitalist economy being exported through colonialism, which has now led us to ecological crisis by prioritising profits over nature and people. See Malcom Ferdinand, *Decolonial Ecology: Thinking from the Caribbean World* (Medford: Polity Press, 2021).

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Aníbal Quijano, "Coloniality and Modernity/Rationality," *Cultural Studies* 21, no. 2-3, March 2007.

9
Traisnel, *Capture*, 10.

whales, is mediated by the technology of encounter, then we can ask how capturing their language through ML still constitutes a relation where knowledge produces power, to invoke Michel Foucault.[10] Similarly, in *The Poetics of Relation* Édouard Glissant described colonialism as a dynamic of understanding the colonised through Western sciences like anthropology and biology, measuring and comparing people by reducing them to a transparent and knowable — and thus, dominatable — subject.[11] This technique of domination, however, also applies to the natural environment.

The colonial expansion of European capitalism left a significant mark on the present ecological conditions of whales, driving up water temperatures and pollution and establishing a global shipping network. From the seventeenth century, imperialism was dependent on the whaling industry, the financial promise of which pushed imperial frontiers. It played a pivotal role in the colonisation of remote outposts such as Greenland and Western Australia, where settlers in turn relied on the export of whaling products to imperial centres.[12] In the process, whales were literally rendered transparent by cooking their blubber into oil. Known for its clarity and lubricative qualities, this was used to illuminate modern metropoles and smear industrial machinery. Whale oil burned in the first streetlights of Enlightenment-era London and in lighthouses that helped explorers, spice traders, slave ships and settlers navigate the seas. Moreover, it provided candles and lubricant for plantations, keeping sugar mills and their enslaved attendants working around the clock.[13] Over the centuries, the result was the near extinction of several species of whales in the service of Imperial "progress", at the cost of many human and non-human others. Post-World War II whales became transparent to their consumers by rendering imperceptible the scent and flavour of their fat, now made into margarine to feed undernourished populations around the world.[14]

The popular imagination of whales as a resource changed when the wider public started *listening* to them, following their representation by scientists and activists as intelligent beings with their own distinctive voices.[15] Marine biologist Roger Payne released best-selling CD *The Songs of the Humpback Whale* (1970) and whale song was included in NASA's space probes Voyager I and II, launched in 1977, which contained messages for extraterrestrial life forms. Hydrophones had thus skyrocketed the reputation of whales from a resource to a symbol of the beauty of our planet. But far before Payne shared the whale song with the public, it was known to military researchers that whales produce complex and far-reaching series of sounds, and toothed whales use echolocation to navigate and hunt.[16]

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Michel Foucault, *The Order of Things. An Archaeology of the Human Sciences* (London, New York: Routledge, 2008 [1966]).

11
Édouard Glissant, *The Poetics of Relation, trans. Betsy Wing* (Ann Arbor: University of Michigan Press, 1997) 189–190.

12
See Bathsheba Demuth, *Floating Coast: An Environmental History of the Bering Strait* (New York: W.W. Norton & Company, 2020) and Graham Huggan, *Colonialism, Culture, Whales: the Cetacean Quartet* (London: Bloomsbury Publishing, 2018).

13
Jeremy Zallen, *American Lucifers: the Dark History of Artificial Light, 1750-1865* (Chapel Hill: University of North Carolina Press, 2019), 25–26. See also Alexis Pauline Gumbs, *Undrowned: Black Feminist Lessons from Marine Mammals* (Chico: AK Press, 2020).

14
Richard York, "Why Petroleum Did Not Save the Whales," *Socius* 3 (2017). Rebecca Giggs, *Fathoms: The World in the Whale* (New York: Simon & Schuster, 2020).

15
D. Graham Burnett, *The Sounding of the Whale: Science and Cetaceans in the Twentieth Century* (Chicago, London: University of Chicago Press, 2013), 529.

