

Current's Wanderers

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ZHdK Department of Design · 2024-2026

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Current's Wanderers
A Real-Time Bridge to Plankton Life

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Project concluded in June 2026

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Abstract

Although unable to resist the water currents that transport them, and therefore seemingly relegated to wandering passengers within aquatic ecosystems, planktonic microorganisms constitute an essential component for the health and stability of global ecological balances, both aquatic and terrestrial. Despite the crucial role they play, the knowledge and awareness that human society possesses regarding this reality remain limited, hindering the development of approaches to environmental conservation that are less anthropocentric and more sensitive to ecological interdependencies. The ways in which humans and planktonic microorganisms perceive and interact with the surrounding world, defined through the concept of Umwelt, differ profoundly due to factors such as differences in scale, anatomical structures, and the ecosystems in which they live. This perceptual separation makes a mutual awareness of each other's existence and of the impact each exerts on the shared environment particularly complex.

Starting from water as a primary element of both physical and conceptual connection, the theoretical framework draws upon the posthuman and feminist ecological philosophy of Astrida Neimanis, integrating it with research demonstrating how an emotional and rational connection can

strengthen proactive behaviors oriented toward the conservation of natural environments. Within this context, the theory of Compassion Fade is taken into consideration, describing the progressive decline of empathy as the number of beings involved increases. In response to this phenomenon, the project builds upon the findings of Pimentel and Kalyanaraman, who highlight how highly immersive embodied experiences may mitigate, or even reverse, this effect toward non-human organisms.

Thanks to a close collaboration with scientists Marta Reyes and Stefanie Eyring from the Aquascope research group at Eawag, the project is grounded in the emotional and knowledge-based connections that have developed over time between the researchers and their object of study.

This collaboration, applied to the theoretical foundations together with the collected scientific knowledge and data, shape the communication model that takes form within several artifacts. The rational compassion is built through two videos realized with the aim of setting a reliable scientific knowledge base combined with an emotional connection thanks to the first-hand experience of the scientists. On top of that an interactive installation that updates itself in real time through data acquired from an underwater microscope in the Greifensee, allows visitors to enter in direct relation with the planktonic microorganisms inhabiting the lake. The experience re-presents a microscopic portion of the lake in a perceptually accessible form for human beings, artificially expanding their possibilities of perceiving and interacting with the aquatic environment. Shaped on water physical properties, the interaction offers the possibility to intervene with the currents that transport planktonic organisms through their continuous wandering across the lake waters. To mitigate the phenomenon of compassion fade, the embodied experience allows visitors to observe, listen to, and tactilely perceive the presence and behavior of the microorganisms in the lake.

The project aims to offer a point of access to planktonic ecosystems capable of fostering forms of understanding and connection that can endure over time, while encouraging the adoption of ecological perspectives able to transcend a strictly anthropocentric vision of the natural world.

Acknowledgments

Although this is a personal Master's thesis project in Interaction Design, its realization would not have been possible without the contribution, support, and presence of all the people who accompanied me throughout this journey.

I would first like to thank my mentors Karmen Franinovic, Luke Franzke, and Anthea Oestreicher, who, through their experience, guided and supported me through every phase of the project development, from the initial conceptualization to the final realization.

A heartfelt thank you goes to Marta Reyes and Stefanie Eyring from the Aquascope Eawag research group, who dedicated time, energy, and expertise to support the project both scientifically and personally, actively contributing to its development and becoming an integral part of it.

A special thank you goes to Duy Bui and all the lecturers of the Master in Interaction Design for the invaluable human and professional support provided to me and to all my fellow students, and for sharing essential knowledge, perspectives, and tools during lectures and Colloquium sessions.

I would like to thank Jana Thierfelder and Patrick Müller for welcoming me into the minor Art & Science, for supporting me throughout the development of the project,

Acknowledgments

and for enabling the essential collaboration with the research centre Eawag.

A special thank you to Sacha Schwarz, Madeleine Hykes, Leon Junge, Paula Meyer-Clason, and Micha Baggenstos, who more than anyone else have been part of my personal journey over these years. Thank you for sharing knowledge, thoughts, and exchanges that were essential for the growth of both the project and the person developing it. Thank you for the generosity with which you shared your expertise and, above all, thank you for your friendship.

I would like to thank all my fellow students in the Master in Interaction Design, the people with whom I shared the atelier spaces of the Master in Design, and my peers from the minor Art & Science.

I would like to thank all the people working within the infrastructure of ZHdK who contribute daily to making possible an environment open to experimentation, research, and personal growth.

I am deeply grateful to my family for their support and for making this experience possible. A special thank you to my father for sharing his experience with me and for worrying about the success of this project almost more than I did.

Thank you to Laura Weber, Carlo Rusca, Saliù Baldé, Aline Brazzola, Zoe Togni and all the people who constantly supported me outside of school throughout these past two years.

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Introduction

When discussing plankton, both the general understanding of the term and the ecological significance of the organisms it encompasses seem to me being often fragmented and imprecise. This lack of clarity also characterized my own initial engagement with the subject, compelling me to confront gaps in my knowledge as well as preconceived assumptions. Although I believed I had a basic understanding of what plankton are, I was ultimately required to acknowledge that I did not even fully grasp the common criterion that defines which organisms fall under this category.

There is a deeply poetic quality in defining a group of living beings by their inability to resist the movement of aquatic currents. These are wandering entities, guided by the forces that animate the very substance composing the entirety of their universe: water. It is precisely this medium that, despite physically separating plankton from the terrestrial environments humans typically inhabit, offers a fundamental point of connection through which these life forms can be approached. When the human body is understood as an open system, water emerges as a substance continuously exchanged and shared with all other organisms on the planet, enabling both a symbolic and material connection with

the rest of life on Earth, including forms of life that remain invisible to us (Neimanis 2017).

Composed largely of organisms too small to be perceived with the naked eye, plankton function as invisible operators, highly complex and specific, silently regulating the balance of natural systems beyond human awareness (Holland et al. 2024). Discovering their extraordinary qualities has profoundly intensified the sense of wonder and fascination I continue to experience toward these forms of life. It is precisely this state of fascination, coupled with the urgency imposed by climate change, that motivates my desire to support and invite others to encounter the reality of the planktonic organisms inhabiting the waters of our planet.

This thesis project represents a personal attempt to articulate the need to bring closer together two worlds that must mutually support one another in order to face the future with greater awareness and care. Through a combination of scientific information, emotional engagement, and sensory involvement, *Current's Wanderers* draws upon the knowledge and passion of those most deeply engaged in plankton research, to reach individuals who have not yet had the opportunity to be surprised by the planktonic universe. In particular, the project focuses on studies conducted by scientists at the Aquascope group of the Eawag research institute, investigating the waters and organisms of Lake Greifensee, in the Canton of Zurich, Switzerland.

To guide the project through the different stages of development, this research asks the following questions:

- How can a non-invasive interactive installation be designed to enable a closer connection between the public and the planktonic microorganisms of local waters, fostering a greater ecological awareness that goes beyond the anthropocentric perspective?

- Which non-invasive methods can be used to translate the presence of planktonic microorganisms to the public?
- Which forms of experiential interaction can facilitate meaningful and emotional engagement between the public and the local plankton species?
- Which ethical considerations emerge and need to be addressed at the intersection between science, society, and planktonic microorganisms?

Approach to the Background Research

In order to build and convey a solid theoretical knowledge base on the topic addressed, an analysis of the existing literature was conducted. This analysis is structured into five chapters that outline the main theoretical references on which the project is grounded. Each chapter includes a section providing further insight, in which I set out my personal views and reflections.

The first chapter, *The Need for a Greater Consideration*, provides a historical and contemporary overview of the current climate crisis, highlighting the need to increase the level of social consideration toward microorganisms and plankton in relation to this subject. The following chapter, *Scientific Context*, delves into the topic of planktonic organisms, presenting their main characteristics, ultimately focusing on the Swiss context and on the studies conducted by the Aquascope group at the research institute Eawag. The third chapter, *History of Plankton-Human Interactions*, offers a chronological selection of the key interactions that have shaped the evolution of the relationship between human society and planktonic organisms. The chapter *Think Like a Body of Water* introduces the fundamental theories that constitute the conceptual foundation of the research project,

Approach to the Background Research

while *Rethinking Agency Beyond Anthropocentrism* concludes by outlining my personal ethical position on planktonic microorganisms, supported by arguing for the necessity of adopting a less anthropocentric perspective when reflecting on the ecological and social implications concerning these forms of life.

To broaden the horizon of design possibilities an analysis of several case studies is presented. The purpose of this in-depth study is to take inspiration from previously explored solutions while preventing critical issues already addressed by other designers. For this reason, following the literature review, twelve relevant projects were analyzed, focusing on different aspects and characteristics. The projects are organized into four categories: *Scientific Monitoring Strategies*, *Communication of Scale*, *Live Data Manifestation* and *Immersive Experiences*. Each project is presented, described, and related to the others in order to extract insights useful for the design development, which are collected at the beginning of each category chapter.

A glossary containing definitions of the more complex terms is provided at the end of the document; these terms are marked with an asterisk *.

[1]

Background Research

- [1.1] The Need for a Greater Consideration
- [1.2] Scientific Context
- [1.3] History of Plankton-Human Interactions
- [1.4] Think Like a Body of Water
- [1.5] Rethinking Agency Beyond Anthropocentrism
- [1.6] Case Studies Analysis

[1.1]

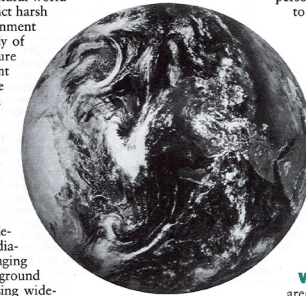
The Need for a Greater Consideration

As early as 1992, 1,700 scientists warned the inhabitants of planet Earth about the critical state of the global climate in a publication entitled “World Scientists’ Warning to Humanity” [1] (Union of Concerned Scientists 1992). At the dawn of the first quarter of the 21st century, the situation does not appear to have improved significantly. In fact, in 2017, a follow-up, or rather, a “second notice”, was published, in which more than 15,372 scientists from 184 countries stated that, with the exception of the stabilization of the ozone layer, other environmental issues were in a state of significant decline (Ripple et al. 2017).

To help address the problem, experts proposed several innovative actions aimed at reducing the human impact on the planet, focusing on various aspects: from the transition to renewable energy sources to improvements in the transportation sector, from the construction industry to deforestation, and so on (Feigin et al. 2023). Among the many perspectives from which climate change and its consequences are studied, however, the microbiological one is unfortunately often overlooked and not taken into account in the development of actions and policies (Cavicchioli et al. 2019), thereby excluding most planktonic organisms from the discussion due

WORLD SCIENTISTS’ WARNING TO HUMANITY

INTRODUCTION Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about.



person in five lives in absolute poverty without enough to eat, and one in ten suffers serious malnutrition.

No more than one or a few decades remain before the chance to avert the threats we now confront will be lost and the prospects for humanity immeasurably diminished.

WARNING We the undersigned, senior members of the world’s scientific community, hereby warn all humanity of what lies ahead. A great change in our stewardship of the earth and the life on it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated.

THE ENVIRONMENT The environment is suffering critical stress:

The Atmosphere Stratospheric ozone depletion threatens us with enhanced ultraviolet radiation at the earth’s surface, which can be damaging or lethal to many life forms. Air pollution near ground level, and acid precipitation, are already causing widespread injury to humans, forests, and crops.

Water Resources Heedless exploitation of depletable groundwater supplies endangers food production and other essential human systems. Heavy demands on the world’s surface waters have resulted in serious shortages in some 80 countries, containing 40 percent of the world’s population. Pollution of rivers, lakes, and groundwater further limits the supply.

Oceans Destructive pressure on the oceans is severe, particularly in the coastal regions which produce most of the world’s food fish. The total marine catch is now at or above the estimated maximum sustainable yield. Some fisheries have already shown signs of collapse. Rivers carrying heavy burdens of eroded soil into the seas also carry industrial, municipal, agricultural, and livestock waste—some of it toxic.

Soil Loss of soil productivity, which is causing extensive land abandonment, is a widespread by-product of current practices in agriculture and animal husbandry. Since 1945, 11 percent of the earth’s vegetated surface has been degraded—an area larger than India and China combined—and per capita food production in many parts of the world is decreasing.

Forests Tropical rain forests, as well as tropical and temperate dry forests, are being destroyed rapidly. At present rates, some critical forest types will be gone in a few years, and most of the tropical rain forest will be gone before the end of the next century. With them will go large numbers of plant and animal species.

Living Species The irreversible loss of species, which by 2100 may reach one-third of all species now living, is especially serious. We are losing the potential they hold for providing medicinal and other benefits, and the contribution that genetic diversity of life forms gives to the robustness of the world’s biological systems and to the astonishing beauty of the earth itself.

Much of this damage is irreversible on a scale of centuries, or permanent. Other processes appear to pose additional threats. Increasing levels of gases in the atmosphere from human activities, including carbon dioxide released from fossil fuel burning and from deforestation, may alter climate on a global scale. Predictions of global warming are still uncertain—with projected effects ranging from tolerable to very severe—but the potential risks are very great.

Our massive tampering with the world’s interdependent web of life—coupled with the environmental damage inflicted by deforestation, species loss, and climate change—could trigger widespread adverse effects, including unpredictable collapses of critical biological systems whose interactions and dynamics we only imperfectly understand.

Uncertainty over the extent of these effects cannot excuse complacency or delay in facing the threats.

POPULATION The earth is finite. Its ability to absorb wastes and destructive effluent is finite. Its ability to provide food and energy is finite. Its ability to provide for growing numbers of people is finite. And we are fast approaching many of the earth’s limits. Current economic practices which damage the environment, in both developed and underdeveloped nations, cannot be continued without the risk that vital global systems will be damaged beyond repair.

Pressures resulting from unrestrained population growth put demands on the natural world that can overwhelm any efforts to achieve a sustainable future. If we are to halt the destruction of our environment, we must accept limits to that growth. A World Bank estimate indicates that world population will not stabilize at less than 12.4 billion, while the United Nations concludes that the eventual total could reach 14 billion, a near tripling of today’s 5.4 billion. But, even at this moment, one

WHAT WE MUST DO Five inextricably linked areas must be addressed simultaneously:

1. We must bring environmentally damaging activities under control to restore and protect the integrity of the earth’s systems we depend on. We must, for example, move away from fossil fuels to more benign, inexhaustible energy sources to cut greenhouse-gas emissions and the pollution of our air and water. Priority must be given to the development of energy sources matched to Third World needs—small-scale and relatively easy to implement.

We must halt deforestation, injury to and loss of agricultural land, and the loss of terrestrial and marine plant and animal species.

2. We must manage resources crucial to human welfare more effectively. We must give high priority to efficient use of energy, water, and other materials, including expansion of conservation and recycling.

3. We must stabilize population. This will be possible only if all nations recognize that it requires improved social and economic conditions, and the adoption of effective, voluntary family planning.

4. We must reduce and eventually eliminate poverty.

5. We must ensure sexual equality, and guarantee women control over their own reproductive decisions.

The developed nations are the largest polluters in the world today. They must greatly reduce their overconsumption, if we are to reduce pressures on resources and the global environment. The developed nations have the obligation to provide aid and support to developing nations, because only the developed nations have the financial resources and the technical skills for these tasks.

Acting on this recognition is not altruism, but enlightened self-interest: whether industrialized or not, we all have but one lifeboat. No nation can escape from injury when global biological systems are damaged. No nation can escape from conflicts over increasingly scarce resources. In addition, environmental and economic instabilities will cause mass migrations with incalculable consequences for developed and undeveloped nations alike.

Developing nations must realize that environmental damage is one of the gravest threats they face, and that attempts to blunt it will be overwhelmed if their populations go unchecked. The greatest peril is to become trapped in spirals of environmental decline, poverty, and unrest, leading to social, economic, and environmental collapse.

Success in this global endeavor will require a great reduction in violence and war. Resources now devoted to the preparation and conduct of war—amounting to over \$1 trillion annually—will be badly needed in the new tasks and should be diverted to the new challenges.

A new ethic is required—a new attitude towards discharging our responsibility for caring for ourselves and for the earth. We must recognize the earth’s limited capacity to provide for us. We must recognize its fragility. We must no longer allow it to be ravaged. This ethic must motivate a great movement, convincing reluctant leaders and reluctant governments and reluctant peoples themselves to effect the needed changes.

The scientists issuing this warning hope that our message will reach and affect people everywhere. We need the help of many.

We require the help of the world community of scientists—natural, social, economic, political;

We require the help of the world’s business and industrial leaders;

We require the help of the world’s religious leaders; and

We require the help of the world’s peoples.

We call on all to join us in this task.

SPONSORED BY THE UNION OF CONCERNED SCIENTISTS, TWO BRATTLE SQUARE, CAMBRIDGE, MA 02238-9105

to their primarily microscopic size (Kingsford 2025).

One of the causes of this neglect lies in the fact that modern society harbors a deep-rooted ignorance regarding microorganisms and their importance for the resilience of life on Earth is often underestimated (Thaler 2021). These tiny life forms are in fact essential, as they determine, for example, the biogeochemical cycles* of our planet, they are responsible for the emission, capture, and transformation of greenhouse gases, and control the fate of carbon in both terrestrial and aquatic ecosystems (Peixoto et al. 2024). Plankton, in particular, are responsible, among other things, for producing approximately 50% of the oxygen in the atmosphere and form the basis of the food chain that sustains both aquatic and terrestrial life (McQuatters-Gollop 2024).

Society's difficulty in recognizing such importance and responsibility in these living beings also stems from the fact that their extremely small size prevents humans from directly perceiving their impact. The general lack of attention given to the microbiological world, can be added to a long-standing and widespread misinformation that generally leads people to erroneously associate microbes with disease (Simard 2023). However, this perception is completely at odds with the reality of the situation, which shows that less than one percent of the total number of microbial species on the planet are considered pathogenic ('Microbiology by Numbers' 2011).

Given the limited awareness of the fundamental role that planktonic microorganisms play in maintaining the balance of the Earth's ecosystem as we know it, I believe it is necessary to bring these life forms closer to the collective imagination and ecological consciousness of contemporary society. This process should initially address the general public and subsequently extend to those responsible for shaping environmental protection policies. Considering the widespread lack of knowledge surrounding this topic, I therefore consider it essential to deepen

the understanding of the basic principles of planktonic biology and to recognize the concrete role that these predominantly microscopic communities play in sustaining the balance of the global ecosystem.

