Sensor Landscapes / *Sensorlandschaft*

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The Arctic is an intricate landscape of sensing instruments and infrastructures. Polar-orbiting satellites track icebergs[1] and observe wildlife;[2] airguns trace undersea topographies;[3] biochemical sensors float in the drift ice;[4] radar stations collect atmospheric data;[5] and hydrophones listen for underwater sounds.[6] Even narwhals are recruited as remote sensors: fitted with radio transmitters to collect data from beneath the ice sheets, in areas otherwise impossible for researchers to access.[7] Increasingly, we navigate the region through senses other than our own.

In part, this is explained by the fact that the Arctic remains one of the least understood and least accessible regions on the planet: obstructed by crushing pack ice, obscured in complete darkness for half of the year, and subject to notoriously frigid temperatures. Only a fraction of the polar sea has been explored — an ocean teeming with mysterious sea creatures — and the contours of surrounding landmasses are blurry, too, with new islands and landforms occasionally emerging

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[1] V. G. Smirnov et al., "Satellite Monitoring of Icebergs in the Arctic Seas," *Russian Meteorology and Hydrology* no. 44 (April 2019): 262–267. https://doi.org/10.3103/S1068373919040058.

[2] Justyna Cilulko et al., "Infrared Thermal Imaging in Studies of Wild Animals," *European Journal of Wildlife Research* no. 59 (December 2012): 17–23. https://doi.org/10.1007/s10344-012-0688-1.

[3] Robert C. Gisiner, "Sound and Marine Seismic Surveys," *Acoustics Today* 12, no. 4 (August 2016): 10–18. https://acousticstoday.org/wp-content/uploads/2016/12/Seismic-Surveys.pdf.

[4] Argo, "What Is Polar Argo?," February 2016. http://www.argo.ucsd.edu/Polar_Argo.html.

[5] Shannon Hall, "Frozen Researchers Will Greatly Improve Arctic Weather Prediction," *Scientific American*, November 11, 2019. https://www.scientificamerican.com/article/frozen-researchers-will-greatly-improve-arctic-weather-prediction/.

[6] Ocean Conservation Research, "Deploying Hydrophones: Listening to the Arctic Ocean," website. https://ocr.org/learn/deploying-hydrophones/.

[7] Pat Brennan, "Narwhal Recruits Track Melting Arctic Ice," NASA: Global Climate Change, October 26, 2017. https://climate.nasa.gov/news/2643/narwhal-recruits-track-melting-arctic-ice/.

from melting glaciers.[8] While the Arctic's Indigenous inhabitants have lived closely entwined with the ocean and the ice for thousands of years, few others have been able to persevere in the inhospitable landscape. A handful of sparsely populated military and research bases, drilling platforms, and the occasional tourist cruise ship are the only other traces of human occupation. To stand a chance at better understanding a region so deeply shrouded in mystery, instruments are sent in our place: to watch and measure and probe the distant terrain.[9]

But it is the effects of climate change that have really supercharged the presence of sensing instruments in recent years and have turned the world's eyes north. With the Arctic warming faster than anywhere else on the planet, geotechnologies find themselves entangled in a tug-of-war between those racing to protect the region and those eager to exploit the changes for financial profit. To one side are climate scientists and environmentalists intent on monitoring the rapidly reconfiguring polar ecologies. They rely on a steady stream of environmental data to generate detailed climate models and make projections for the future, as warming temperatures in the Arctic are not only detrimental locally, but also threaten to amplify global warming worldwide.[10]

Meanwhile, extractive industries and national governments rely on the same technologies to stake their influence over the region, as melting sea ice promises unprecedented access to untapped oil and gas reserves and control over emerging shipping routes.[11] Remote sensors are tasked with constructing digital models of subterranean worlds to determine the statistical probability of petrochemicals. Satellites map icebergs to generate commercial shipping routes across the thawing ocean. Instruments and algorithms are even charged with mediating an

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[8] Jessie Yeung, "Melting glaciers in the Russian Arctic reveal five new islands," *CNN,* October 23, 2019. https://www.theguardian.com/environment/2019/oct/22/melting-glaciers-reveal-five-new-islands-in-the-arctic.

[9] This piece builds on ideas developed in previous publications:
Carolyn Kirschner, "Remote Sensing the Arctic: An Exploration of Non-Human Perspectives of the Territory," *Evental Aesthetics* 10, no. 1 (March 2021): 3–28;
Carolyn Kirschner, "NO_POLE: Data-Scapes and Digital Ecologies," *Perspecta* 54 (2021).

[10] Aiguo Dai et al., "Arctic amplification is caused by sea-ice loss under increasing CO2," *Nature Communications* 10 (January 2019). https://doi.org/10.1038/s41467-018-07954-9.