16
Burnett, *The Sounding of the Whale*, 537–538.

Indeed, knowledge of whale voices did not emerge from nowhere. In 1964, U.S. Navy engineer Frank Whatlington had handed a recording to Payne, allegedly with the instruction to go and save the whales.[17] Behind closed doors, whales had been listened to for over two decades. It began when during World War II the Navy set out to classify mysterious underwater noises heard by submarines, because these noises might give away enemy submarines or become false targets known as phantom enemies.[18] Submarine warfare had by then learnt to make use of the Sound Fixing and Ranging (SOFAR) channel, a layer of water of which the interaction of temperature and pressure allows certain sounds to travel thousands of miles.[19] The U.S. Navy used the acoustic duct for their Sound Surveillance System against Soviet submarines and made use of sonar to map the ocean floor, in which whales and other large marine animals became a disturbance and had to be recognised reliably.[20] To the initial disbelief of colleagues, Payne established that the Navy were not the only ones using the SOFAR channel: baleen whales used it to communicate with each other, even so far as between Ireland and the Caribbean.[21] Their voices interfered with military science, but also became an inspiration to its development of sonar technology.

In *The Sounding of the Whale* historian of science D. Graham Burnett explains the stakes in studying how whales used sound and navigated their surroundings during World War II and the Cold War.[22] By peering into their skulls, the Navy could apply cetacean evolutionary accomplishments like sonar organs and complex communication for potential espionage, to the further exploration and domination over sea-space.[23] Their library of voices remains largely classified even today because of the risk that the enemy might copy whale noises to mask their presence or communicate encoded messages through whale-like sounds. Whale bodies again became a resource for domination and transparency, this time in hands of the Navy.

Similarly, Project CETI operates on the imagination that sperm whales as "encoders" are available for the appropriation of science. This implies a familiar anthropocentric power relation in which whales become a natural resource for the advancement of the economy, now in a process of data extraction that in the human context has been called "data colonialism."[24] In light of the recent scramble for the development of AI, different actors behind Project CETI have considerable incentives for backing the project. Still, a step as significant as breaking the language barrier between humans and animals deserves careful consideration, especially when rapid developments in NLP leave ethical frameworks to catch up, with its application to animals being especially

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Lynn Turner, "Podcasting: The Becoming-Space of Voices," paper presented at Wild Minds, ICA London, (March 31, 2017), https://research.gold.ac.uk/id/eprint/20365/.

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Burnett, *The Sounding of the Whale*, 537–538.

19
Karen J. Bakker, *The Sounds of Life: How Digital Technology is Bringing us Closer to the Worlds of Animals and Plants* (Princeton: Princeton University Press, 2022), 15.

20
Burnett, *The Sounding of the Whale,* 537–543.

21
Roger Payne and Douglas Webb, "Orienation by Means of Long Range Acoustic Signaling in Baleen Whales," *Annals of the New York Academy of Science* 118, no. 1 (1971).

22
Burnett, *The Sounding of the Whale*, 537.

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Burnett, *The Sounding of the Whale*, 543.

24
Nick Couldry and Ulises A. Mejias, "Data Colonialism: Rethinking Big Data's Relation to the Contemporary Subject," *Television & New Media* 20, no. 40 (2019).

25
Peter Singer and Yip Fai Tse, "AI Ethics: The Case for Including Animals," *AI and Ethics* 3 (2023).
One concern would be how to prevent knowledge acquired now from becoming weaponised in the future, as has happened with countless inventions.

↑fig.2 Ariel Guzik, *Nereida capsule*, 2007, Espiritu Santo Island, Baja California Sur, photograph by Raúl González.

understudied.[25] NLP is proven to reproduce harmful biases and errors, and in the case of Project CETI the chatbot would speak back to whales based on unsupervised translation.[26] This allows space for errors in what is communicated with the whales, without the opportunity for intervention. The extensive computational system behind ML is highly pollutive, and the considerable carbon footprint and costliness make it doubtful whether using AI is the most appropriate and effective method for saving the whales.[27] If translating whale language is more speculative than it looks at first sight, it becomes necessary to ask who or what this project is really *for*: protecting whales, or, at least to some, furthering technological development?

Although some successes in recognising codas are made, whether translation will eventually happen is still uncertain.[28] Even if language can be identified and the chatbot and whale can converse, a whale's experience of its world might be so different that there is insufficient overlap with human languages for translation and, importantly, interpretation to take place. This resonates with Ludwig Wittgenstein's argument that linguistic communities have such different experiences of the world that translation is severely limited.[29] If we assume that sperm whales are highly intelligent species capable of abstract thought, will ML be able to decode that which is not connected to visual clues like diving, hunting, or resting? Moreover, Project CETI is built on the expectation that communicating with whales will intensify efforts to save them. But knowledge of noise- and environmental pollution and their effects on cetaceans has existed for decades within bioacoustics research and marine biology.[30] This urges us to reflect on whether whales will be listened to, if and when they reply. Given historical inaction around global whale protection, there is reason to be sceptical of the premise that recognising whales as intelligent will lead to their prioritisation over global cargo shipping, military interests, wind farm development, fishing and pollutive industries, and the prospects of deep-sea mining.[31] I suggest that the key to ethical interspecies communication is not about improving our apparatus for listening to animals and our environment, but about rethinking *how* we listen.