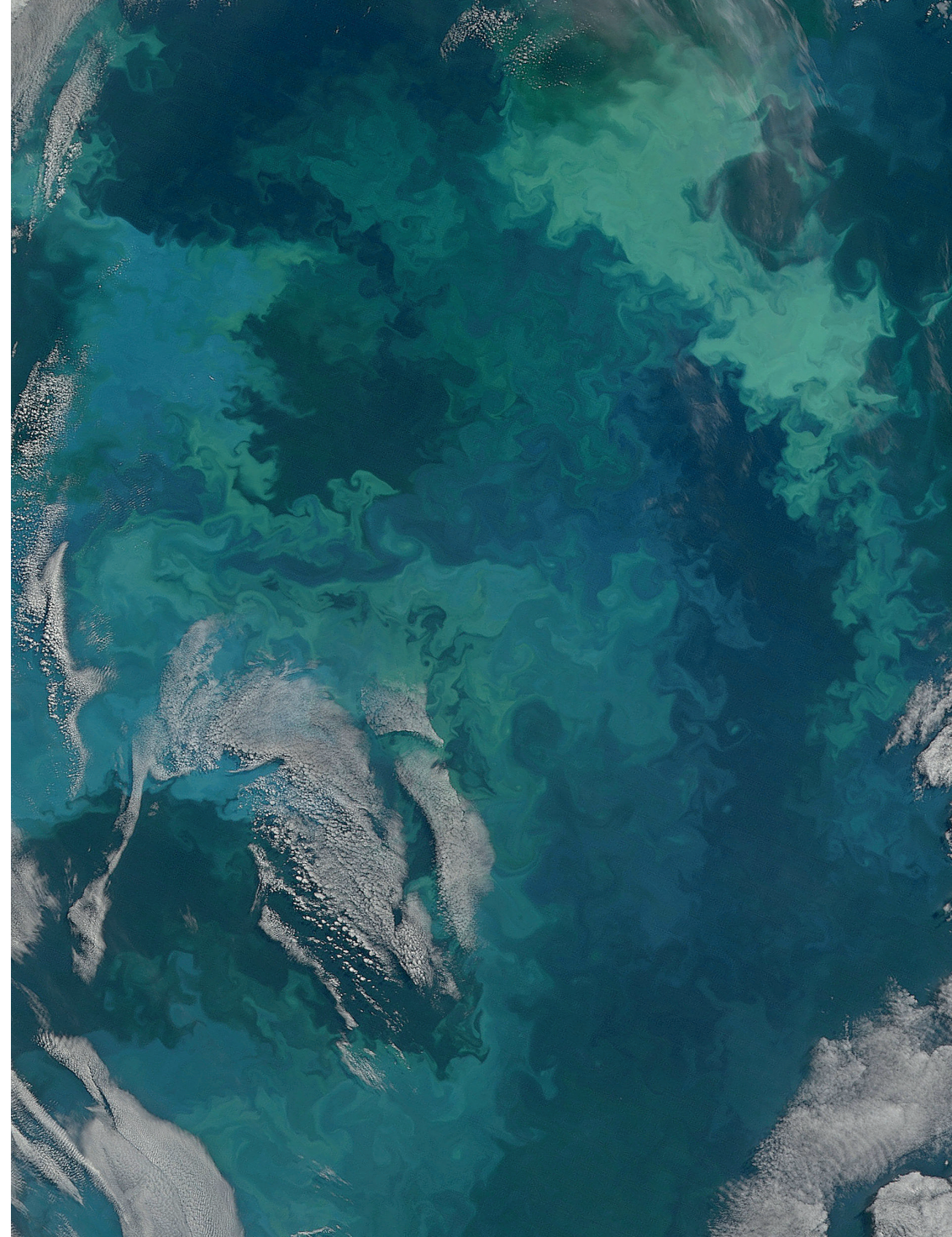
[1.2]

Scientific Context

Building upon the limited public awareness highlighted in the previous chapter, the following section introduces the key concepts necessary to contextualize the research within its scientific framework. The aim is to further explore the topic from a scientific perspective in order to identify fundamental elements that could eventually be incorporated and translated into the final project.

The term “plankton”, derived from ancient Greek and translatable as “wandering” or “drifting”, was coined by German physiologist Viktor Hensen (1835-1924) in 1887. It refers to the collective group of living organisms inhabiting large bodies of water, whose mobility is insufficient to resist currents, rendering them passive to their flow (Etymonline, n.d.).

It is therefore not a group defined by phylogenetic* or taxonomic* criteria, but rather represents an ecological category based on a specific lifestyle. It includes a wide variety of organisms (animals, plants, algae, bacteria, archaea) united by the way they inhabit and interact with their environment: suspended within the water column and unable to actively resist the hydrodynamic forces that drag them along (Biol. Libr. 2018).



[2] Phytoplankton Bloom in the Barents Sea
(NASA Goddard Space Flight Center 2010)

Plankton can be classified according to various criteria, including size, type, and the duration of their drifting state (US Department of Commerce, n.d.). However, the most fundamental categories distinguish planktonic individuals into three functional groups: phytoplankton (autotrophic* organisms), zooplankton (heterotrophic* organisms), and mixoplankton (mixotrophic* organisms) (Millette et al. 2024).

Although some species, such as the *Cyanea capillata* jellyfish [3] belonging to the Megaplankton category, can reach sizes of several meters (Hosia et al. 2015), in most cases planktonic individuals are extremely small, making them invisible to the naked eye (Greene 2024). As such, plankton are largely hidden from human sight but colonize almost all bodies of water on the planet, performing a wide range of functions that are essential for maintaining the ecological balance that sustains life on Earth (Sahoo et al. 2024).

Copepods [4], for instance, are among the most common and easily recognizable forms of zooplankton and they are found in nearly all oceans, seas, and freshwater environments, including subterranean cave systems, serving as a crucial food source for many small fish species ('About COPEPOD', n.d.). Phytoplankton [5], for their part, produce approximately 50% of the oxygen present in the atmosphere, thereby playing a vital role in sustaining both aquatic and terrestrial ecosystems (NASA Earth Observatory 2016).

The estimated 100,000+ species of plankton that inhabit our planet's waters (McQuatters-Gollop 2024), play a pivotal role in maintaining the overall health of the planetary ecosystem, as variations in the composition of its communities can trigger large-scale effects, significantly impacting both marine ecosystems and, consequently, the global environment (Holland et al. 2024).

The current climate crisis however, by causing continuous warming of aquatic systems, is disrupting ocean mixing processes. This disruption leads to a reduction in the availability of essential nutrients for planktonic organisms, parti-



[3] *Cyanea Capillata*
(W.carter 2019)



[4] Copepods of different species
(Savitsky 2019)

cularly phytoplankton, which form the foundation of aquatic food webs. As a result, the ecological balance, and ultimately the survival of many other life forms, is under significant threat (Venegas et al. 2023).

In 2022, a study examining the responses of marine phytoplankton to multiple environmental stressors employed machine learning models to identify global tipping points in phytoplankton productivity and resilience under the influence of eight distinct stress factors (Ban et al. 2022). The findings indicate that, if current emission trends persist, approximately 50% of tropical regions will reach critical thresholds in phytoplankton productivity decline by 2100 (Ban et al. 2022).

In freshwater lake systems, which contain smaller water volumes compared to marine environments, rising temperatures are often accompanied by remarkable increases in pollutants such as phosphorus ('Lake Water Quality', n.d.). A study conducted on ten Swiss lakes revealed that, although each lake exhibits a unique response, the combined effects of warming and pollution negatively impact the network of interactions among plankton species, thereby altering the balance of the entire lake ecosystem (Merz et al. 2023).

Among these lakes, Greifensee [5], located in the canton of Zurich, stands out due to its high level of eutrophication*, primarily caused by pollution from surrounding urban areas ('Lake Water Quality', n.d.). The lake's oxygen concentration is so low that artificial aeration is required to maintain a minimum of 4 milligrams of dissolved oxygen per liter of water ('Lake Water Quality', n.d.). While necessary, this intervention reflects a severe ecological imbalance and a marked loss of biodiversity ('Lake Water Quality', n.d.). To monitor the system, scientists continuously collect meteorological data, perform chemical analyses of nutrients, measure physical profiles of the water column, and capture underwater plankton imagery, thus offering valuable insights into the lake's physical and biological dynamics (Merz et al. 2023).



[5] Aerial view of Greifensee
(Krapf 2012)



[6] Aquascope Underwater Camera
(Steiner Jonas, n.d.) (AQUASCOPE 2025)

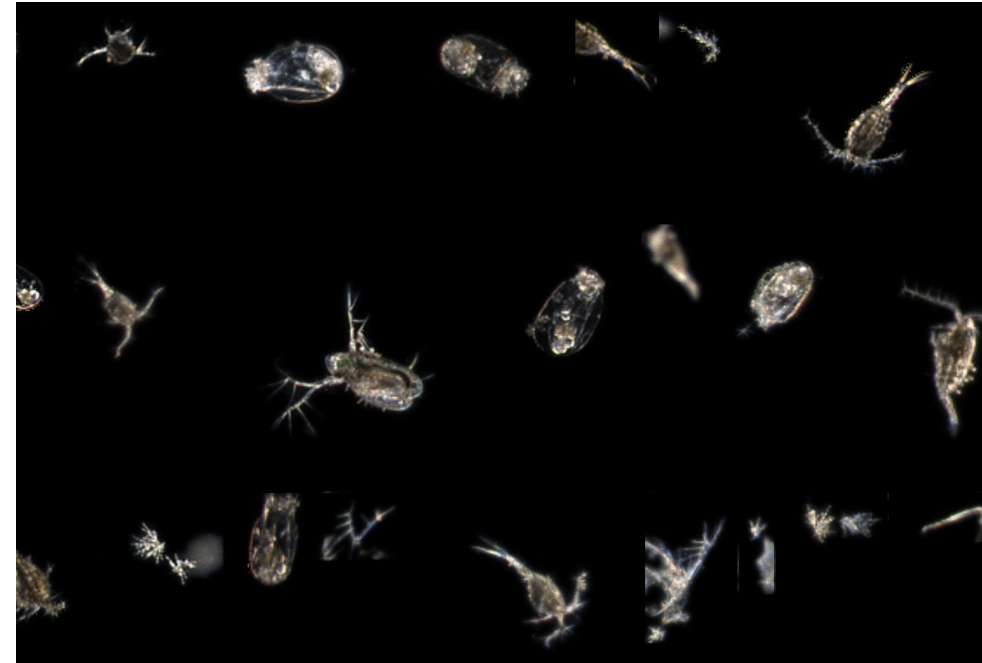
The monitoring of plankton in the waters of Lake Greifensee is carried out through a comprehensive set of data collection and analysis processes, led by scientists at Eawag, one of the world's leading research institutes in aquatic science (Merz et al. 2023). A primary tool employed, is an automated underwater camera [6] permanently installed at approximately 3 meters depth, which continuously captures images of plankton throughout the day. This technology allows the observation of organisms in their natural environment without disturbing their daily activities (Merz et al. 2021).

The camera can detect organisms ranging in size from approximately 10 micrometers to 1 centimeter, thus encompassing nearly the entire planktonic food web (Merz et al. 2021). The collected images are subsequently analyzed using a series of deep learning models* specifically developed to classify freshwater plankton into 35 taxonomic classes*. The most accurate models achieve a classification precision of 98% (Kyathanahally et al. 2021). In addition to image-based monitoring, water samples are regularly collected for automated scanning flow-cytometry* (AQUASCOPE 2025), a procedure that allows rapid and precise identification, counting, and characterization of individual cells and microorganisms within the samples (McKinnon 2018).

The inability to resist the force of currents is not only the defining characteristic shared by all planktonic organisms, but also, in my view, a point of connection that is both easily understandable and empathetically relatable for human beings. This characteristic is the origin of the title of this thesis project, “Current’s Wanderers”, which describes these organisms as wandering passengers of aquatic currents.

Given that these organisms are found in almost every body of water on the planet there are many possibilities for geolocating the project. The lake Greifensee seems, however, to represent an ideal freshwater environment in

which to situate the development of this research. Its high level of eutrophication provides a significant example of the effects of anthropogenic pollution, while the studies conducted by scientists at Aquascope offer more than sufficient data for selecting the information to be communicated back to the public.



[7] Aquascope Underwater Camera Images on the Website (AQUASCOPE 2025)

History of Plankton-Human Interactions

The previous chapter presented an accurate, although broad, overview of current scientific knowledge surrounding the planktonic world and one of the most advanced techniques used to study it. However, understanding the historical path which preceded today's approaches in terms of research and representation, may provide relevant insights and considerations for further formal and conceptual reflections.

Even before the term “plankton” was coined by Viktor Hensen (1835-1924) in 1887 and adopted to describe a specific group of living organisms, these life forms had already been studied, observed, and depicted. Logically, the first species to be described were the larger, multicellular ones visible to the naked eye, such as jellyfish and parasitic copepods (Calbet 2024). As early as Ancient Greece, Aristotle identified a parasitic copepod, classifying it, along with jellyfish and other soft-bodied organisms, under the category “Zoophyta”, a conceptual grouping used for centuries to describe organisms perceived as intermediate between plants and animals (Calbet 2024).

The earliest visual representations of plankton like

jellyfish and parasitic copepods date back instead to Guillaume Rondelet's “Histoire entière des poissons”, published in 1554 [8]. About a century later, in 1688, Stephan Blankaart produced the first known illustration of a free-living copepod [9] in his work “Schou burg der rupsen, wormen, mäden, en vliegende dierkens daar uit voortkomende” and around the same period, Antonie van Leeuwenhoek, using his rudimentary microscope, pioneered the study of protists, revealing a previously unseen world of unicellular plankton (Calbet 2024).

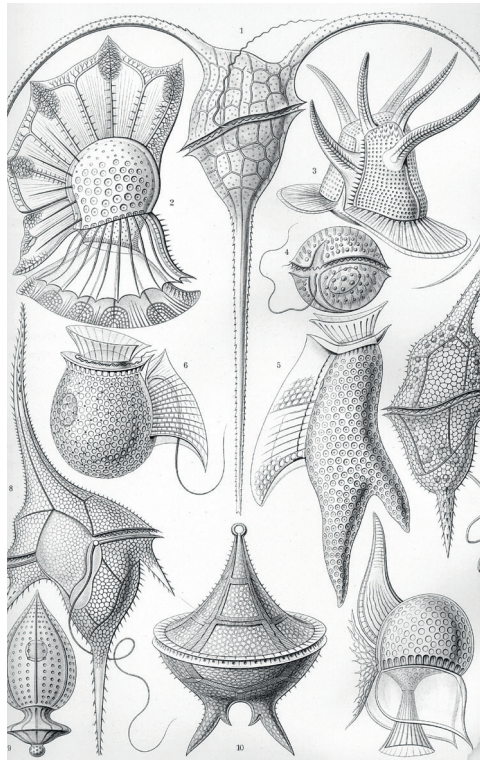


[8] A parasitic copepod below and a fish gills above (Calbet 2024)

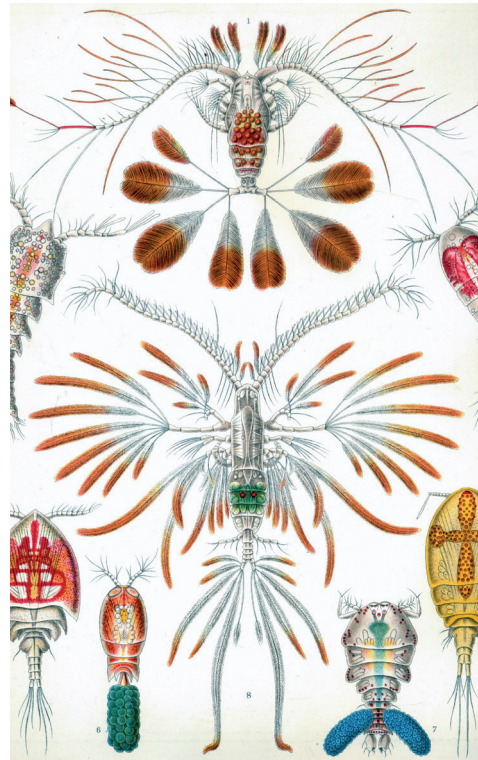


[9] The first illustration of a free-living copepod (B) (Calbet 2024)

A pivotal figure in the scientific depiction of plankton was the German zoologist and illustrator Ernst Haeckel (1834-1919), who at the end of the nineteenth century was one of the first to successfully merge scientific accuracy with aesthetic sensibility (Willmann 2017). His illustrations [10] [11] enabled the recognition of anatomical structures recurring in nature and contributed to the dissemination of Darwin's theory of evolution (1859) (Halpern and Rogers 2021). But it was thanks to his use of accessible and highly influential visual language that his work had a significant impact not only in the scientific field, but also in the artistic and design world, contributing to the dissemination of scientific knowledge among the general public and marking a turning point in the history of scientific visualization (Costantino 2015).

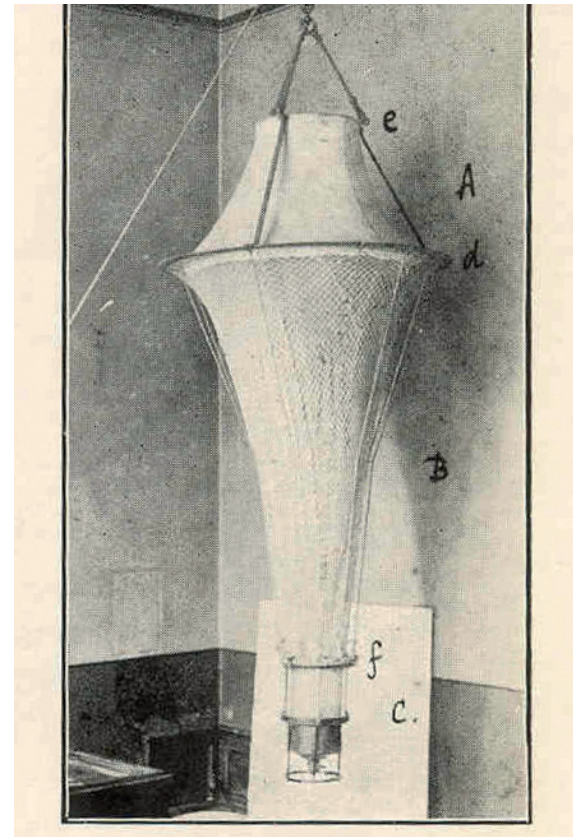


[10] Haeckel's Dinoflagellate Illustration (Haeckel 1904b)



[11] Haeckel's Copepods Illustration (Haeckel 1904a)

During the same period, German physiologist Viktor Hensen (1835-1924) coined the term “plankton” to describe all animal organisms passively transported by ocean currents (Calbet 2024). He also designed the “Hensen net” [12], a device for the quantitative collection of plankton samples, which, despite technological updates, remains in use today in oceanographic research (Calbet 2024). A few years later, Alister Hardy (1896-1985) developed the “Continuous Plankton Recorder”, another tool still in use, which utilizes the movement of vessels to systematically gather data on plankton species encountered along navigation routes (Calbet 2024).