[11] Neil Shea, "Scenes from the New Cold War Unfolding at the Top of the World," *National Geographic*, May 8, 2019. https://www.nationalgeographic.com/environment/2018/10/new-cold-war-brews-as-arctic-ice-melts/;

ongoing territorial dispute over the Arctic Ocean, in an area currently designated as international waters, where Canada, Denmark, Norway, Russia, and the USA are each scrambling to claim portions of the polar seabed. It is an unusual conflict in which authority is not wielded through the brutal use of military force, but rather through the possession of information. Effectively, guidelines set out by the United Nations Convention on the Law of the Sea (UNCLOS) rely on remote sensors to draw up borders across the Arctic Ocean — tasked with extracting and electronically scanning through troves of geological data to determine whether the portions of seabed in question are a natural continuation of each nation's continental shelf and therefore rightfully theirs.[12]

In a region where humans are few and far between, the networked machines have become indispensable operators in global affairs. They hold multiple, conflicting roles: as wildlife conservationists, climate strategists, venture capitalists, explorers, and warfare negotiators — often rolled into a single piece of hardware. Commercial organizations like Andøya Space off the northern coast of Norway (see p. tk), which hires out its vast sensing infrastructures and 25,000 km^2 test range to scientific institutes and furtive military operations alike, perfectly encapsulate the complicated, multifaceted role that sensing technologies play in the Arctic.[13] The instruments oscillate between competing agendas, between protecting and exploiting the landscape, and in the process — as captured by the photographs in this book — turn the far north into a stage-set for unfolding tensions between economic, environmental, and geopolitical pursuits.

Fittingly, the majority of sensing instruments in use today emerged from military applications across the two World Wars and the Cold War, where they were used primarily for enemy surveillance. Scientists promptly adapted and repurposed technologies for environmental research when early military systems were declassified in the 1960s. International space programs, in turn, delivered the necessary interest and sponsorship for continued technological advances.[14] By the 1970s, the first real-time satellite imagery of the Arctic was transmitted from space, and early ground-sensing infrastructures were installed, including European Incoherent Scatter Scientific Association (EISCAT) radar stations, which

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[12] United Nations, "United Nations Convention on the Law of the Sea," November 10, 1982. https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf.

[13] Andoya Space, "What we Do," website. https://www.andoyaspace.no/.

[14] Gerald K. Moore, "What is a Picture worth? A History of Remote Sensing / Quelle est la valeur d'une image? Un tour d'horizon de télédétection," Hydrological Sciences Bulletin 24, no. 4 (April 1979): 477-485. https://doi.org/10.1080/02626667909491887.

are still operational to this day (see p. tk).[15] Gradually, the Arctic was extruded upwards and downwards, as new layers of information were added to the terrain: from scans of subterranean rock formations to readings of the polar stratosphere.

How will our perceptions of landscapes and ecologies be altered by this growing reliance on synthetic senses to understand, interact with, and make decisions about the planet? Could we find entirely new ways of seeing and sensing the world in the instrument landscapes of the far north?

Remote sensors encounter their surroundings by translating environmental stimuli — temperature, pressure, light — into electrical resistors and voltage signals.[16] They construct digital models of the polar ecologies from these measurements, converting the distant landscape into a format that allows it to be transmitted across the globe and stored on networked servers. It is these electronically fabricated versions of the Arctic that most of us are familiar with, the official maps, surveys, and satellite images that effectively become placeholders for the physical terrain, steer international decision-making, and shape imaginaries of a region rarely encountered in person.

But as the tangly polar ecologies are funneled through automated machine sensors and squeezed onto silicone chips, gaps and glitches are inevitable. Satellites tasked with monitoring shipping routes across the Arctic Ocean, for example, only recognize ships if they are larger than 20 pixels — misidentifying smaller ships as waves.[17] Elaborate wave formations, in turn, are routinely misidentified as ships.[18] Polar bears are equally elusive. Their dense fur coat absorbs portions of the electromagnetic spectrum, making them invisible to infrared cameras tasked with

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[15] EISCAT Scientific Association, "About EISCAT," website. https://eiscat.se/about/sites/eiscat-tromso-site/.

[16] Jennifer Gabrys, *Program Earth: Environmental Sensing Technology and The Making Of A Computational Planet* (Minneapolis: University of Minnesota Press, 2016), 8.

[17] Christina Corbane et al., "A Complete Processing Chain for Ship Detection Using Optical Satellite Imagery," *International Journal of Remote Sensing* 31, no. 22 (2010): 5837–5854. https://doi.org/10.1080/01431161.2010.512310.

[18] Peder Heiselberg and Henning Heiselberg, "Ship-Iceberg Discrimination in Sentinel-2 Multispectral Imagery by Supervised Classification," *Remote Sensing* 9 (November 2017). https://doi.org/10.3390/rs9111156.

wildlife observation.[19] In a strange pairing, ecological conceptions of the Arctic have become a direct measure of technological capacity — of resolution and processing power.

What's more, the alien mechanisms of machine cognition make for a fundamentally different way of encountering the world. Where scientific categories and classifications insist on crisp taxonomic boundaries, and Western worldviews have trained many human eyes to do the same, it is a logic that is glaringly incompatible with the inner workings of the instrument landscape. Through electronic eyes, boundaries between what is human, animal, landscape, or technology, between waves and ships, polar bears and ice floes, become indistinct. The Arctic is turning into an assemblage of pixels with no clear beginnings or ends, prone to omissions and distortions.