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On the limitations of NLP, see Emily M. Bender et al, "On the Dangers of Stochastic Parrots: Can Language Models Be Too Big?," paper presented at ACM Conference on Fairness, Accountability and Transparency, Canada (March 3, 2021) 5–6, https://dl.acm.org/doi/10.1145/3442188.3445922.

27
On financial and environmental costs, see Bender, '"Stochastic Parrots," 3–4. Project CETI received over 30 million dollars support from the Audacious Foundation, with sponsors being philanthropist billionaires Richard Branson and Ray Dalio. Elizabeth Kolbert, "Can We Talk to Whales?," *The New Yorker*, September 4, 2023, https://www.newyorker.com/magazine/2023/09/11/can-we-talk-to-whales.

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Recently an article was published that explained the likely discovery of what would be analogous to vowels in sperm whale communication: Gasper Begus et al, "Vowels and Diphtthongs in Sperm Whales," Vice, December 7, 2023, https://www.vice.com/en/article/4a35kp/scientists-have-reported-a-breakthrough-in-understanding-whale-language.

29
Ludwig Wittgenstein, *Philosophical Investigations*, *trans. G.E.M Anscombe* (Oxford: Basil Blackwell, 1968).

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Susan E. Parks et al., "Short- and Long-term Changes in Right Whale Calling Behaviour: The Potential Effects of Noise on Acoustic Communication," *The Journal of the Acoustical Society of America* 122, no. 6 (2007); Mark Peter Simmonds et al., "Not So Easy Listening: Making Sense of the Noise About Acoustic Pollution," *The Journal of Ocean Technology* 9, no. 1 (2014); Hans Slabbekoorn et al. (eds), *Effects of Anthropogenic Noise on Animals* (New York: Springer Science + Business Media, 2018).

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For an overview of the inadequacy of global marine mammal conservation laws, see Cameron Jefferies, *Marine Mammal Conservation and the Law of the Sea* (New York: Oxford University Press, 2016).

↑fig.3 Ariel Guzik, *Holoturian capsule on its first expedition*, 2018, San Juan de la Costa, Baja California Sur, photograph by Raúl González.

Nereida: interspecies communication and the right to opacity

One night in 2014 off the coast of Costa Rica, Ariel Guzik and his team submerged a tubular capsule of fused quartz with a stringed instrument at its core into the deep. The capsule, named *Nereida*, was designed to facilitate subtle interaction with cetaceans. *Nereida* was the result of testing and refining prototypes since 2007, adjusting their sonic capacities and observing the responses of dolphins and whales in the Sea of Cortez. While the crew drifted on the surface that night, below them a pod of dolphins surrounded the capsule. The strings within *Nereida* responded to the voices of the dolphins, who like other toothed whale species rely on echolocation to "see" their prey and surroundings. The inquisitive group stayed around for hours, listening to the man-made emissary echoing their vocalisations.[32] Nicola Triscott, researcher of the intersections between art and science, describes listening to the recording:

"Over the subtle chiming tones of *Nereida*, a "choir" of dolphins' whistles of frequency-modulated pure tones is heard, underlain with the deep reverberations of humpback whales, probably present at a far greater depth. The serendipitous intermixing of tones and sounds gives the impression of a musical performance, as though this sound-based community is harmonising with Nereida's chimes."[33]