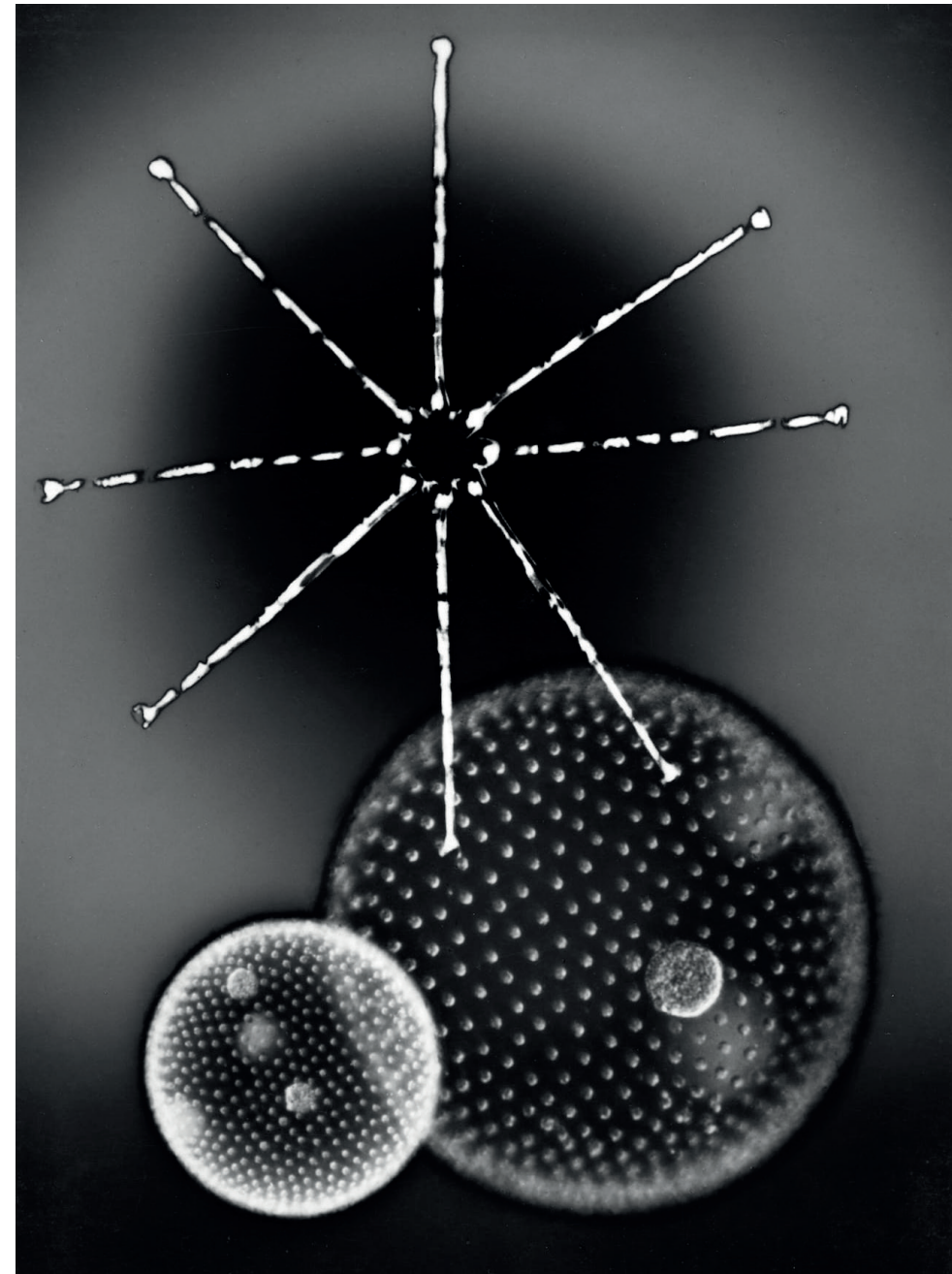
[12] Hensen Quantitative Net (Herdman 1923)

With the advent of photography, thanks to its instantaneity and precision, this medium was also gradually used initially for scientific and documentary purposes (Heiferman and Kelly 2019), and later also as a tool to enhance the aesthetics of planktonic forms. In the first half of the twentieth century, the photographic work of Carl Strüwe (1898-1988) [13] exemplified this shift, highlighting the physical characteristics of plankton species through a visual language that bridged science and art (Roston 2016).

During the second half of the twentieth century and the beginning of the twenty-first, scientific research on plankton increased significantly (Woods 1999), highlighting the crucial role of these organisms in biogeochemical cycles and, consequently, in the overall health of Earth's ecosystems (Grigoratou et al. 2022).

The expansion of scientific knowledge then seems to have progressively encouraged the increasingly greater inclusion of ecology and plankton in fields beyond science, stimulating interest in artistic and design disciplines that began to explore their aesthetic, symbolic, and conceptual significance. A particularly significant example is Plankton Manifesto, a collaborative and forward-looking movement grounded in art, creativity, and empathy. Its primary goal is to foster awareness of the planktonic universe by integrating and harmonising ideas, perceptions, forms, and sounds (Plankton Manif., n.d.).

As knowledge, awareness and sensitivity toward the planktonic world continue to grow, these organisms appear to be taking on central roles in interdisciplinary projects. Initiatives that not only can support scientists in enhancing the effectiveness of their research processes, but might also promote modes of observation and interaction with plankton from a more ecocentric perspective helping mitigate the anthropogenic impact on their ecosystems.



[13] Carl Strüwe's Plankton Photography (Dunne 2016)

In recent years for example, artists and designers have increasingly collaborated in synergy with the scientific community to pursue a wide range of objectives through projects and initiatives such as, for example Artists-in-Labs Program (‘Über Uns - AIL’, n.d.) and Arts at CERN (‘Arts at CERN | Where Art Meets Science’, n.d.).

Each of these milestones, together with many others, has contributed to shaping the way planktonic organisms are studied and perceived today. For this reason, while embracing the recent expansion of scientific knowledge, I believe that raising awareness and building research around this topic should not mean looking exclusively toward technological innovation, but also considering which aspects of this broader historical trajectory may strengthen the message and provide an increasingly solid foundation for the future.

The illustrations of Ernst Haeckel, for example, do not, in my opinion, lose relevance with the advent of photography; rather, they complement its interpretative and communicative limitations. Observing a sample through a microscope, although it allows me to access greater detail and information, will never completely replace what I experience when looking at a water sample directly at the lake and observing it with the naked eye, as hundreds of our ancestors likely did even before the time of Aristotle.

Think like a Body of Water

Building upon the previous chapter, the following paragraphs present the main theoretical foundations considered in the design development of this research project. The objective is to identify one of the many possible perspectives through which the issue may be discussed and addressed. By drawing on elements of connection rooted in our collective imagination, I aim to bring our understanding closer to a perceptual realm that is extremely distant from our own: the world of plankton.

In 1934, Jakob von Uexküll introduced a philosophical approach to understanding living beings as individual subjects, through their specific modes of perceiving the world, their *Umwelt* (Schroer 2021). With this term, he sought to encompass both what an organism is able to perceive, defined as the *Merkwelt*, and the set of effects it produces by influencing its surrounding environment, defined as the *Wirkwelt* (Uexküll [1934] 2010).

*Focusing on the relationship between planktonic micro-organisms and human beings, I believe it becomes evident that the *Wirkwelt* of both constantly come into contact*

*and, at times, collide. Referring back to the two examples mentioned in previous chapters, the oxygen production of phytoplankton enables human beings to breathe, while anthropogenic pollution destabilises the balance of the aquatic systems inhabited by planktonic organisms. Concerning the *Merkwelt*, however, the ways in which these two groups perceive the surrounding world appear, in most cases, to be profoundly different. The vast difference in scale, together with their distinct anatomical structures, means that conscious mutual perception between the two groups and their effect on the surrounding environment occurs only very rarely.*

When speaking about plankton, one inevitably thinks of water, the element they inhabit, which determines their movements across most of the planet's aquatic systems and connects them to the entire surrounding natural environment (Biol. Libr. 2018).

But water is not only of great importance to plankton. It is the element that, more than any other, connects human beings to the world around them: from the water found in seas and oceans to the water that constitutes a large part of the human body (Neimanis 2017). This connection lies at the core of Astrida Neimanis's "Bodies of Water: Posthuman Feminist Phenomenology", a work that proposes a feminist phenomenology inviting us to rethink the relationship between body, subjectivity, and environment, moving beyond anthropocentrism and the idea of the human body as a closed entity separated from the rest of the natural world (Neimanis 2017).

Among other questions, Neimanis reflects on how to overcome the traditional separation between body and environment, proposing that we "think like a body of water" or consequently like another living organism, in order to open our thinking towards a deeper connection with the ecosystem of which we are a part. Since the human body is

largely composed of water, it can be understood as a fluid, dynamic, and permeable entity. From this perspective, identity and subjectivity are not fixed but porous, traversed by flows, evaporations, and absorptions that connect and extend the human body in a continuum with other forms of life (Neimanis 2017).

The sharing of water thus emerges as the common factor that unites and connects the human body to aquatic environments and to other living organisms. It can function as both a physical and conceptual bridge, capable of generating an extended form of empathy towards the natural world with which we share the planet (Neimanis 2017).

Building on this conceptual foundation, water appears to possibly function as a key element in helping people overcome differences in scale and form connections with planktonic entities. In order to achieve this, however, it is necessary to build a communicative model by applying additional strategies capable of bringing society closer to complex and little-known ecological issues, such as the ecological relevance of planktonic microorganisms.

According to the study “Using the Health Belief Model to Explore the Impact of Environmental Empathy on Behavioural Intentions to Protect Ocean Health”, feelings of empathy towards a given ecological issue can help increase the perceived severity and urgency of the problem (Kim and Cooke 2021). Similarly, feelings of compassion towards a suffering environment may encourage attitudes and behaviours that promote nature conservation (Pfattheicher et al. 2016).

Empathy and compassion therefore appear to be two key elements in the construction of experiences capable of establishing emotional connections with ecological issues and encouraging a shift away from an anthropocentric

perspective. A closer examination of the actual meaning and implications of these two terms, however, reveals certain potential complications.

Empathy refers to the ability to understand and share the feelings of another individual (‘Empathy’ 2025), while compassion implies concern and a desire to alleviate the suffering of others (‘Compassion’ 2025).

These complications emerge from studies such as Paul Bloom’s “Against Empathy”, in which he argues that a purely empathetic or compassionate bond may be insufficient or unstable in promoting healthy, long-term, and non-superficial environmental behaviour (Bloom 2018). The theory of “Compassion Fade” further highlights the difficulty of maintaining consistent emotional engagement when the subject in question is represented by a large number of entities (Västfjäll et al. 2014).

Despite the apparent relevance of emotional engagement, these challenges clearly indicate issues that must be addressed and overcome in order to develop an effective and meaningful communication model.

To avoid experiences that are ephemeral or superficial, Paul Bloom proposes a more objective approach, referred to as “Rational Compassion”. Within this framework, empathy and compassion with the feelings or suffering of another life form should be guided by reasoned concern and supported by objective elements, such as data and reliable sources, in order to promote more impartial, fair, and effective moral actions (Bloom 2018).

The involvement of scientists and domain experts, together with the use of trustworthy data and knowledge, may therefore be key in completing the communicative strategy, supporting the establishment of a more solid

and lasting emotional connection by integrating both rational and affective dimensions. In the field of plankton research, this would involve establishing a collaborative relationship with microbiologists or ecologists who are willing to share reliable information and personal insights based on their experience with the organisms they study.

With regard to the theory of “Compassion Fade”, and thus the difficulty humans face in maintaining sustained emotional engagement when confronted with a large number of entities, Pimentel and Kalyanaraman have confirmed that this phenomenon also manifests in relation to non-human life forms. However, the authors emphasise that it is possible to mitigate, or even reverse, the loss of compassion towards multiple entities through the creation of immersive experiences characterised by a strong sense of embodiment (Pimentel and Kalyanaraman 2022).

From a theoretical perspective, the concepts presented in this chapter may potentially provide a solid foundation for a communicative model applicable not only to projects concerning planktonic organisms, but also, with the necessary adaptations, to projects aimed at bringing the public closer to ecological issues involving a multiplicity of life forms.

Rethinking Agency Beyond Anthropocentrism

Ethical positioning within the field of microbiology constitutes an essential but complex territory, characterised by ambiguities, limitations, and potential contradictions. As a designer and researcher involved in this project, and following an extensive process of research and critical reflection, I seek to propose a shift in perspective oriented towards respect and consideration for all forms of life. While this vision may appear utopically compelling, I do not believe that such considerations should be applied uniformly at an individual level to all living organisms inhabiting our planet.

Attributing the same level of attention, care, or ethical consideration to a bacterium and to a mammal is not only impractical, but also risks becoming conceptually and ethically problematic, both for operational reasons and for more fundamental ethical concerns. What appears instead both possible and necessary is to recognise microorganisms not as isolated entities, but as collective systems and biological communities of fundamental importance to the balance of natural ecosystems.

I therefore do not consider the goal to be individual-level equity, but rather a form of measured and sy-

stemic ethical consideration, extended to all forms of life present on planet Earth.

The current situation, however, is far from satisfactory. As mentioned in the introduction, microscopic life forms such as most plankton are frequently overlooked by human society in various sectors like the fight against climate change (Cavicchioli et al. 2019). An individual's ability to act and, consequently, to produce a specific effect, known as "agency" ('Agency' 2025), is in fact often overlooked by humanity when it comes to microorganisms due to the difficulty of perceiving their impact on the surrounding environment and widespread ignorance on the subject (Thaler 2021).

At the core of this issue, along with ignorance and misinformation lies anthropocentrism, a philosophical perspective in which the human being is regarded as the central or most significant entity in the world. A paradigm deeply rooted and originating from numerous western religious traditions and philosophical schools (Boslaugh, n.d.).

Western ethical theories, developed over the centuries, have prioritised the intrinsic values of human beings, thus contributing to the current environmental crisis. This crisis cannot be therefore attributed to the functioning of ecosystems, but rather to the immoral structure of our ethical system (Rajesh and Rajasekaran 2019).

Humans in fact tend to attribute agency only to life forms that resemble themselves, often conflating agency with intelligence (Ingold 2008). According to Braverman, humans also tend to assess the capacity for agency based on the size of organisms: "Size is an important, yet often overlooked, aspect of how we imagine wilderness, as well as how we imagine agency" (Braverman 2023).

These assumptions are reflected, for example, both in widely known global activities that are causing the current global change, but also in more specific fields such as in biomonitoring practices aimed at evaluating the ecological sta-

tus of aquatic environments such as rivers, lakes, streams, and ponds (Koperski 2023). In these contexts, invertebrates such as plankton are routinely sampled, studied, and ultimately killed. This is possible because they are excluded from ethical considerations within environmental protocols, often resulting in unnecessary mortality (Koperski 2023).

Although this is an extremely specific example, it illustrates an ethical exclusion that seems to be symptomatic of a still rigid and anthropocentric notion of what constitutes a biological individual and, consequently, a morally considerable subject.

Similarly, at certain extremes even public science communication efforts sometimes might fail to consider ethical aspects adequately. A representative case is the Micropia museum in Amsterdam, where living organisms are displayed in a manner similar to traditional zoos, yet discussions on euthanasia or killing are not central (Braverman 2023). The two anonymous museum’s microbiologists interviewed by Irus Braverman explain that although they express a certain connection with these organisms, they do not consider them animals, and in some cases, such as viruses, not even living beings, reflecting a broader human tendency to disregard entities invisible to the naked eye as ethically relevant, rendering them effectively “killable” (Braverman 2023).

A shift in perspective thus seems necessary. One that abandons anthropocentrism in favor of an ecocentric orientation as an essential pathway toward sustainability, recognizing and affirming the intrinsic value of all elements of nature (‘Why Ecocentrism Is the Key Pathway to Sustainability’ 2017). In recent years, several initiatives in favour of non-human life forms have been launched to support this change, such as the one included in the 2019 European Green Deal, which aims to plant 3 billion trees across Europe, taking into account the native origin and properties

of each species (‘3 Billion Trees’ 2025).

Although the microbial world remains somewhat neglected, even in this context we are beginning to see new approaches that consider these organisms relevant and worthy of ethical consideration. In particular, the emergence of new technologies in biomonitoring practices now makes it possible to obtain equivalent or even superior scientific results directly in situ, significantly reducing invertebrate mortality. Such methods include environmental DNA (eDNA) analysis, the collection of microscopic images in the field, and the application of machine learning techniques (Koperski 2023).

Even in the field of public outreach, technology helps communicators to inform and raise awareness in society without directly involving microorganisms. An example is the “Noise Aquarium” project, which uses 3D simulations of planktonic environments to raise awareness about noise pollution as perceived by aquatic microorganisms (ARTIST STATEMENT – NOISE AQUARIUM, n.d.).

By taking an active role in this debate through the present project, I consider it essential to express my intention to adopt techniques that, as far as possible, do not invade or interfere with the natural life dynamics of planktonic organisms. This choice is not intended to reinforce a separation between human beings and other forms of life, but rather to promote an approach grounded in active consideration and the greatest possible respect toward every living organism.

[1.6]

Case Studies Analysis

In the following chapter dedicated to case study analysis, twelve projects are examined and compared. These are organised into four subchapters according to the typology and objectives of each project. Personal conclusions are outlined at the beginning of the analysis in each chapter.

[1.6.1] Scientific Monitoring Strategies

Within the first subchapter, three projects related to scientific monitoring strategies are presented. They are united by a shared focus on the qualitative assessment of bodies of water, while differing in their modes of implementation and practical application.