Discrepancies between different nations' models in their submissions to UNCLOS, in turn, reveal attempts to capitalize on these slippery digital terrains. The inevitable technologically driven glitches between the physical planet and its electronic counterparts are compounded by concerted efforts by the Arctic Nations to strategically manipulate the terrain in their favor, to make their territorial claims more viable — "to hide, to scan, to camouflage, to self-display and to trick the world into seeing things not as they are but as they could be or should be."[20] Rather than creating a single master image of the landscape by which to resolve the dispute, the Arctic Ocean has started to multiply into countless, contradictory versions of itself, with competing political agendas infiltrating the purportedly objective proceedings.

As the Arctic is increasingly digitized, paradoxically, the very instruments deployed to rationalize, conquer, and contain the mysterious polar region are unveiling disorienting, politically charged doppelgängers of the landscape, pieced together from bits, bytes, and pixels. The polar ecologies are expanding in multiple dimensions, far beyond what is visible to the naked eye.

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[19] Jessica A. Preciado et al., "Radiative Properties of Polar Bear Hair," *ASME 2002 International Mechanical Engineering Congress and Exposition* (November 2002): 57–58. https://doi.org/10.1115/IMECE2002-32473.

[20] Stephanie Holmes, "Breaking the Ice: Emerging Legal Issues in Arctic Sovereignty," *Chicago Journal of International Law* 9, no. 1 (June 2008): 323–51. https://chicagounbound.uchicago.edu/cjil/vol9/iss1/13;
Benjamin H. Bratton, "Further Trace Effects of the Post-Anthropocene," *Architectural Design (AD)* 89, no. 1 (February 2019): 14–21.

The physical terrain, too, is proving slipperier than once expected and rather incompatible with prevailing Western fictions of a rigid planet that lends itself to being neatly drawn up and divided with lines on a map. Streams of remote sensing data transmitted from the far north reveal a landscape in perpetual motion, where sea levels are rising and tectonic plates are shifting, while underwater volcanoes erupt and spew new land. The instruments watch as turbulent currents perpetually rearrange the topography of the sea floor and icebergs leave deep gouges as they scrape across the sediments. Seaquakes create deep-set fissures and fractures, continents separate, and the ocean grows, while the Earth's magnetic field erratically shifts and scrambles navigation systems along its way. It is a version of the landscape that is difficult to square with Capitalist and colonial enterprises, with the static logics underpinning extractive industries and tourism, national borders, and nation states.

Sensing infrastructures installed in the Arctic join a long history of attempts at capturing the far north — from centuries-old myths and fantastical maps that encircled the region long before anyone set eyes on it, to fraught polar expeditions at the turn of the twentieth century that triggered an international race to conquer the North Pole. Where nations in these early days relied on planting flagpoles into the ice to mark their dominance over the region, today they rely on parabolic radar dishes, servers and data storage facilities, fields of antennas, automated surveillance systems, meteorological stations, floating research platforms, and unmanned aircraft to do the same.

In the surreal landscapes that emerge, humans are vastly outnumbered by machines and sites are often optimized for machine presence rather than our own. Instruments have become so deeply entangled in the polar ecologies that they are like a new technological species, flickering as they interact with their surroundings. Just as Indigenous populations have long known: the precarious polar landscape is sentient and "equipped with a sense of hearing, sight, and smell."[21] This expanding electronic consciousness plays a central role in the geopolitical future of the far north and allows us to construct elaborate computational models of the distant past. Machine sensors allow us to better understand the world — to take a closer look, to map, measure, and reveal things with data.

But as we encounter the rapidly changing polar ecologies through senses other than our own, could the Arctic also become a production site for a new set of environmental narratives?

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[21] Julie Cruikshank, *Do Glaciers Listen?: Local Knowledge, Colonial Encounters, and Social Imagination* (Vancouver: UBC Press, 2006), 229.

Through machine eyes, we see versions of the landscape that outpace prevailing worldviews — shaped by computational logics far beyond the reach of human senses and Western norms. Perhaps the strikingly harsh and fragile instrument landscapes captured in the following pages are entry-points into otherworldly alter-egos of the planet, unfamiliar visual and material languages, and untapped ecological imaginations — a world where we are no longer at its center.

Bio:
Carolyn Kirschner is a designer and researcher with a background in architecture. She currently holds teaching positions as Adjunct Professor at Parsons School of Design in New York, and as Associate Lecturer at Goldsmiths, University of London. Her work explores the growing entanglements of humans, non-humans, bits, bytes, delicate ecologies, and emerging technologies, using design as an investigative tool to better understand our present challenges and to speculate on broader socio-cultural shifts. Carolyn's work has been published and exhibited internationally. She holds a Master of Architecture from the Royal College of Art in London.