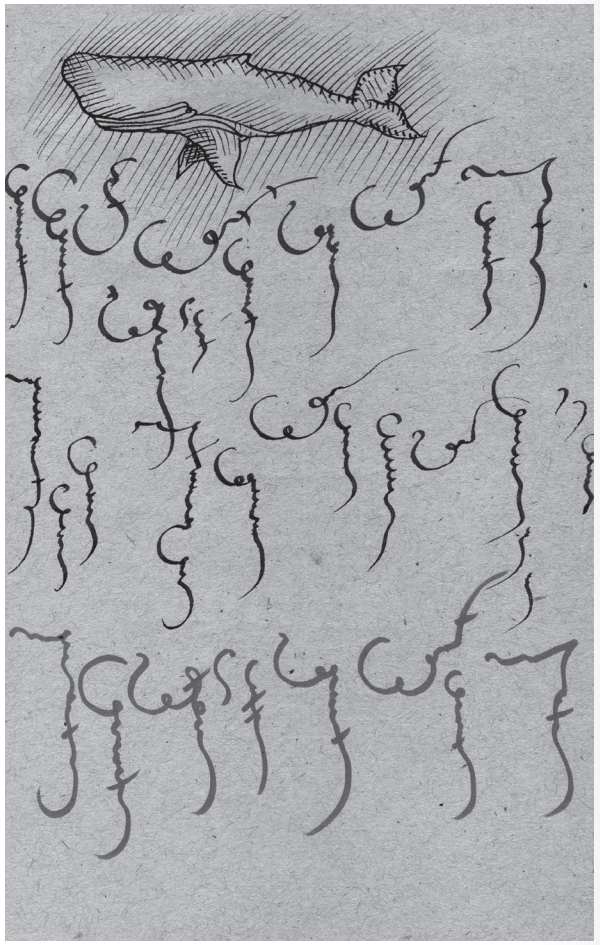
Guzik's attempts at interaction with cetaceans are part of his Nature Expression and Resonance Research Laboratory founded in 1990. Cetacean communication is a primary focus among projects that translate the normally inaudible voices of their environment into sound. To this end, Guzik designs and builds instruments that reflect the electromagnetic energy of plants, and movements of sun and water currents, accompanied by illustrations that invite the viewer into his vision of interspecies relationality. The Research Laboratory promotes "re-enchantment of the world" by seeking languages and forms of expression that transcend species boundaries. In the cetacean project, the team has elicited responses from humpbacks, grey whales and bottlenose dolphins in Baja California and Costa Rica on a number of occasions, as well as near Inverness, Scotland.

32
Nereida is purely acoustic and does not use microphones or amplifiers.

33
Nicola Triscott, "The Re-Enchantment of the Ocean: Ariel Guzik's Cetacean Encounters" in *Holoturian*, ed. Nicola Triscott (Edinburgh: Arts Catalyst (2015), 11.

Guzik explains to me that his work relies as much on imagination as on actual interactions, and on creating the context for an encounter.[34] He explicitly distances his intentions from "certain practices of scientific materialism that have become [...] a form of appropriation for dissection, exploitation and control." Instead, the interactions with cetaceans are "conceived as acts whose transcendence does not unfold in a demonstrative or didactic sense; they respond only to an *intention* of communication with beings different from us, but also in search of something essentially universal, creating a scenario in which an encounter could take place." For Guzik, communication is disconnected from linguistic transaction: "There is no interpretation, translation or emulation of the language of others."[35]

Occasionally, he stages performances that combine the sounds of these instruments with field recordings of natural soundscapes and improvised instrumental music. I attended one of such settings at the Spore Initiative in Neukölln.[36] The experience is perhaps best described as being drawn into Guzik's world of enchantment with natural soundscapes through the beauty of the sounds and the extreme concentration with which he performed. He showed exactly that focus, that intention of communication and listening, that I imagine is central to his interactions with whales. It brings its own entrancing feeling of connection. That night an interspecies encounter between animals, instruments, artist, and audience took place in the room, when rainforests, singing whales and the chiming tones of his various instruments reached us as we melted into the pillows and carpets in the room. Intrigued by this meditative atmosphere, I started to wonder what is exchanged or, in Guzik's words, what "transcends" between humans and animals: is there such a thing as a shared aesthetic experience beyond species boundaries? What languages exist that go beyond words, that depend on our readiness to appreciate that which is unfathomable?



↑fig.4 Ariel Guzik, *Cetacean Calligraphy*, 2014, ink on paper, courtesy of Ariel Guzik.

Both Project CETI and Guzik's Laboratory start from the notion of interspecies communication, but they conceive of it in very different ways. Gruber states

34 Ariel Guzik, email conversation with the author, March 27, 2023.

35 Guzik, email conversation, 2023.

36 This took place on September 16, 2023.

"we're calling it interspecies communication, but it's really about really tuning in to sperm whales, and understanding what they're saying," indicating a form of listening that depends on positivist reliability of codes and what could be seen as infiltration.[37] Guzik, on the other hand, speaks of invitations, of intentionality when any certainty of communication or even interaction is beyond grasp, and finds the main value in the act of listening itself. In its emphasis on the intention behind listening rather than on its success, Guzik's artistic practice brings three challenges to the scientific paradigm of knowledge production: it starts from invitation rather than invasion, foregrounds opacity, and prioritises imagination over proof.