For each project, the following aspects are analysed and compared:

- the project description, in order to provide a general overview of the processes and objectives associated with the implemented practices;
- the scientific topic addressed, to contextualise the strategies being applied;
- the modes of interaction with organisms, in order to assess the level of consideration given to the involved forms of life;
- the technologies employed, to obtain a comprehensive understanding of the technological tools required to carry out these practices.

Presenting my personal conclusions drawn from the analysis of the three scientific monitoring strategies, I first believe that Aquascope demonstrates the effectiveness and importance of minimising disturbance and interference with the natural course of planktonic life. The use of the underwater microscope, together with imaging and machine learning techniques, primarily allows organisms to be observed and studied directly within their native environment, maintaining a greater methodological distance and a higher degree of observational objectivity.

Secondly, but no less importantly, this technique appears to position human beings within a more balanced relationship with planktonic organisms. Rather than relying on

sampling practices that remove populations of organisms from the lake in order to analyse them in laboratory settings, this approach demonstrates a less anthropocentric form of respect toward the natural dynamics of the observed ecosystems.

Nevertheless, a few potential drawbacks should be highlighted. Although this system proves extremely effective from the perspective of quantitative analysis, I believe that it may simultaneously reinforce a physical and emotional distance between human beings and the observed body of water. The growing demand for analytical efficiency appears, at least in part, to come at the expense of the quality of mediation directed toward the public. The techniques used to communicate the collected data appear, in fact, to be secondary to the scientific objective and do not seem to stem from a specific study of communication. In addition, direct presence in the field and contact with the object of study, both for scientists and communicators, risks to become progressively less central, shifting the experience of knowledge toward a relationship more focused on data and less on the sensitive and perceptual properties of the observed phenomenon.

By contrast, PlanktoScope appears to demonstrate how a DIY, mobile, and customisable system can make access to the planktonic world more tangible and accessible. Even individuals without specialised scientific knowledge are able to independently produce images, data, and interpretative assumptions regarding planktonic phenomena. Furthermore, the system can be configured in multiple ways, adapting to the practical needs and ethical considerations of different users.

At the same time, however, its use requires a certain degree of dedication which, from a practical perspective, I do not consider particularly effective in reaching a broader public.

Finally, FreshWater Watch highlights the value and effectiveness of active community involvement, both for scientific data collection and for broader communication and

awareness-raising purposes. In this case as well, the approach appears to be better suited to a relatively limited number of individuals who are personally motivated to contribute to data collection. Nevertheless, the sense of community that both FreshWater Watch and PlanktoScope are able to stimulate and foster represents a potentially valuable asset for establishing a strong social network of people interested in the topic.

AQUASCOPE

[Initiated in 2018 is a project part of Eawag research institute.]

[Description]

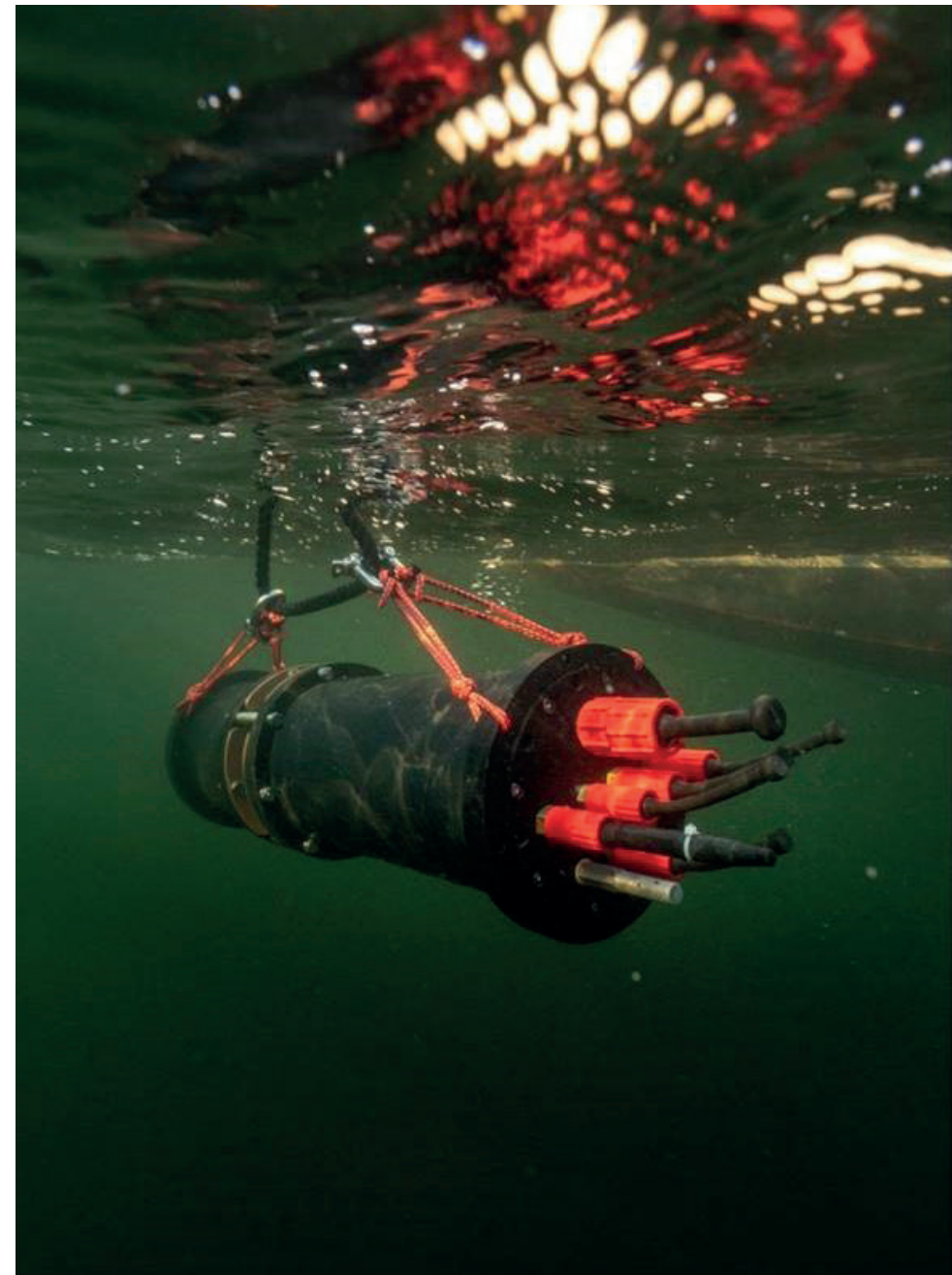
Aquascope was initiated in 2018, when the first underwater camera was deployed in Lake Greifen (Zierl 2020). The project is managed by a team of scientists from the Eawag research institute and aims to study plankton directly within their natural environment, while avoiding interference with species dynamics ('About Aquascope' 2019). In relation to local plankton communities, the project investigates physical and chemical changes in water quality, as well as interactions with natural antagonists such as parasites and herbivores ('About Aquascope' 2019). More specifically, Aquascope seeks to identify and understand the mechanisms that regulate plankton communities in order to predict their dynamics across spatial and temporal scales ('About Aquascope' 2019).

[Scientific Topic]

The project focuses on freshwater lakes in Switzerland and the planktonic organisms inhabiting them, with particular attention to two bodies of water: Lake Zug and Lake Greifen (AQUASCOPE 2025). The distinctive feature of Aquascope lies in its use of microscopic underwater cameras that capture daily images of plankton populations in both lakes. This approach enables the collection of reliable and continuous data without directly interfering with the ecological dynamics under observation ('About Aquascope' 2019).

Plankton function as key indicators of the ecological status of surface waters; consequently, observing their natural dynamics is of fundamental importance for monitoring and assessing the quality of aquatic ecosystems (Zierl 2020).

[Modes of interaction with organisms]



[14] Underwater Microscope
(‘About Aquascope’ 2019)

In line with its objective of minimizing interference with natural processes, the Aquascope project largely avoids direct contact between scientists and the organisms involved in research and analysis. Data collection is primarily carried out through sensors and technological systems designed to acquire information in the least invasive manner possible (‘About Aquascope’ 2019).

Taking lake Greifensee, the most extensively studied body of water within the project, as an example, preliminary fieldwork allowed me to observe data collection activities firsthand. Near the centre of the lake, a floating research station is installed, equipped with multiple sensors for measuring the physical and chemical properties of the water, as well as an underwater camera submerged at a depth of approximately three metres.

Externally, the camera appears as a metal cylinder roughly one metre in length and twenty-five centimetres in diameter, featuring a narrow slit in its protective casing. Through this opening, lake water flows naturally, carrying planktonic organisms with it. These organisms are captured by a microscopic camera positioned at the centre of the opening. The continuous daily image acquisition minimally disrupts planktonic microorganisms, while providing highly reliable data on their natural dynamics (Zierl 2020).

[Technologies employed]

Plankton observation within the Aquascope project is mainly based on the Scripps Plankton Camera (SPC), developed by the Jaffe Laboratory for Underwater Imaging at the University of California, San Diego. The system consists of a powerful LED light source combined with a dual-magnification underwater microscope. Water and drifting plankton flow freely through the space between the light source and the lenses, allowing organisms to be observed undisturbed

in their natural environment (Zierl 2020).

Originally designed for marine ecosystems, the SPC was adapted for freshwater use by incorporating two lenses with different magnifications and reducing the distance between the light source and the camera. These modifications ensure that sufficient light reaches the lenses, even in the relatively turbid waters of the lake, resulting in clear and detailed images (Zierl 2020).

Throughout the year, the camera captures one image per second for ten minutes every hour (Zierl 2020). The data are recorded and transmitted to the laboratory via a computer integrated into the Aquascope system, where they are analysed using a machine learning model. Although this model is still under development, in certain conditions it is already capable of achieving accuracy rates of up to 98% (Kyathanahally et al. 2021).

The collected data are made publicly accessible through the websites datalakes-eawag.ch, and aquascope.ch. The first one features an interactive graph displaying near-real-time concentrations of different plankton species, with an approximate delay of one hour (‘Datalakes’, n.d.). The second one shows a selection of the pictures captured by the underwater microscope (AQUASCOPE (AQUASCOPE)).

PLANKTOSCOPE

[Started in 2022; initially developed by Thibaut Pollina, Adam G. Larson, Fabien Lombard, and Hongquan Li.]

[Description]

PlanktoScope is a project dedicated to the development and dissemination of an open-source instrument designed to enable high-throughput quantitative imaging of plankton samples in aquatic biology and ecology. Its compact size, ease of use, and low production cost make it suitable for a wide range of applications, including the monitoring of laboratory cultures and natural microplankton communities ('PlanktoScope', n.d.).

By adopting a fully open-source approach, the platform aims to foster a continuously evolving network of designers, researchers, and users who collaborate to expand the tool's capabilities, accessibility, and overall impact ('PlanktoScope', n.d.).

[Scientific Topic]

As stated on the official website, at the core of the project lies plankton, a group of organisms that, through their passive transport across aquatic systems, constitute the largest daily movement of biomass on the planet ('PlanktoScope', n.d.).

Enhancing understanding of these organisms is a central objective of the initiative, alongside the development of new, high-quality documentation strategies. These approaches seek to deepen knowledge of the complex web of life in aquatic environments and to clarify how human activity influences these systems ('PlanktoScope', n.d.).

[Modes of interaction with organisms]

As an open-source project that can be freely modified and adapted, PlanktoScope seems to not prescribe a single mode of interaction with the organisms under observation.

Users appear to be able to define and customise their own



[15] Planktoscope in use on the banks of a body of water (FairScope, n.d.)



[16] Image of an Environmental Sample ('PlanktoScope - How It Works', n.d.)

sampling procedures, workflows, and usage strategies according to their specific needs and contexts. Responsibility for ethical sample handling, such as returning samples to their original water body or disposing of them appropriately, is therefore the responsibility of each user.

[Technologies employed]

From a hardware perspective, PlanktoScope features a modular design built around a wooden frame that houses, protects, and supports its components during operation and transport. The processing unit is based on a Raspberry Pi 4 paired with a Pi Camera, whose optical system is simplified using two inverted M12 lenses. The tube lens remains fixed, while the objective lens is interchangeable, enabling multiple optical configurations ('PlanktoScope - How It Works', n.d.).

A motorised stage enables fine adjustment of focus for the interchangeable imaging module, onto which either µ-Slide I Luer chambers or conventional microscope slides can be mounted, depending on the operational mode. Fluid handling is managed by a peristaltic pump driven by a stepper motor, capable of achieving a flow precision of approximately 0.1 ml/min, allowing controlled movement of the sample through the flow cell when required ('PlanktoScope - How It Works', n.d.).

On the software side, the Raspberry Pi generates an autonomous Wi-Fi network that provides access to a web-based interface from a range of devices, including smartphones, tablets, and laptops. This interface is built using Node-RED and offers both front-end and back-end functionality. The graphical user interface enables the acquisition of standardised raw images accompanied by metadata, which can then be processed through a Python-based pipeline utilising MorphoCut for image processing and EcoTaxa for visual exploration and taxonomic annotation of plankton images ('PlanktoScope - How It Works', n.d.).

FRESHWATER WATCH

[Started in 2012 by Earthwatch, WaterAid, and WWF.]

[Description]

FreshWater Watch is a global citizen science initiative promoted by Earthwatch Europe and launched in 2012. The project actively involves citizens, local communities, schools, businesses, and research institutions with the objective of monitoring, protecting, and, where possible, restoring the health of freshwater ecosystems, including rivers, lakes, ponds, streams, and reservoirs. Its mission is twofold: first, to collect reliable and scientifically robust data on water quality across a wide range of geographical contexts; and second, to educate participants, raise environmental awareness, and encourage local action through direct public engagement (Bishop et al. 2025).

To support these goals, the project employs a digital platform, available both as a web interface and a mobile application, which enables the collection, visualisation, and exploration of data through tools such as interactive maps. In parallel, FreshWater Watch provides standardised test kits, training programmes for volunteers, and establishes partnerships with communities, governmental bodies, and other relevant stakeholders (Bishop et al. 2025).

[Scientific Topic]

The scientific focus of FreshWater Watch lies in the investigation of the chemical and physical characteristics of freshwater systems, with particular emphasis on anthropogenic pollutants. The monitored parameters include nutrient concentrations, turbidity, colour variation, and the presence of algae. These indicators are essential for identifying processes such as eutrophication, habitat degradation, and environmental changes linked to land use, agricultural runoff, urban discharge, and climate change (Bishop et al. 2025).

The methodologies adopted by the project are standardi-

sed and designed to be both replicable and comparable across different sites and temporal scales. This approach ensures that the collected data can contribute not only to local scientific studies but also to the development of broader monitoring frameworks and global indicators, including those required by the European Water Framework Directive (Bishop et al. 2025).

[Modes of interaction with organisms]

FreshWater Watch does not involve explicit direct interaction with living microorganisms through laboratory-based cultures or microbiological experimentation. Instead, interaction with biological systems occurs indirectly, through the measurement of environmental parameters that serve as proxies for the microbial and ecological health of freshwater bodies. In particular, the observation of algal presence and abundance functions as an indicator of eutrophication, a phenomenon closely associated with nutrient availability and environmental conditions that shape the composition and functioning of microbial communities (Bishop et al. 2025).

[Technologies employed]

The project relies on a combination of low-cost, standardised field tools and digital infrastructure. These include chemical test kits for nitrates and phosphates, instruments for measuring turbidity, clarity tubes for assessing water transparency, and observational tools for recording parameters such as water colour, algal presence, riparian vegetation, and surrounding land use (Bishop et al. 2025).

Collected data are entered into a digital platform that enables volunteers to geolocate and timestamp their observations, visualise results on interactive maps, and track ecological trends over time while receiving feedback on the environmental status of the monitored water bodies. All data collection and management procedures follow standardised protocols to ensure scientific reliability, comparability, and quality control (Bishop et al. 2025).

Within the second subchapter, three projects related to the communication of scale are presented. They share a desire to communicate the differences in scale that govern the world around us, while differing in the ways in which they put this into practice.

For each project, the following aspects are analysed and compared:

- the project description, in order to provide a general overview of the processes and objectives associated with the implemented practices;
- the message conveyed, to understand the design choices made to build the final product;
- the type of media used for communication, to analyse the design choices dedicated to each project.

Beginning with some concluding reflections on Powers of Ten, the project appears to demonstrate how a linear narrative combining visual and auditory elements can make otherwise difficult-to-grasp concepts comprehensible. It is precisely through its simplicity that I believe this audiovisual work maintains a remarkable capacity to remain relevant even decades after its original release.

The key factors that, in my opinion, make it highly effective are, firstly, its starting point at a scale closely connected to the collective imagination of human beings, which establishes a clear and shared reference from the very beginning. Secondly, the visual coherence and simplicity — particularly through the constant use of the square and a single numerical value as dimensional references — focus attention on one specific factor, helping the viewer to comprehend a concept that would otherwise remain highly abstract. Finally, the auditory narration establishes and maintains a constant yet balanced rhythm in the delivery of information,

complementing the visual content without overwhelming the average viewer's ability to absorb and process new notions.

By contrast, I believe the strength of Picoplanktonics lies in its adoption of a material-driven and exhibition-based approach capable of engaging audiences on a more experimental level and orienting them toward speculative future scenarios. I consider the physical manifestation of novel materials particularly significant, as it not only narrates but concretely demonstrates how collaboration with microscopic organisms can contribute to the creation of structures at a scale meaningful to human beings. The audience is invited to adopt a speculative mode of thinking that departs from conventional production paradigms, which generally exclude collaboration with microscopic forms of life. If understood and embraced, this shift in perspective may represent the project's primary strength.

Finally, regarding White Gold, I find particularly compelling the way data is collected and communicated through multiple complementary strategies. The project frames an apparently simple substance as the outcome of a dense entanglement of actors and variables spanning microbial, animal, human, and environmental dimensions. This complexity is coherently reflected in the diversity and articulation of the approaches through which the project itself is developed and presented.

POWERS OF TEN

[Directed by Charles and Ray Eames, produced in 1977 for IBM.]

[Description]

Powers of Ten is a scientific and educational film conceived and directed by Charles and Ray Eames, produced in 1977 for IBM. The film organises a vast amount of scientific knowledge into a continuous visual narrative: starting with a picnic scene on Lake Michigan, the camera zooms out by a factor of ten every ten seconds, moving from the human level to the cosmic scale, to the edges of the known universe. Then the movement reverses, penetrating the human body, cells, atoms and finally the nucleus of a proton, the smallest unit of matter known at the time (Schuldenfrei, n.d.).

The first experimental version dates back to 1963, followed by a longer version in 1968 and finally the definitive version in 1977. The film was initially screened at scientific conferences, including a gathering of a thousand physicists, and was subsequently adopted in educational contexts, becoming a widely used teaching tool in American schools (Schuldenfrei, n.d.).

[Message]

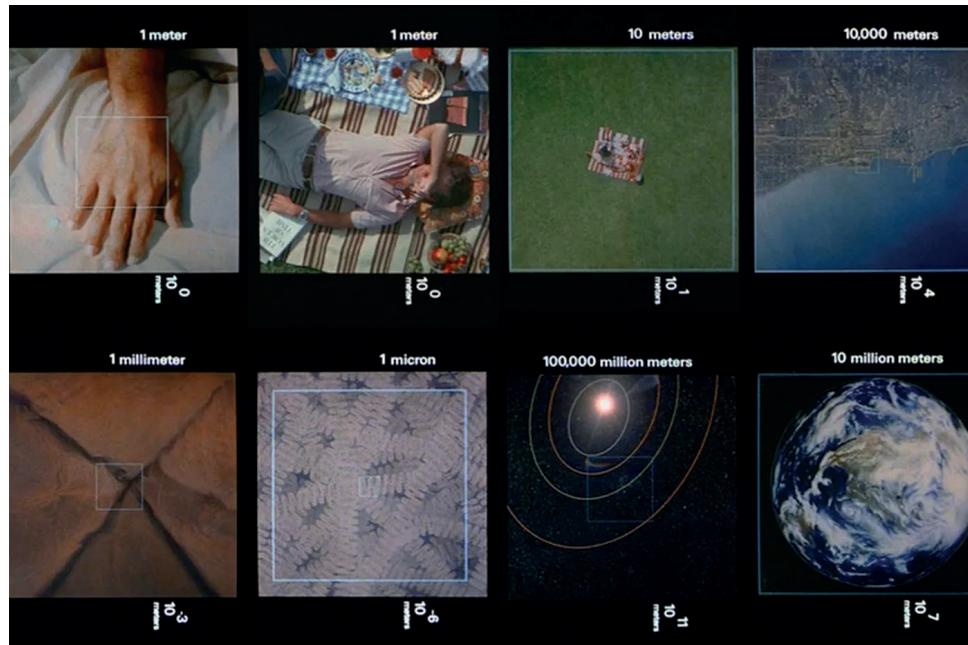
The fundamental message of Powers of Ten is twofold. On the one hand, it invites scientific wonder: showing that the universe, from enormous galaxies to tiny protons, is governed by comparable proportions and common laws. On the other, it conveys an ecological and humanistic message, explicitly introduced by Charles Eames during the Harvard Lecture: the need to recognise that there are no "innocents" in environmental degradation and that material well-being has come at an ecological cost, as in the case of Lake Michigan, chosen not by chance as the symbolic location for the film (Schuldenfrei, n.d.).

[Type of Media]

According to Eric Schuldenfrei, Charles and Ray Eames' film uses a visual language constructed from real scientific mate-

rials and images collected from various disciplines, with the aim of organising knowledge into a continuous narrative. The work uses astronomical photographs taken by NASA, which are “repositioned in support of the nascent environmental movement, demonstrating the extreme isolation and vulnerability of Earth floating in space” (Schuldenfrei, n.d.). These iconic images serve to show Earth as the only possible place for life, reinforcing the ecological message introduced in Harvard lectures in 1970 (Schuldenfrei, n.d.).

In the film, the visual sequence moves smoothly through the scales of the cosmos and matter: the camera gradually moves away from the initial scene of a picnic, to the edge of the universe, then reverses direction and penetrates the human body, reaching the subatomic level. The regular progression of magnification, a factor of ten every ten seconds, structures the narrative as a “visual equation” linking astrophysics and molecular biology (Schuldenfrei, n.d.).



[17] Stills from Powers of Ten (1977)
(Honey 2025)

Schuldenfrei emphasises that Powers of Ten stands out for its ability to integrate material from different scientific fields “into a single visual narrative,” transforming astronomical photographs, microscopic images and scientific diagrams into a coherent filmic flow (Schuldenfrei, n.d.).

This visual organisation, rather than a cinematographic technique in the traditional sense, seems to represent a systemic method of thinking for the Eames, in which editing and scale can become tools for making the connections between microcosm and macrocosm perceptible.

In this way, film technology does not seem to be limited to filming or animation devices, but also extends to the development of its conceptual structure: the use of exponential progression and scientific images as a means of making visible the complexity and interdependence of natural and human phenomena.

PICOPLANKTONICS

[Curated by the Living Room Collective, presented at 19th International Architecture Biennale in Venice in 2025.]

[Description]

Picoplanktonics is a project curated by the Living Room Collective, presented at the Canadian Pavilion during the 19th International Architecture Biennale in Venice in 2025. The idea is to explore the possibility of cooperating with nature, not to exploit it, but to build environments that contribute to healing the planet. The project takes picoplankton as its starting point, in particular marine cyanobacteria, which, more than two billion years ago, played a decisive role in transforming the Earth's atmosphere by absorbing CO₂ and releasing oxygen ('Picoplanktonics', n.d.).

The proposal experiments with living architecture: large-scale structures obtained through robotic printing that contain living cells of *Synechococcus* PCC 7002, a photosynthetic organism that consumes CO₂, generates minerals and oxygen, and strengthens the structure itself. The living sculptures, initially manufactured in the laboratory, were transferred to the Canada Pavilion, which was modified to provide light, humidity and heat so that the bacteria could continue to grow ('Picoplanktonics', n.d.).

During the exhibition, these living structures are not static but constantly evolving: bacteria continue to "build" and modify in response to environmental conditions. In this sense, the work is conceived as an open experiment, which places architecture at the service of life rather than vice versa, and invites us to rethink the relationship between the built environment, the environment and mutual care ('Picoplanktonics', n.d.).

[Message]

The designers define Picoplanktonics as an ongoing experiment that proposes a reciprocal relationship between living structures, the built environment and human beings. A pla-

ce to rethink how we can build in order to prioritise ecological resilience rooted in responsible management and care ('Picoplanktonics', n.d.).

The message does not appear to be that of perfect architecture, but rather that of a fragile environment, exposed to disease and death like any living organism. The desire to educate people to conceive of buildings as part of larger biological cycles seems to emphasise the need for a symbiotic rather than extractive approach.



[18] Installation at the Biennale di Venezia ('Picoplanktonics', n.d.)

Andrea Shin Ling emphasises her enthusiasm for inviting the public to participate in this open experiment and revealing all stages of the material's life, including growth, disease and death, collectively imagining a regenerative design approach that aims to restore the planet. (Can. Counc. Arts, n.d.).

[Type of Media]

In Picoplanktonics, technology appears to be at the service of life, not its replacement. The structures in the pavilion, which are the main means of communication with the public, were created using a new biofabrication platform developed at ETH Zurich, capable of printing living materials on an architectural scale, representing a significant advance in sustainable construction technologies (Dogan 2025).

WHITE GOLD

[Mona Baiutti's 2022 Master's thesis in Interaction Design.]

[Description]

White Gold is Mona Baiutti's master's thesis in Interaction Design, presented in 2022 at ZHdK. The project explores the complex life cycles of milk production in Switzerland, considering them on a biological, organic, emotional and social level. Through an ethnographic and design-based approach, Baiutti investigated the ecological relationships and multi-species interactions that underlie milk, compiling the results in a multisensory installation and a digital platform. The main objective of the project is to restore value and respect to milk, highlighting not only the final product but also the vital efforts and processes that make it possible, with a view to transparency and awareness-raising (Baiutti 2022).

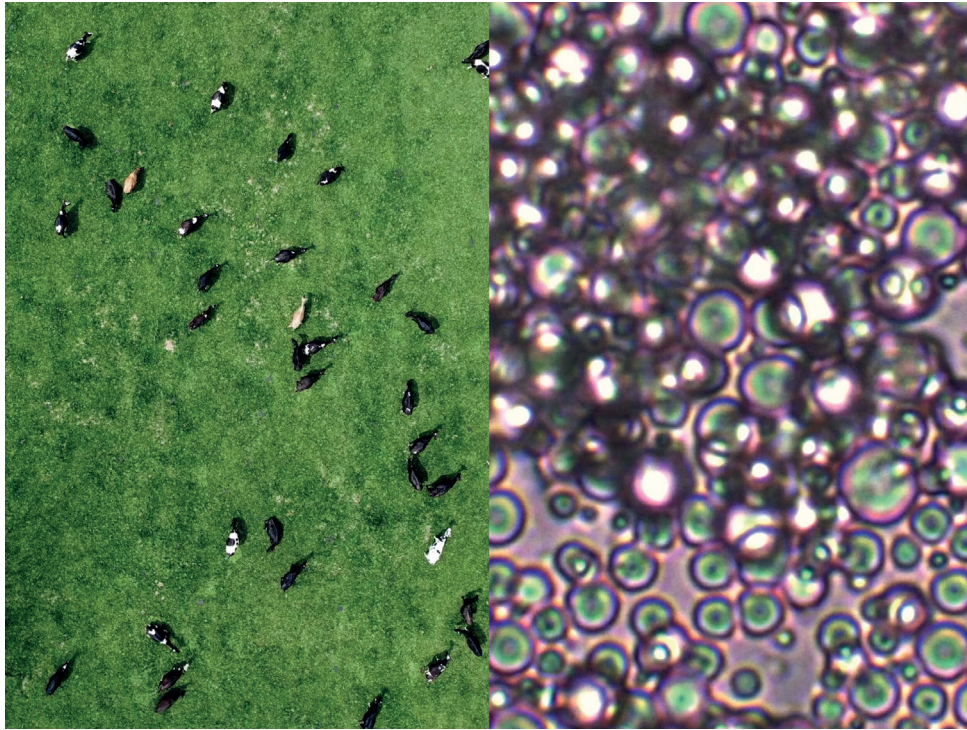
[Message]

Through White Gold, Mona Baiutti challenges the anthropocentric view of milk, showing how this food is not simply a consumer product, but the result of a complex network of vital relationships. The project denounces the growing distance between consumers and production processes, accentuated by agricultural modernisation and romantic or advertising narratives that mask the reality of livestock farming practices. At the same time, the work aims to rebuild a relationship of respect and awareness towards milk, encouraging transparency and recognition of the efforts of all species involved (Baiutti 2022).

[Type of Media]

From a technical point of view, the project is based on a combination of ethnographic methods and interaction design tools. Baiutti used audio recordings, photographs, videos, interviews and a collection of objects as tools for observation and documentation (Baiutti 2022).

These materials were reworked into interactive prototypes, culminating in a final installation that integrates visual and audio elements. At the same time, the designer developed an interactive web platform that allows users to navigate between the multispecies stories in a non-linear manner (Baiutti 2022).



[19] Macro and Micro Actors in the Life Cycles of Milk (Baiutti 2022)

[1.6.3] Live Data Manifestation

Within the third subchapter, three projects related to the action of manifest live data are presented. They share the desire to transmit information and data in real time, but differ in the ways in which they put this into practice.

For each project, the following aspects are analysed and compared:

- the project description, in order to provide a general overview of the processes and objectives associated with the implemented practices;
- the message conveyed, in order to understand the design choices made to arrive at the final product;
- ways of engage with the public, to analyse the different ways in which the senses and minds of users are stimulated;
- the technologies employed, to obtain a comprehensive understanding of the technological tools required to carry out these practices.

Projects centred on the real-time manifestation of data emphasise, in my view, the communicative relevance of the “here and now.” Within exhibition installations designed to engage the audience’s emotional dimension, I believe that the real-time factor further amplifies this effect, transforming the experience into something unique and deeply connected to the present moment.

In the case of Phonos, for example, my reflection, based primarily on my direct experience of the installation, concerns the fact that the behaviour of the work continuously changed without ever repeating itself. This characteristic generated in me a strong sense of attraction and connection. I could not predict what would happen moments later, and I was aware that what I had just heard had been experienced only by me at that precise instant. Despite the fact that it

was an inanimate object, I experienced an unexpected feeling of emotional connection.

This effect was further reinforced by additional elements, such as the narrative surrounding the project, the scenographic construction of the installation, the visitor journey, and the exhibition space in which the work was situated.

Tecuitlatl and Sonomatter, although employing different expressive modalities, similarly enable audiences to perceive the effects of otherwise invisible activities occurring within the space by drawing on sensory stimuli that extend beyond the visual domain, particularly sound. Although, from an ethical standpoint, I do not fully endorse the idea of deliberately exploiting living beings for purposes that are not strictly scientific, I believe this is the strength of these two projects. The real-time dimension is in fact determined by the presence of living microorganisms within the installation itself. It is their activity as living beings that shapes the sonic output, thereby giving the work a communicative force capable of establishing a potential emotional connection with the audience.

PHONOS

[Created by Marc Vilanova between 2020 and 2022.]

[Description]

Created between 2020 and 2022 by sound and visual artist Marc Vilanova, Phonos is a sculptural installation that interacts with the public through 208 recycled loudspeakers, restored and modified to receive a unique infrasound (Vilanova, n.d.).

Despite its monumental size, Phonos invites proximity, drawing viewers close to hear the delicate sounds it produces. People have the opportunity to relate to the sounds that surround us, particularly those that we as human beings are biologically unable to hear: infrasounds (Vilanova, n.d.).

[Message]

Phonos aims to raise public awareness of low-frequency vibrations known as infrasound, which have been little studied and regulated. As they are not biologically perceptible to the human body, their value in shaping ecosystems and influencing the well-being of humans and other living beings is often overlooked. The installation thus transforms into a living organism that breathes and pulsates, creating an intimate and shared experience to tune the public into imperceptible acoustic ecologies (Vilanova, n.d.).

[Public Engaging]

As described on the artist's official website, Phonos is an installation that, despite its monumental size, invites viewers to come closer (Vilanova, n.d.).

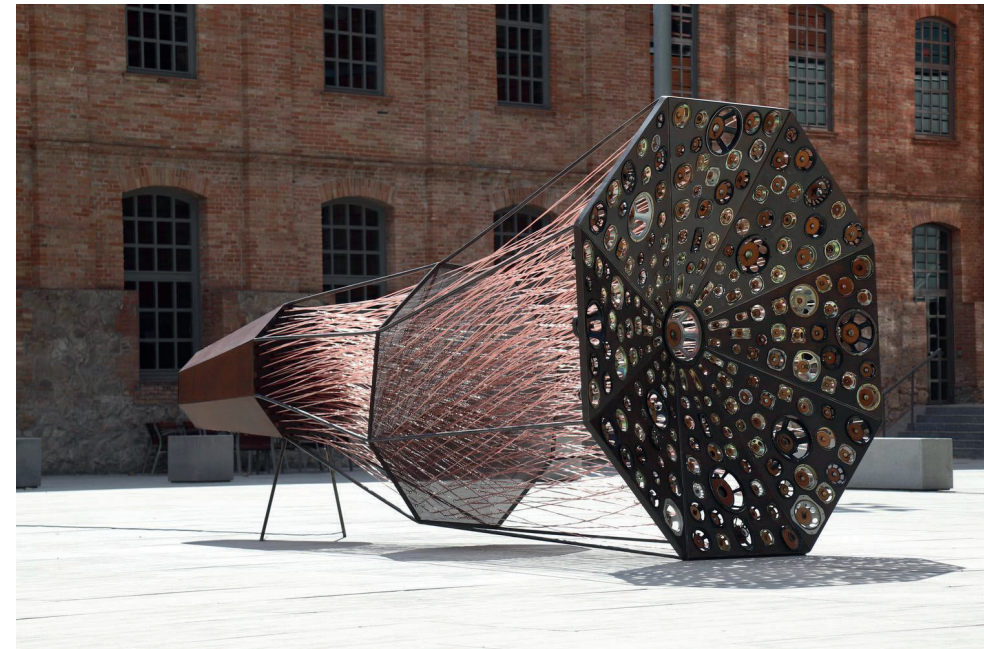
This statement is difficult to understand without having experienced the project first-hand. However, having seen the work at Ars Electronica 2025, everything makes sense. The first phase of enjoyment is entirely visual. The work is immense and attracts the attention of the pu-

blic from far away, solely through sight. It appears static, silent and not very dynamic, but its form intrigues and invites people to come closer. A few metres away, the second phase begins through the sense of hearing, thanks to which the first faint sounds produced by Phonos begin to be perceived. Only when you stand next to it are you really able to fully perceive what is being produced. All 208 loudspeakers vibrate delicately at different rhythms and intervals, recalling and imitating the collective behaviour of various types of animals. Standing in front of Phonos, you are passive spectators of a constant dialogue between grandeur and delicacy, between the collective and the individual, between the technological and the analogue. Reading the description of the work, however, the third phase of the experience begins, and we understand that the work allows us to hear infrasounds that we would never be able to perceive; it does so through an animal and collective language that reminds us of behaviours heard and experienced in the past.

[Technologies Employed]

Physically, the installation measures 3 metres high, 3 metres wide and 5 metres deep. 208 audio channels are connected to the same number of loudspeaker cones, 104 amplifiers, 26 audio interfaces and various audio cables (Vilanova, n.d.).

The sequence of actions that brings the installation to life starts with custom software, based on models of collective animal behaviour, which generates 208 distinct infrasound signals. The signals are passed through 26 audio interfaces and 104 amplifiers, reaching 208 loudspeakers. Deprived of their membranes and therefore unable to produce conventional sounds, the loudspeakers translate the electrical data into mechanical movement/vibration, thus restoring the presence of inaudible frequencies through perceptible mechanical phenomena (Vilanova, n.d.).



[20] Phonos installed in a square (Vilanova, n.d.)

TECUITLATL.

[Developed by Fara Peluso in 2023.]

[Description]

Tecuitlatl. An algae sound installation is a transdisciplinary work by Fara Peluso developed in 2023, in collaboration with philosopher María Antonia González Valerio and with the contribution of sound artist Hüma Utku. Presented in international contexts such as the Weltmuseum in Vienna, the installation focuses on Spirulina, a cyanobacterium traditionally used by the Aztecs as food, to construct a narrative that intertwines historical memory, cultural practices and ecological reflection. Through an installation that combines algae cultivation, historical research and sound experimentation, the work invites the public to engage with the history of “tecuitlatl”, the green bread produced with Spirulina in Lake Texcoco, and with the contemporary transformations of aquatic ecosystems subject to eutrophication and climate change (Peluso, n.d.).