According to Guzik, the strings only respond to the vibrations of cetacean communication, allowing for the choice between refusal and playful interaction. Though one will never know cetacean perspectives on these interactions and how they experience the choice between staying, having to swim on, or keeping silent. Triscott's description of *Nereida* harmonising with multiple cetaceans who surround the capsule for an extended time suggests curiosity and, perhaps, enjoyment. As such, Guzik's work allows for reflection on the ethics of exchange. This is especially relevant compared with CETI's inescapable long-term observation system, when in addition to noise pollution of the ocean, research by marine biologists is already thought to negatively affect Dominican whales.[38] Guzik tells me that *Nereida* is carefully designed not to add disturbance to whales. Upon reflecting the voices of cetaceans, the instruments emit sonorities with a spectrum of amplitude and frequency far below the background noise of the sea. But more important than the instruments themselves is the creation of a context; a careful, unselfish scenario of encounter.[39]

As resistance against the colonial apparatus of transparency, Glissant insists on the right to opacity.[40] This is the right to be different, to be irreducible to a subject that is there to be explored by science. It entails a fundamental ethics of humility towards the other, based on the assumption that one cannot and should not know everything about another, which preserves equality. Guzik applies a parallel stance to the colonised non-human. His listening without understanding allows for interspecies relationality in which we cannot know all a whale knows, and the need to respect their lives and habitats comes exactly from the possibility that a whale is always more, entails more futures and ecological entanglements, than we humans can positively identify. In other words, if we know how a whale thinks, colonial history has demonstrated that this will at some point be instrumentalised for someone's interests just like the first point of communication and translation with Indigenous peoples led to domination, not to understanding and respectful exchange. Decolonial relationality, it follows, allows space for the ungraspable and for refusal.

Closely related, Guzik's artistic listening practice foregrounds the need for imagination. Jacques Derrida

37 The Audacious Project, "What If We Could Communicate with Another Species?," YouTube Video, 2:01, September 18, 2020, https://www.youtube.com/watch?v=DLyldhjjAWs.

38 Shane Gero and Hal Whitehead, "Critical Decline of the Eastern Caribbean Sperm Whale Population," *PLOS ONE* 11, no. 10 (2016).

39 Guzik, email conversation, 2023.

40 Glissant, *Poetics of Relation*, 191–192.

wrote that thinking with animals requires poetry rather than philosophy or science, because the perspective of animals necessarily remains a mystery, reminding us of our limitations.[41] Inspired by this, art historian Steve Baker argues that art is especially suitable for attending to animals' inherent "overspill" from representation: artistic expression as a mode of enquiry leaves room for unanswered questions, openness towards that which is not knowable.[42] Baker indicates that art is capable of opening up these questions and challenging our common assumptions about the human-animal relation, which makes "art [...] a serious tool of investigation and a powerful lever to instigate social change."[43] According to Guzik, since whales have the biggest brains on earth and have existed for thousands of years before us, we have to see them as ancestors, not in an evolutionary timeline but as beings that inhabit this planet and know it intimately. "But they don't have hands, or tools," he tells me. "Therefore I know that they must be the big philosophers of the sea."[44]

Conclusion

Guzik's philosophy of interspecies communication proposes to assume cetacean intelligence even if this is unproven, inviting the whales and the audiences into a context of tentative encounter whilst holding space for the whales' right to opacity. Though one could argue that there is an inevitable level of extraction in making art for and about animals, the Laboratory's attempts to facilitate humble exchange suggest that there are multiple modes of listening. These cannot be separated from a long history of interspecies entanglement, especially with regard to whales.

Approaching Project CETI from a postcolonial perspective allows for reading it as a continuation of the long imperial history of resource-making, rather than as a revolutionary breaking point. Especially in the context of the ocean as a seemingly void, but in fact deeply politicised space of unstable law-making, exploration for mineable resources, military exercises, global traffic, exchange of bodies and goods and climate disaster, there is a need to challenge the imperative of technological progress and techno-fixes for environmental crises. If we follow Guzik's example, it becomes clear that instead of improving the *ability* to listen through technological innovation and as such inspire change, a more ethical avenue for exploring interspecies communication in the Anthropocene would be to take a step back and reflect on *how* one listens to, and thus acts in relation to animals.