[Message]

The central message of Tecuitlatl is an invitation to rethink the relationship between humans and micro-organisms, overcoming the logic of exploitation and rediscovering the possibility of coexistence and listening. The work highlights the contradictions between the ancient Aztec practice of harvesting tecuitlatl and the current commercialisation of algae as the “superfood of the future”, emphasising how contemporary capitalist logic neglects both historical memory and ecological balance (Peluso, n.d.).

At the same time, the installation seems to give “voice” to algae, allowing them to emerge as narrative agents capable of bearing witness to the effects of the Anthropocene and prompting collective reflection on the processes of environmental devastation currently underway. In this sense, the project might not seem to limit itself to denoun-

cing the consequences of the climate crisis, but suggests the possibility of constructing new shared memories and new ecological narratives.

[Public Engaging]

The audience is involved not only as spectators, but as an integral part of the narrative experience. The sound installation was presented in Vienna as part of the exhibition Science Fiction(s) – Apokalypse, where viewers were able to immerse themselves in the acoustic landscapes generated by algae and environmental recordings (‘»Science Fiction(s)«’ 2023).

Previously, at Art Laboratory Berlin, Peluso had shared the project in prototype form through workshops and public conversations, creating an opportunity for exchange with visitors and researchers (‘DIY Hack the Panke’, n.d.).

In these contexts, the audience does not seem to limit itself to observing, but appears to be invited to listen, reflect and discuss, establishing a dialogue that broadens the scope of the work from sensory experience to critical awareness.

[Technologies Employed]

From a technical point of view, the work integrates various tools and methodologies. Spirulina is cultivated using tanks and aquatic systems that allow the organisms to be kept alive and observable (Peluso, n.d.).

Sound recordings are then probably grafted onto this biological substrate, likely using special microphones capable of picking up the vibrations sought by the artist. These materials are then most likely processed and assembled into a sound composition that becomes the central element of the installation.

The installation therefore includes audio diffusion systems, containers for cultivation, lighting and the environmental conditions necessary for the survival of algae (Peluso, n.d.).



[21] Tecuitlatl. Installation
(Peluso, n.d.)

SONOMATTER

[Developed by Sabina Hyoju Ahn, Stefan Tiefengraber, Rania Shin, Sey Parc and Minsung Kim in 2016.]

[Description]

Sonomatter is a sound installation and performance that transforms bioelectric signals generated by microorganisms into sound. The artist constructs a series of Winogradsky Columns, small autonomous ecosystems composed of mud and water, which serve as the basis for generating electricity through microbial fuel cells (MFCs). Over time, the bacteria present in the mud produce electricity until they exhaust their nutrients, thus closing a complete life cycle (Ahn 2019).

A custom circuit, called a Bioelectricity-Controlled Oscillator (BCO), converts the bioelectric energy generated by the MFCs into audible sound signals, simultaneously consuming the same energy to control the frequency and rhythm of the oscillator (Ahn 2019).

[Message]

Through Sonomatter, Sabina Hyoju Ahn explores the life cycle and transformation of energy as phenomena that unite life and death, technology and biology. The project reflects on the ecological value of living matter and the role of art as a mediator between human perception and invisible processes (Ahn 2019).

Mud, described as a substance that “takes in valueless things such as dead bodies and digests them into nutrients to grow living things”, becomes a metaphor for biological regeneration and vital continuity. The work invites us to consider matter as a living, active entity capable of generating energy and sound, and to recognise the profound connection between microscopic life and human life. (Ahn 2019).

[Public Engaging]

During exhibitions and performances, the audience can hear

the sounds generated by the columns and observe the light variations synchronised with the electrical activity of the microorganisms. In some cases, the artist guides viewers to touch the surface of the water or cylinders, thereby changing the speed and intensity of the sound (Ahn 2019).

Ahn describes the audience's response as particularly positive: many people linger in the installation space, immersed in a sound environment that takes on meditative and organic characteristics. Some viewers from the field of electronic music appreciated the sound structure produced by a very narrow voltage range (0.6–0.7 V), perceiving the performance as a “microbial orchestra” in which the artist acts as conductor (Ahn 2019).

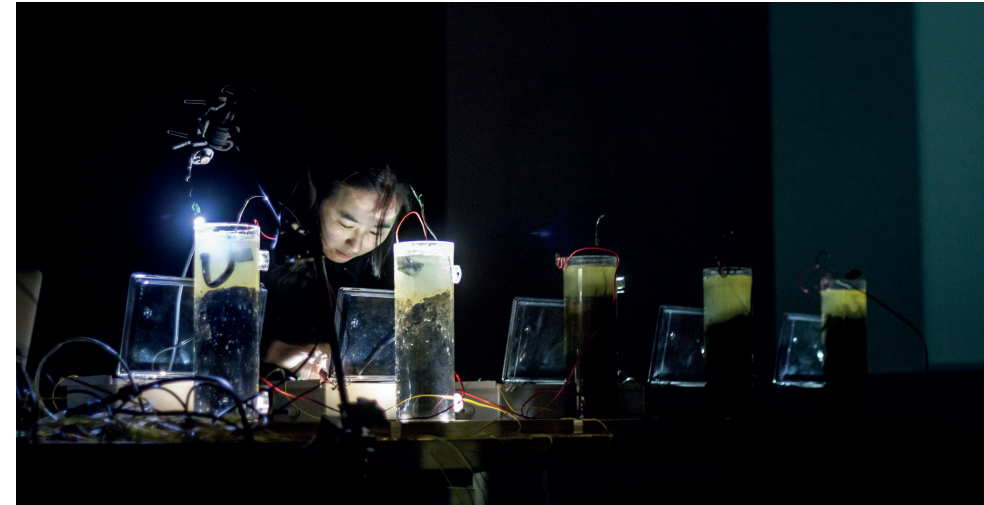
[Technologies Employed]

The Sonomatter technical system combines bioelectronic devices and analogue sound synthesis instruments. Each Winogradsky Column contains a Microbial Fuel Cell (MFC) that produces electricity thanks to the metabolic activity of bacteria.

MFCs are constructed with 99% carbon felt electrodes to prevent corrosion and facilitate biofilm formation. The voltages produced by microorganisms range from a few millivolts to approximately 1.1 volts, with a stable average of 0.5–0.7 V for more than a year. The electrical signal is sent to the Bioelectricity-Controlled Oscillator (BCO), a circuit specifically designed to convert bioelectricity into sound. The BCO uses an amplifier chip to increase the voltage and a hexagonal Schmitt oscillator chip to generate sound waves. The variation in bioelectric voltage directly influences the frequency and duration of the oscillation (Ahn 2019).

During performances, Ahn uses a DIFAS interface matrix developed by Lex van den Broek, which allows him to sequence and modulate signals from different columns and connect them to Max/MSP music software. In static installations, however, the sounds come solely from speakers built

into the electronic boxes. The project also incorporates a visual component using an endoscopic camera and LEDs synchronised with the sound signals, which project the interior of the columns onto a screen, making microbial activity visible (Ahn 2019).



[22] Sonomatter Installation and Performance (Ahn 2019)

[1.6.4] Immersive Experiences

Within the fourth subchapter, three projects involving an immersive experience for the public are presented. They share the multisensory stimulation of the viewer immersed in the experience, but differ in the ways in which they put this into practice.

For each project, the following aspects are analysed and compared:

- the project description, in order to provide a general overview of the processes and objectives associated with the implemented practices;
- communicative language, in order to understand what choices were made to engage the audience in an immersive way;
- ways of engage with the public, to analyse the different ways in which the senses and minds of users are stimulated;
- the technologies employed, to obtain a comprehensive understanding of the technological tools required to carry out these practices.

The selected immersive installations enable experiences that engage participants' bodies through different forms of multisensory stimulation.

Regarding Noise Aquarium, although I find the scanning process and the creation of the 3D models particularly interesting, I consider the visual representations highly spectacular yet less effective from a formal and stylistic perspective. Nevertheless, the enormous scale at which the organisms are represented creates an intriguing reversal of perceptual dynamics, positioning the viewers on the opposite side of the dimensional relationship.

On a sonic level, I find myself reflecting on a similar di-

[1.6.4] Case Studies Analysis: Immersive Experiences

lemma. I consider the presence of a disturbing sonic response associated with planktonic activity particularly relevant, as it coherently represents the reality of the observed phenomena. However, considering the reversal of scale established visually, I wonder whether it might have been equally compelling to apply a similar logic to the auditory experience, where the plankton themselves would generate invasive and unpleasant sounds, leaving human spectators at their mercy and unable to control or interrupt them.

Concerning the virtual reality experience and the bodily involvement of the participant, I believe that without directly experiencing the installation myself, I do not possess the necessary tools to formulate a sufficiently relevant reflection on the matter.

Focusing subsequently on the project Anthos, I consider the possibility of collective participation and its consequent effects on the experience to be particularly significant. Potentially, this approach allows users to transcend the notion of individuality and perceive themselves as part of a collective system that influences the surrounding environment through different effects and consequences.

The Effects of Embodying Wildlife in Virtual Reality on Conservation Behaviors, particularly regarding the research outcomes, presents a fundamental relevance to the planktonic theme. As previously outlined in the theoretical research, the possibility of mitigating, and potentially reversing, the probable effect of compassion fade through a highly embodied immersive experience represents an essential element in approaching the vast world of planktonic microorganisms through design.

I find especially significant the results concerning the impact that multisensory immersive experiences can have on audiences, both in the short term and in fostering a future-oriented perspective capable of encouraging more proactive attitudes toward supporting specific ecological issues.

NOISE AQUARIUM

[Directed by Victoria Vesna and Alfred Vendl,
presented in 2017.]

[Description]

Noise Aquarium is a project directed by Victoria Vesna and Alfred Vendl, developed with the contribution of Martina Fröschl, Stephan Handschuh, Thomas Schwaha, Ruth Schnell, Glenneroo and Paul Geluso (COLLABORATIVE TEAM – NOISE AQUARIUM, n.d.).

It is an interactive installation that immerses the audience in a three-dimensional “aquarium” where plankton are projected at a dramatically enlarged scale, aiming to shift the perspective through which people perceive these organisms. The project seeks to raise awareness about noise pollution, a factor already known to affect large marine species but still poorly understood regarding its impact on planktonic microorganisms (ARTIST STATEMENT – NOISE AQUARIUM, n.d.).

[Communicative Language]

The project communicates through an artistic and immersive tone, with a technical-scientific component derived from scanning and animation techniques used to replicate reality as closely as possible (MICRO CREATURES – NOISE AQUARIUM, n.d.).

The approach seem to therefore not be purely didactic or informational: the experience is visual, auditory, and evocative. The audience appear to not read data but rather lives within an altered ecosystem, communicated through a hybrid language that merges aesthetic pleasure and immersive experience with scientific accuracy.

[Public Engaging]

Several setups of the installation exist, but generally the

audience enters an immersive space where their own sound, movement, and presence influence the visualized plankton ecosystem. For instance, visitors generate sounds that disrupt the plankton’s equilibrium, and only when the environment is quiet does the ecosystem return to “normal,” accompanied by a whale song (‘Diving into Deep Space with Noise Aquarium’ 2018).

The interaction seem therefore bodily, through movement and presence in space, auditory through the sounds generated by the audience, and visual through the projections of plankton and aquatic environments. The participant becomes the main agent capable of influencing the simulated ecological system.



[23] Noise Aquarium Installation with Visitors
(ABOUT – NOISE AQUARIUM, n.d.)

[Technologies Employed]

The 3D models of the microorganisms were created using tomographic scanning (MICRO CREATURES – NOISE AQUARIUM, n.d.), a technique used to produce a three-dimensional image of an object's internal structures by observing and recording variations in how energy waves pass through them ('Definition of TOMOGRAPHY' 2025). These scans were then combined with observations of the microorganisms' behavior to create animated 3D models that resemble real organisms as closely as possible (WORKFLOW – NOISE AQUARIUM, n.d.).

In some versions of the installation, an interactive platform seem to invite visitors to step onto it with their bodies. While technical details are not publicly available, it appears to rely on a pressure-sensor system that detects shifts in body weight distribution, producing direct effects on the produced images and sounds in the surrounding space.

ANTHOS

[Project by Yiannis Kranidiotis, Sam Nester, Giovanni Paolo Randazzo, Alba Bernini, Ana Montero Castaño, Irene Guerrero Fernandez in 2024.]

[Description]

Anthos is a project by Yiannis Kranidiotis, Sam Nester, and Giovanni Paolo Randazzo, in collaboration with scientists Alba Bernini, Ana Montero Castaño, and Irene Guerrero Fernández. It was commissioned by the European Commission's Joint Research Centre as part of the SciArt Resonances IV program ('Anthos' 2024). The work is an immersive light and sound installation highlighting the importance of pollinators and how human activities and pollution are placing stress on these ecological systems ('Anthos | SciArt: Science Art Society', n.d.).

[Communicative Language]

Both visually and sonically, the language used is abstract and technical, representing pollinator networks through simple forms and integrating environmental data such as CO₂, temperature, and humidity ('Anthos' 2024).

The approach is more abstract and systemic than narrative: the audience does not receive discursive explanations but instead experiences a dynamic system through visual and auditory stimulation driven by real-time data.

[Public Engaging]

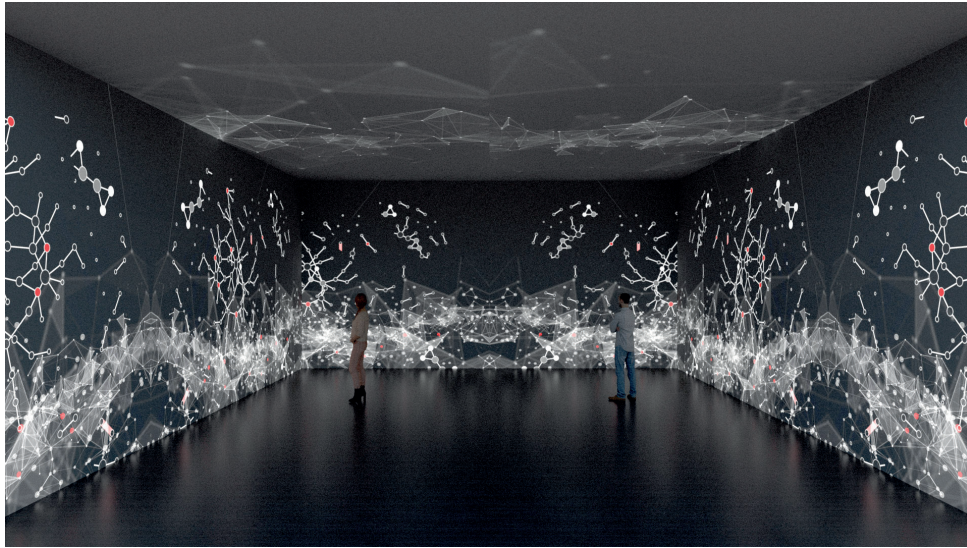
As the audience enters the space, their presence modifies the parameters detected by the sensors, which in turn alter the visual and auditory behavior of the simulated ecosystem ('Anthos' 2024).

This is not a device the user operates, but rather an immersive context where the conditions of the environment and

the participants themselves activate the system.

[Technologies Employed]

Environmental sensors are employed to monitor CO₂, temperature, and humidity within the installation. Real-time data feed a plant–pollinator network model based on complexity theory, generating synchronized visualizations across multiple walls and soundscapes (‘Anthos’ 2024).



[24] Anthos Installation with Visitors
(‘Anthos’ 2024)

THE EFFECTS OF EMBODYING WILDLIFE IN VIRTUAL
REALITY ON CONSERVATION BEHAVIORS

[Published in 2022 by Daniel Pimentel and Sri Kalyanaraman.]

[Description]

Published in 2022, the research project «The Effects of Embodying Wildlife in Virtual Reality on Conservation Behaviors», explores how the embodiment of wild animals within a virtual reality environment can influence attitudes and behaviors toward nature conservation. In the experience, participants embody a sea turtle of the species *Caretta caretta* and virtually encounter environmental threats such as fishing nets and plastic debris within an ecologically themed immersive context. The goal of the practice is to raise awareness of marine wildlife and strengthen participants’ willingness to engage in conservation behaviors (Pimentel and Kalyanaraman 2022).

[Communicative Language]

The experience uses a language that simulates the appearance of a real natural ecosystem: the user assumes the perspective and virtual body of a turtle in a realistic underwater environment, with simulated swimming movements and visible environmental threats such as nets, waste, and boats (Pimentel and Kalyanaraman 2022).

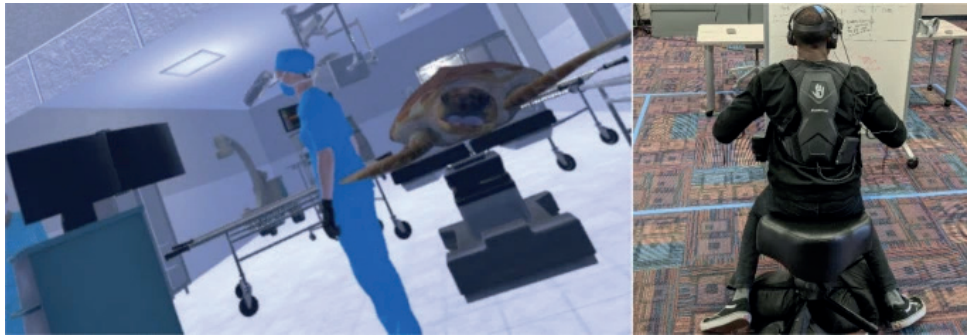
[Public Engaging]

Participants enter the VR experience by wearing the headset, controllers and haptic device, thus assuming the perspective and body of a sea turtle. Through movements and actions such as swimming, surfacing and avoiding dangers, they interact physically and perceptually through visual and tactile stimuli, and reflect on their own vulnerability embodied in an animal. At the end of the experience, hypothetical donations or conservation-related behaviors are measured to assess whether the immersive embodiment

concretely influences prosocial intentions and conservation behavior (Pimentel and Kalyanaraman 2022).

[Technologies Employed]

The setup includes a VR headset, body tracking to synchronize user movements with those of the turtle avatar, and haptic feedback via a SUB-PAC-like system on the back and body to simulate the turtle's shell. The experience is developed using 3D simulation software and features custom hardware designed to support a non-bipedal posture (Pimentel and Kalyanaraman 2022).



[25] Immersive setup
(Pimentel and Kalyanaraman 2022)

[2]

Design Process

- [2.1] Methodology
- [2.2] Field Studies
- [2.3] Interviews Analysis
- [2.4] Preliminary experiments
- [2.5] Work in Progress Exhibition
- [2.6] Advanced Experiments
- [2.7] Hybrid Affections Exhibition
- [2.8] Final Outcomes

[2.1]

Methodology

Following the literature review and case study analysis, the project shifted towards a more practice-oriented approach, initially centred on fieldwork activities and subsequently on the iterative prototyping of interactive artefacts. All activities were consciously developed in relation to the theoretical framework established during the preceding research phase.

Although I possessed a basic scientific understanding of the topic prior to the project, I deliberately approached the research from the perspective of a non-expert. This decision was intended to facilitate a closer alignment with the perspectives and knowledge gaps of the intended audience, while allowing new insights and assumptions to emerge directly from the research process.

With the aim of establishing the foundations for fostering rational compassion through a combination of reliable scientific knowledge and emotional engagement, a collaboration was initiated with scientists Marta Reyes and Stefanie Eyring. The objective was both to gain a comprehensive understanding of the scientific context and to explore the subjective experiences that shape their relationship with planktonic organisms.

Both researchers are aquatic ecologists at the Eawag

research institute and members of the Aquascope project. Through their support, I was able to directly experience several of the practical activities involved in plankton research and to engage with their personal perspectives on the organisms and ecosystems they study.

This collaboration enabled the development of five fieldwork activities, conducted both individually and alongside the researchers. These experiences provided opportunities to observe and better understand the practices, environments, and technologies involved in plankton research in Switzerland, while also exploring how emotional connections with these organisms may emerge through direct engagement. By repeatedly encountering Lake Greifensee and its surrounding environment, I was able to develop a first-hand understanding of some of the ecological dynamics that characterise the lake ecosystem.

To further investigate how emotional connections with planktonic life are formed and maintained, a semi-structured interview lasting approximately forty minutes was conducted with Marta Reyes and Stefanie Eyring. The discussion focused on perceptions, emotions, experiences, and reflections emerging from their daily research activities, with particular attention given to the three contexts identified as central to their practice: the lake, the laboratory, and the data generated through monitoring technologies.

The fieldwork activities and interview, recorded using the video ethnography method, collectively served as a bridge between the theoretical research and the subsequent design phase. Beyond providing scientific knowledge, they offered insights into the emotional, perceptual, and experiential dimensions of plankton research, informing both the conceptual framework and the development of the artefacts presented in the following chapters. The conclusions emerging from these investigations are presented and analysed in the chapters Fieldwork Analysis and Interview Analysis.

Following this exploratory phase, the prototyping pro-

cess was structured into three iterative cycles of design, development, and evaluation. The first two iterations were presented within public exhibition contexts, providing opportunities to observe audience interactions, collect feedback, and assess the effectiveness of the emerging artefacts. The third and final iteration, which resulted in the artefacts presented in this thesis, will be exhibited as part of the final Master's Thesis Exhibition following the completion of the present research project.

The prototyping activities were guided by the communication model established during the theoretical research phase and informed by the insights gathered through fieldwork and interviews. More specifically, the design process sought to explore ways of reducing the perceptual distance between human beings and planktonic organisms while fostering enduring forms of rational compassion. To achieve this, successive iterations progressively incorporated immersive and embodied forms of engagement, combining scientific mediation, multisensory interaction, and direct participation in order to create meaningful encounters with otherwise inaccessible forms of life.

[2.2]

Field Studies

This chapter presents, describes, and analyses the fieldwork activities carried out during the initial phases of study and development of the research project Current's Wanderers. In particular, five different field operations are examined, conducted with the following objectives:

- establish a collaborative relationship with scientists who are experts in the field;
- acquire an adequate level of scientific knowledge on the topic;
- engage in first-hand field experiences, and gather unexpected insights that will help with the development of the project;
- collect material that is useful and necessary for project development.

All activities were documented using video ethnography methodology, producing audiovisual material intended for analysis and use in subsequent design phases.



[26] Plankton net on the surface of Lake Greifensee
(17.12.2025)

[2.2.1] Sampling at Greifensee Part 1

The first fieldwork activity took place on March 6th 2025 on the waters of Greifensee, where I accompanied Marta Reyes and Stefanie Eyring, two scientists from the Aquascope group within the Eawag research institute. The day was mild and sunny, offering ideal conditions for the collection of audiovisual material and for observing the environmental context in which we were operating.

After meeting at Stettbach railway station, we travelled by minivan to the lakeshore. During the journey, the scientists shared information regarding the activities planned for the outing, as well as some expectations related to their scientific observations. Upon arrival, the measurement instruments were transferred from the vehicle to the motorboat that would take us toward the centre of the lake basin. After putting on life jackets, we began navigating toward the floating measurement station, where the day's scientific activities were to take place.

Already at this early stage, the importance of field operations for scientific research became evident. The excitement associated with the discovery of the unknown was clearly perceptible: Marta and Stefanie explained how not everything can be measured remotely and how unexpected

[2.2.1] Field Studies: Sampling at Greifensee Part 1



[27] Surface of Lake Greifensee
(6.3.2025)



[28] Underwater microscope at Greifensee
(6.3.2025)

events can often only be detected through direct observation. Shortly thereafter, confirming this point, cyanobacterial blooms appeared on the lake surface, surprising the scientists, who had not expected such an abundant presence at that time of year.

After approximately fifteen minutes of navigation, we reached the measurement station and moored the boat. Inside the structure, the data collected by the sensors were presented and explained to me, including physical and chemical parameters of the water at different depths. At the same time, samples of zooplankton and phytoplankton were collected at various levels, intended for subsequent laboratory analysis. The underwater microscope known as Ariel was also retrieved, cleaned, and its operation and scientific relevance were explained to me.

I actively participated in many of these operations, assisting with measurements and acquiring essential information to better understand the scientific context in which we were working. This experience allowed me not only to gain a more articulated understanding of the scientific perspective on the topic, but also to attune myself more closely to the world of the scientists and planktonic microorganisms. Once all activities were completed (sample collection, data download, cleaning of the microscope and station) we returned to shore to load the materials destined for the laboratory in Dübendorf.

Thanks to this first field experience, I was able to establish a solid and lasting collaborative relationship with the scientists, who demonstrated a deep passion both for scientific research and for the dissemination and sharing of their knowledge with a broader audience. The direct experience and the collection of audiovisual material also allowed me to physically enter the world of planktonic microorganisms, acquiring information primarily related to their technical and scientific aspects.

Following the sampling activity of March 6th 2025, after loading the equipment into the minivan, the scientists and I returned to the Eawag centre in Dübendorf. During a shared lunch, I had the opportunity to further explore their willingness, both personal and institutional, to make their discoveries and knowledge accessible to society.

We then moved to the laboratory, where I was shown the scientific instruments used to analyse the samples collected from the lake. As an initial activity, we observed portions of the samples under the microscope: just a few drops of lake water were sufficient to reveal an extraordinary diversity of planktonic organisms, ranging from diatoms and cyanobacteria to copepods and rotifers.

During the observation, Marta and Stefanie described in real time what appeared under the lens, explaining the properties and characteristics of the different species with an enthusiasm that seemed renewed with each observation. Their passion was clearly conveyed through their tone of voice and expressions, engaging me emotionally. They also demonstrated various filters and observation techniques capable of highlighting specific plankton categories, allowing me to identify details that would otherwise have remained invisible.

After spending a significant amount of time observing samples under the microscope, we moved to other areas of the laboratory. First, I was shown the archive, which preserves historical manuals and observation reports produced using analogue methods. This space also houses ancient slides of great scientific value, as well as carefully preserved older samples that are still suitable for observation and analysis. Shelves filled with analogue material testify to decades of detailed plankton research conducted in Switzerland.

Finally, we visited the room dedicated to the preservation and cultivation of numerous pure samples of different plankton species originating from various Swiss freshwater basins.

The laboratory visit and the guided microscopic observations not only enabled me to better understand their research activities, but also prompted reflection on how the scientists' emotional engagement and passion can become effective tools for engaging a wider audience.

From the Greifensee expedition on March 6th 2025, I was able to retain two vials containing samples of zooplankton and phytoplankton. The following day, March 7th 2025, after returning to school, I borrowed a microscope from the Physical Computing Lab within my institution and attempted to individually replicate the experience previously shared with the scientists.

I spent the entire day observing a few drops of water taken from the samples. The experience proved to be profoundly different: the absence of the scientists' commentary and passionate explanations initially left me disoriented, making it more difficult to fully understand the observed dynamics. At the same time, working independently allowed me to experience different emotions: I was responsible for deciding where to look, which sample to observe, and at what magnification, freely exploring a miniature world that I myself had collected from the lake.

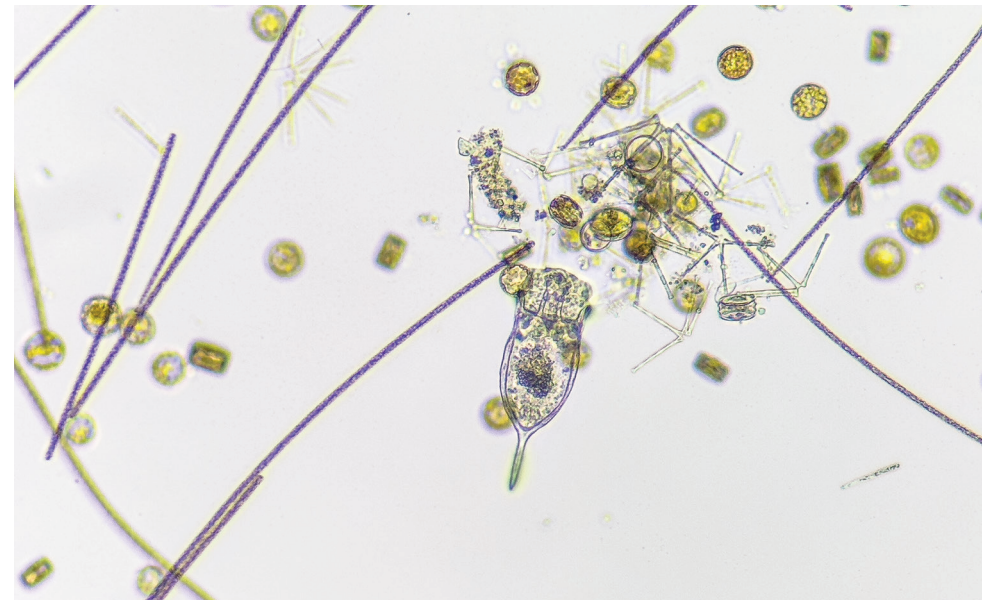
Gradually, I became emotionally engaged even without the support of Marta and Stefanie. I particularly recall the sense of satisfaction in recognising species previously observed or encountering others that I had only seen in books or online. To document the experience, I used an adapter that al-

lowed me to take photographs and record videos with my phone, collecting material that proved extremely useful both for future project development and for process documentation.

However, this activity also generated an ethical conflict within me: at that moment, I was directly responsible for the collected samples and, consequently, for the almost inevitable death of the organisms contained within them. Despite the limited ecological impact of my actions, due to the small quantity of samples and the educational value of the experience, I became aware of my desire to continue the project in the least invasive and harmful way possible for any living organism. From that point onward, any further sampling or handling of plankton was carried out only when strictly necessary and using the most ecological methods possible.



[29] Copepod with eggs under the microscope
(7.3.2025)



[30] Keratella and Diatoms under the microscope
(7.3.2025)

[2.2.4] Individual Sampling at Limmat

On November 26th 2025, during the Work in Progress exhibition of thesis projects, I carried out my first individual sampling activity at the Limmat River. Using a plankton net lent to me by my thesis supervisor Anthea Oestreicher, I went to the river and, after several casts, was able to collect a few centilitres of filtered water, potentially rich in planktonic microorganisms.

The objective of this operation was twofold: on the one hand, I wanted to personally experience the sampling activity; on the other, I was interested in observing the reactions of exhibition visitors when confronted with living organisms within the exhibition space. The sampling was conducted in a limited quantity and in an area very close to the school building, allowing me to return the samples to the river at the end of the exhibition and making the operation targeted and ecologically sustainable.

The sampling process initially proved more complex than expected, but once I understood how to properly handle the net, I was able to obtain samples that, to my surprise, were extremely rich in planktonic microorganisms. Observing them under the microscope allowed me to discover species I had never seen before, eliciting surprise and en-

[2.2.4] Field Studies: Individual Sampling at Limmat

thusiasm among the exhibition visitors. Some spectators, to my great satisfaction, expressed ethical concerns regarding the inclusion of living organisms within the exhibition space, particularly given that those placed under the microscope were highly likely to die.

At the end of the exhibition, I returned to the river and released the samples back into its waters, preserving the health and integrity of over 90% of the volume of water collected.



[31] Sampling with plankton net
(26.11.2025)

[2.2.5] Sampling at Greifensee Part 2

On December 17th 2025, on a cold autumn morning, I returned to Greifensee together with Marta and Stefanie. In continuity with the first outing in March, the planned activities were similar: water sampling at different depths, maintenance of the measurement station and underwater microscope, and monitoring of data collection sensors.

My objective, however, was partially different. Having already acquired substantial information during the first expedition, this time I focused on more accurate audiovisual recording of moments and actions that were less relevant from a scientific standpoint but potentially significant from a communicative and outreach perspective. The intention was to complement the previously collected material by adopting a slightly different point of view.

Although the activities carried out were largely the same, the knowledge accumulated over the preceding nine months allowed me to experience the fieldwork differently, observing the scientists' gestures, behaviours, and thoughts more closely without having to concentrate on acquiring additional scientific knowledge. In addition, the scientists were given a disposable camera, used as a cultural probe to enable them to potentially communicate their perspective to a gene-

[2.2.5] Field Studies: Sampling at Greifensee Part 2

ral audience by capturing moments they considered relevant or simply interesting to be shared.



[32] On the boat at the Greifensee
(17.12.2025)

[2.2.6] Microscope Observation Part 2

On 16 April 2026, I returned to the Eawag laboratory in Dübendorf for a final visit to observe a water sample collected from Lake Greifensee together with Marta and Stefanie. The purpose of this activity was to document the uniqueness of both the scientific and emotional dimensions of their observational practice, capturing visual material through the microscope while simultaneously recording their conversations and spontaneous reactions.

Earlier that morning, Marta had carried out the routine monitoring activities at the lake's measurement station and had brought back the water samples designated for laboratory analysis. Together, we gathered around the optical microscope used by the research group and began the observation session.

From the very first moments, the experience proved to be highly engaging. The observation of a planktonic organism carrying two eggs containing its offspring immediately generated excitement and emotional engagement among those present, creating the moment of collective fascination I was looking for.

Initially, I had intended to remain a passive observer, focusing solely on documenting the researchers' work.

[2.2.6] Field Studies: Microscope Observation Part 2

However, within a few minutes I found myself actively participating in the discussion, commenting alongside the scientists on the remarkable organisms appearing under the microscope. I particularly remember correctly identifying two plankton species and being met with genuine appreciation and enthusiasm from Marta and Stefanie, which further strengthened my sense of involvement.

The enthusiasm generated during the session did not go unnoticed within the laboratory. On several occasions, other researchers, intrigued by the exclamations coming from the room, entered to see what was happening and eventually joined the observation themselves.

My initial goal had been to collect approximately ten minutes of footage. However, the observation continued for more than thirty minutes, and the only factor that ultimately brought it to an end was the lack of available storage space on my phone, which interrupted the video recording.

As the researchers explained, the biological composition of the samples varies considerably from week to week. At times, phytoplankton species dominate; at others, zooplankton are more abundant. In some cases both groups are present in large numbers, while in others overall biological activity is relatively limited. In the particular sample observed during this session, the majority of the identified organisms belonged to the zooplankton community, which nevertheless represents only one portion of the diverse planktonic ecosystem inhabiting Lake Greifensee.

[2.2.7] Cultural Probes

In an attempt to involve the scientists more directly in the design process and gain additional insights into their personal perspective, they were given a disposable analog camera during the last fieldwork session. The instruction provided asked them to capture moments, objects, or places that, from their point of view, were meaningful in communicating their work and the subject of their research to the public.

Marta and Stefanie produced eighteen photographs depicting both fieldwork activities at the lake and observations and procedures carried out in the laboratory. The limited timeframe did not allow them to complete the task as thoroughly as they would have liked; nevertheless, several interesting considerations can still be drawn from the collected material.

Among the photographs taken in the laboratory, one in particular documents a moment in which a microscope observation was shared with other people through a computer monitor. From my personal experience, it happened several times that, during particularly exciting observations, other researchers would gather around, drawn in by the collective enthusiasm generated by the discovery. This episode highlights how the researchers' passion and their way of experiencing their

[2.2.7] Field Studies: Cultural Probes

relationship with plankton can spontaneously attract other people, arousing curiosity and interest toward what emotionally engages them.

The other most relevant photographs produced by the scientists were taken at the measurement station on Greifensee. In my view, this location also represents a key space, potentially even more intimate than the laboratory itself. It is here that Marta and Stefanie come into direct contact every week with the waters hosting the plankton they study and with the instruments used to collect the data essential to their research, such as the underwater microscope.



[33] Marta and Stefanie when the camera was returned to me (16.04.2026)



[34] Photo taken by Marta and Stefanie at the Greifensee
(Date Undefined)



[35] Photo taken by Marta and Stefanie at the Greifensee
(Date Undefined)









[39] Photo taken by Marta and Stefanie at the Eawag Laboratory
(Date Undefined)



[41] Photo taken by Marta and Stefanie at the Eawag Laboratory
(Date Undefined)



[40] Photo taken by Marta and Stefanie at the Greifensee
(Date Undefined)



[42] Photo taken by Marta and Stefanie at the Greifensee
(Date Undefined)

Interview Analysis

The interview conducted on November 24th, 2025, with scientists Marta Reyes and Stefanie Eyring at the Eawag research institute in Dübendorf focused on exploring the roots of the emotional connection that has developed over the years between them and the planktonic microorganisms that constitute the subject of their daily research. The aim of the meeting was to outline a perspective on this relationship that was as articulated and in-depth as possible. What follows is a concise analysis of the most relevant aspects that emerged from the responses collected.