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41 Jacques Derrida, *The Animal that Therefore I Am*, trans. David C. Wills (New York: Fordham University Press, 2008).

42 Steve Baker, *Artist/Animal* (Minneapolis: University of Minnesota Press, 2013), 100.

43 Baker quotes Bryndis Snæbjörnsdóttir. Baker, *Artist/Animal*, 14.

44 Personal communication with Guzik, September 17, 2023.

AMPLIFIED ABSTRACTIONS

AUTOMATED SUBSERVIENCE, UBIQUITOUS CONTROL, AND THE POTENTIALS OF SONIC PRACTICE

Taufan ter Weel

Machines express the social formations that produce and engage with them. This involves the production of concepts and artefacts — a process that is both discursive and material-energetic, it is entangled. The advent of electronic media and computing machines, in which electromagnetic energy is used as a carrier of information (or more precisely, as a carrier wave in the process of information), radically changes and complicates the relations between bodies and their associated environments.[1] This technological evolution, ranging from early electric telecommunication and radio to ubiquitous computing, transforms how we engage with the environment with which we reciprocally produce subjectivity and make sense of life.[2] Transmission at the speed of light modifies our sense of proximity or space-time, facilitating seemingly unconfined telecommunication, real-time remote sensing, and control. Coupled with the increasing precision of clock time and processing speed, signal transmission enables and keeps on advancing radio-navigation and localisation.[3] Both the human dependence on machines to act on our surroundings and the interdependencies between these machines grow rapidly. Compatibility is vital. At the same time, the clarity or comprehensibility of the machines' inner workings decreases, which is partly inherent in their expanding complexity.[4]

With the current convolutions of ubiquitous computing and capitalism, all of this is creating the conditions for unprecedented forms of control and automation. We could call this *ubiquitous control*, which is both continuous and spatially diffuse, and *automated subservience,* in which habit and decision-making are affected at a preconscious stage by machinic processes such as modulations and probabilistic operations. The utilisation of predictive algorithms, for instance, enables one to anticipate events and affect one's choices prior to interpretation and reasoning.[5] Capitalist power increasingly functions through asignifying processes, which cannot be grasped through representational thinking.[6]

1 A signal in the general technical sense is understood as a carrier of information transmitted through a medium (in analogy with the propagation of sound). Information is impressed into a carrier wave (electromagnetic/vibrational energy) through the process of modulation. These electromagnetic signals are imperceptible to the human sensory apparatus, while they constantly surround us. They can be converted into perceivable information only through demodulation or decoding by means of machines (by technological mediation, with screens and loudspeakers at the ends or moments of transduction).

2 Here we can draw on the notion that the process of individuation cannot be decoupled from the associated milieu with which it co-evolves, as proposed by the philosopher of technology Gilbert Simondon. In other words, individuals do not pre-exist the processes and relations from which they emerge. In light of Simondon's notion, information can be understood not as that which is transmitted (that is, information as fully-formed pre-existing entity) but as in-forming process. See Gilbert Simondon, *Individuation in Light of Notions of Form and Information*, trans. Taylor Adkins (Minneapolis; London: University of Minnesota Press, 2020).

3 Regarding GPS and the "technicity of time," see Adrian Mackenzie, *Transductions: Bodies and Machines at Speed* (London, New York: Continuum, 2002), 87–115.

4 The incomprehensibility of human-machine-environment couplings goes hand in hand with the successive crises of representation, or the decline of the symbolic and semantic, which cannot be understood in isolation from the uncertainties we are confronted with today, produced by the techno-scientific milieu which we are a part of.

5 Automated subservience is closely connected to various concepts such as "algorithmic governmentality" (Antoinette Rouvroy), "proletarianization of sensibility" (Bernard Stiegler), "machinic enslavement" (Félix Guattari, Gilles Deleuze, Maurizio Lazzarato, and Gary Genosko, among others). To fully explain all the conceptualisations concerning this problem would require a lengthy discussion outside the scope of this article.

6 Both uncritical glorifications of technological progress and technophobic perspectives undoubtedly stem from representational thinking. Rather than labelling technology itself as good or bad, the directions of technological development are critical to the way we relate to others and our environment.