The primary motivations the scientists cite when describing what drives them to work in this field of research are linked to the beauty, ecological importance, diversity, and dynamism of the planktonic universe. Both emphasize that, in order to establish an emotional connection, it is essential to become familiar with organisms' distinctive characteristics, peculiarities, and uniqueness; much in the same way as in human relationships. The planktonic realm is described as an extremely vast and varied system, capable of continually surprising and offering new stimuli for discovery, thereby constantly nurturing curiosity and the desire for knowledge. Among the aspects that elicit the greatest sense of won-

der, they highlight certain abilities and behaviors that appear surprisingly complex for unicellular organisms, yet which these organisms are able to perform, generating amazement even among experienced researchers.

Another recurring theme throughout the interview is that of invisibility, closely linked to the microscopic size of plankton. Both scientists point out how fascinating, and at the same time surprising, it is to realize that the water we observe every day and perceive as transparent actually contains a far greater amount of life than is commonly imagined. This invisibility often contributes to an underestimation of aquatic biodiversity by non-experts, who lack the tools or knowledge necessary to recognize it.

Among their daily research practices, laboratory-based microscopic observation emerges as one of the most emotionally engaging activities. It is in this context that plankton appear to “come to life”: they interact with one another and reveal unexpected behaviors that continually surprise the scientists. However, this mode of observation also establishes an asymmetric and unidirectional relationship, in which the researcher occupies a position of observer looking down, while plankton remain objects of study rather than being considered potential collaborators within the research process.

The use of an underwater microscope, by contrast, allows for a more regular connection with the biological activity present in the waters of the studied lake, reducing the temporal distance between the moments of sample collection and subsequent laboratory observation. The scientists note, however, that compared to laboratory microscopy, the images obtained are more static, two-dimensional, and less experientially engaging. Furthermore, the ability to actively control the point of observation, characteristic of laboratory microscopes, fosters a greater degree of emotional involvement.

Field activities, such as weekly outings on the lake, emerge as one of the most stimulating and emotionally engaging moments of their routine, as they enable direct contact

with the ecological context of their object of study. Physical presence on site is described as essential for grasping aspects of the ecosystem that would otherwise remain undetectable. Although sensor-generated data provide a detailed and in-depth perspective, they are not sufficient to convey a complete understanding of the system, which can only be achieved through direct, multisensory observation of the lake. During fieldwork, the activity that fosters the strongest connection with planktonic organisms is identified as the collection of zooplankton and phytoplankton samples.

The three dimensions that structure their daily practices, the laboratory, the lake, and the data generated by measurement systems, form a triangular balance that enables the scientists to develop a comprehensive view of their object of study. This configuration not only ensures a more complete understanding of the observed phenomena, but also helps maintain a high level of interest and motivation, encouraging the continuous discovery of new and unexpected elements.

For Marta and Stefanie, it is essential that society recognizes the value and importance of plankton for the health of natural ecosystems, avoiding the tendency to underestimate them on the basis of their small size, which makes their role difficult to perceive and quantify. Among the aspects that bring them the greatest satisfaction in their work are contributing to the discoveries of other researchers and engaging in public awareness and outreach activities, made possible through the sharing of their passion and knowledge. Among the practical recommendations they offer to those who wish to contribute to the protection of planktonic organisms, a simple yet clear message emerges: the importance of caring for water bodies by preventing pollution and actively promoting their protection and preservation.

[2.4]

Preliminary Experiments

During the first prototyping phase, several possible approaches and design directions were explored. Four of these were further developed and presented during the work-in-progress exhibition, where they were tested with multiple users. The aim is to identify which artefacts and interactions are capable of fostering, as identified in the theoretical literature review, rational compassion and an immersive, embodied experience among the target audience. The results of the exhibition are presented in the chapter Work in Progress Exhibition.

[2.4.1] Video Essay

Both the interview conducted in the laboratory and the videos collected through video ethnography during the fieldwork sessions at Greifensee, thanks to the expressiveness and experience of Marta and Stefanie, succeed in conveying not only reliable scientific information but also a profound emotional connection with plankton.

By combining these two materials, an introductory video was created. The purpose of this artefact is to establish a solid foundation of rational compassion for the communicative model described in the theoretical research. In particular, the video uses the scientists as mediating figures, providing not only a clear and accessible layer of foundational knowledge, but also demonstrating through visual and auditory elements that it is possible to develop an emotional and affective connection with planktonic microorganisms.

[2.4.2] Reading the Sample

Following multiple microscope observation sessions with the scientists Marta and Stefanie, I became aware of how emotionally engaging their way of commenting on the samples collected from the lake could be. Their personalities, combined with the element of surprise generated by the high diversity and fluctuation of planktonic communities in terms of species, led me to experiment with an additional audiovisual artefact.

I decided to bring this experience outside the scientific laboratory by combining the visual dimension of microscopic imagery with the commentary of the two scientists. In this case as well, the objective was to merge scientifically accurate information with a personal and emotional component, contributing to the establishment of a sense of rational compassion.

[2.4.3] Data from Underwater Microscope

Aquascope is one of the few research institutes worldwide capable of providing the public with near real-time data on the planktonic activity of an observed body of water, in this case Lake Greifensee. Currently, this information is communicated through quantitative graphs illustrating species population densities updated on an hourly basis, together with static images captured by the underwater microscope.

Although I find these methods highly fascinating, I believe they do not fully convey the richness of what they represent. As also emerged during the interview process, what is missing is the personality of plankton, expressed through their movements, their dimensions, and the highly diverse forms that distinguish each organism.

I therefore decided to develop a visualisation based on simple forms, primarily intended to convey the dynamic quality of the organisms' movement within the body of water. The objective was to test whether this representation, combined with the real-time factor, could contribute additional communicative impact.

[2.4.4] SenseSpace Immersive Experience

The final of the four initial experiments focused on the involvement of the human body, with the intention of developing an embodied experience capable of counteracting a probable effect of compassion fade, as highlighted in the theoretical research.

In this case as well, I relied on simple visual forms and, through a body tracking system developed by Professor Max Reiner, users were able to interact with plankton within a simulated aquatic environment. Through a wall projection, visitors could observe and engage with the virtual space by moving within the area monitored by the cameras.

The plankton, abstractly represented as spheres, floated within the virtual environment through a sinusoidal motion intended to simulate their drifting behaviour in a liquid body. At irregular intervals of approximately 15–20 seconds, a simulated current disrupted the stability of the organisms before gradually allowing them to reorganise. One visitor at a time could enter the dedicated interaction area, where the software identified their presence. Taking inspiration from the project Head Tracking for Desktop VR Displays using the Wii Remote by Johnny Chung Lee the projection in front of the user shifted the visualisation to adopt their personal point of view within the virtual environment. This effect would tran-

[2.4.4] SenseSpace Immersive Experience

sform the flat projection by reacting to body movement as if it were a real window creating a realistic illusion of depth and space (‘Johnny Chung Lee - Projects - Wii’, n.d.).

The visitors’ movements in addition, depending on their direction, position, and intensity, influenced the behaviour of the fluid and, consequently, the stability of the planktonic community. The sinusoidal drifting motion, the simulated currents, and the movements generated by the visitors were all connected to sonic feedback reproducing water displacements, helping to immerse the audience within an underwater atmosphere.

Work in Progress Exhibition

The Work in Progress Exhibition was held in the Galerie 1&2 space within the ZHdK campus. On display were the unfinished final-year projects of second-year students on the ZHdK Master's programme in Interaction Design.

The goal was to both present and showcase the state of the project at that stage and test the prototypes while collecting feedback regarding the participants' experiences.

The exhibition path of my project began with an informative introduction to planktonic phenomena combined with a selection of photographs collected from the web in order to communicate the morphological diversity characterising different plankton species. This introductory section was considered important for establishing a preliminary understanding of the topic, although not strictly essential for comprehending the subsequent artefacts. Nevertheless, the photographs helped generate a sense of fascination among visitors, which in most cases persisted throughout the exhibition experience.

Following the introduction, the audience encountered the first version of the video essay. The comprehensiveness of this artefact itself made the initial introduction potentially redundant. The video was received with enthusiasm

and interest, particularly due to the visual and conceptual connections established between the interview and the fieldwork moments at the lake and in the laboratory. Among the collected comments, several visitors noted how seeing visual evidence of what had previously been described in the interview reinforced the scientists' words and contributed to establishing a sense of trust.

Subsequently, the one-minute scientist's Reading the Sample experiment was presented. To my surprise, it was received extremely positively, being described simultaneously as humorous, engaging, and informative. Its strength appeared to lie in the scientists' natural ability to combine scientific explanations delivered in an extremely colloquial manner with jokes and emotional reflections derived from their long-term personal experience with microorganisms. However, its short duration left some participants wishing to see a more extended version.

Although not originally planned, two scientific instruments related to plankton studies were also included within the exhibition: a plankton net and an optical microscope. The plankton net did not generate any particularly notable reactions, whereas the microscope sparked the ethical debate I had hoped for. Inside the microscope was a water sample collected only moments earlier from the nearby Limmat River.

Visitors were initially fascinated by the possibility of directly observing living organisms through the microscope lenses. Subsequently, however, many began questioning whether the inclusion of living beings as exhibition artefacts constituted a forced gesture that did not align ethically with their personal values. I witnessed several conversations on this topic, and most participants, perhaps also influenced by the other exhibited artefacts, concluded that the act of forcing living organisms outside their natural environment for exhibition purposes was not a choice they personally supported.

The following section was dedicated to the presentation of real-time data from the underwater microscope located at

the measurement station on Greifensee. This first iteration was perceived with both interest and confusion. The real-time connection with the lake strongly stimulated curiosity and fascination, while the uncertainty mainly derived from the difficulty of understanding the dimensional scale of the representation and from the excessive abstraction of the chosen visual forms. The coloured spheres, which represented the planktonic individuals identified by the underwater microscope in the Lake Greifensee, were ultimately unable, apart from some randomised movement, to communicate meaningful characteristics of the organisms themselves.

The subsequent installation, the SenseSpace Immersive Experience, received very similar feedback. Once again, the plankton were represented through spheres perceived as excessively anonymous to establish any significant emotional connection with the audience. The most interesting aspect highlighted by visitors instead concerned the physical properties determining the spheres' movement, particularly the sinusoidal drifting motion and the movements generated by the visitors' changing positions.

Despite this, the instability of the tracking system caused the movement of human bodies to appear slightly delayed and insufficiently fluid, breaking part of the immersive illusion. The sonic feedback, however, was received very positively. Given the particularly abstract visualisations, sound became an essential element for reconnecting the experience to the presence of water.

One particularly interesting piece of feedback suggested how fascinating it would be to directly connect the real-time data from the lake to the SenseSpace immersive experience, further strengthening the sense of connection with a locally recognizable body of water.

To summarise, the conclusions drawn from these experiments allowed me to establish the foundations for the continuation of the project into a new phase of prototyping and experimentation. The thematic introduction was confirmed

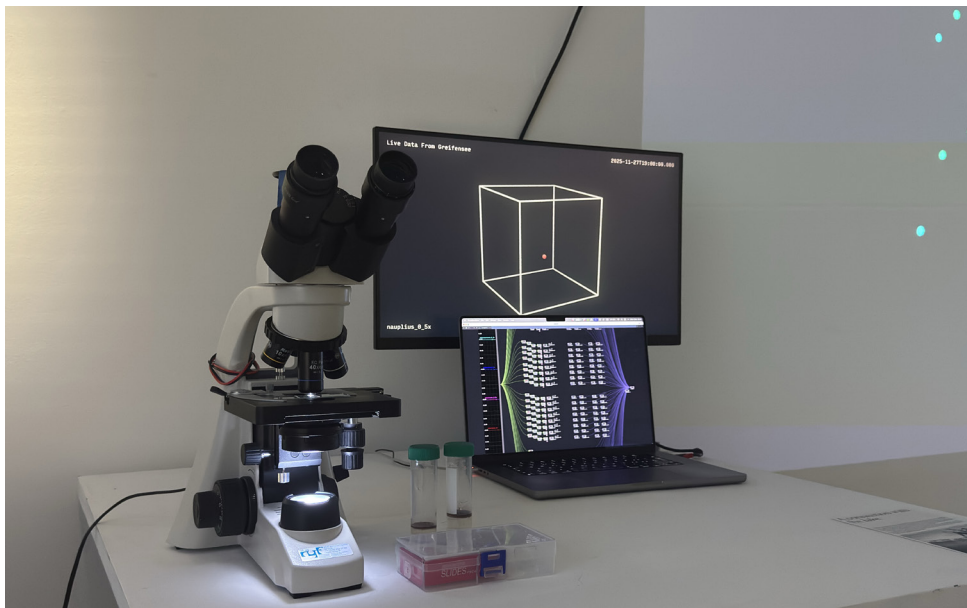
to be important but not essential, and its presence in a more concise form could potentially strengthen the narrative structure. Both videos were positively received and require further development: in the first case by emphasising the relationship between the interview and the visual content, and in the second by extending its duration and applying the format to the observation of a real sample. The microscope and the plankton net functioned primarily as temporary experimental tools for collecting visitors' opinions and will not undergo further development iterations. The real-time data visualisation from the lake and the SenseSpace immersive experience both require an aesthetic language that is less abstract and more representative of the actual properties of planktonic organisms. These two experiences could potentially be merged into a more impactful installation, ideally based on a more stable technological system and on a different form of interaction capable of stimulating multiple senses without necessarily involving the entire human body. The sonic feedback, together with the introduction of the physical properties of liquids, should ideally be maintained and further developed in future iterations.



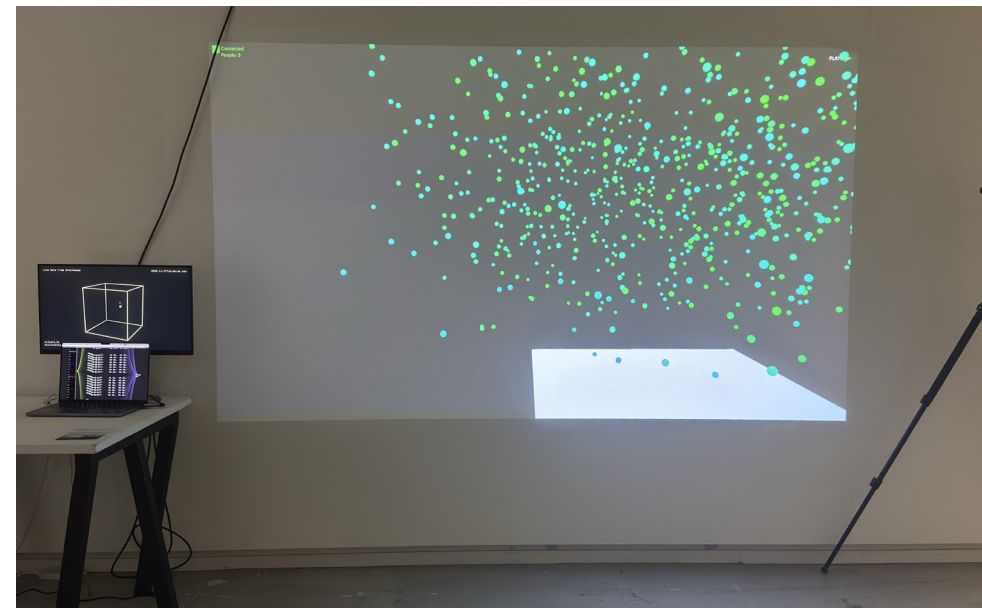
[43] Exhibition setup
(1.12.2025)



[45] Reading the Sample
(1.12.2025)



[44] Data from underwater microscope station
(1.12.2025)



[46] SenseSpace Immersive Experience
(1.12.2025)

Advanced experiments

During the second cycle of experimentation within the prototyping phase, the objective was to further develop the conclusions emerging from the feedback collected during the first iterations, continuing toward the same goal identified in the theoretical literature review: fostering rational compassion and an immersive, embodied experience for the target audience.

The developed artefacts were exhibited and tested during the Hybrid Affections exhibition, where qualitative feedback and observations were collected from visitors. The creation and the results of the exhibition are further discussed in the chapter Hybrid Affections Exhibition.

Building upon the positive outcomes of the first iteration, the video essay was completed and expanded through the integration of additional audiovisual recordings, with the aim of visually representing even more the themes and reflections expressed by the scientists during the interviews.

The additional material includes footage captured during the last fieldwork session at Lake Greifensee in December 2025, together with numerous microscopic recordings of plankton samples obtained with Marta and Stefanie in April 2026. These materials were selected and edited to accompany and contextualise the scientists' narratives, enabling the audience to establish an even more direct connection between the scientific accounts and the organisms being discussed.

pressing the experience to fit conventional attention spans. For this reason, the final outcome consists of a 24 minutes recording that documents almost the entirety of an authentic scientific microscope observation of a plankton sample collected from Lake Greifensee.

Following the particularly positive reception of the first iteration, the second version was further developed and expanded. As described in the chapter Microscope Observation Part 2, thanks to the collaboration of Marta and Stefanie, I had the opportunity to observe, participate in, and document an entire laboratory microscope observation session involving a water sample collected from Lake Greifensee earlier that same day.

The resulting material consists of approximately thirty minutes of audiovisual recordings, including both the microscope imagery and the spontaneous conversations and commentaries of the two scientists throughout the observation process.

Although the initial intention was to create a concise piece lasting between five and ten minutes, I ultimately decided to preserve most of the original recording. This decision was motivated by a desire to communicate not only the scientific content of the observation but also its temporal dimension. Natural processes, as well as the scientific practices used to investigate them, unfold according to their own rhythms, which often differ from the expectations of immediacy and rapid consumption that characterise contemporary digital media.

Maintaining an extended duration therefore encourages viewers to adapt to the pace of observation rather than com-

Following the partial dissatisfaction that emerged from the interaction tests with the SenseSpace Immersive Experience, I decided to step back and retrace the previous stages of the design process. During this reflection, I came across a statement made by scientist Stefanie Eyring during the interview conducted at the research laboratory: “we can’t hear them, smell them or touch them.”

Connecting this statement to the theoretical research phase, the reason for this limitation can be linked to the concept of *Merkwelt*, which, according to the theory developed by Uexküll in the early twentieth century, encompasses everything an organism is capable of perceiving (Uexküll [1934] 2010). The profound difference between human perceptual capabilities and those of plankton, combined with the extreme dimensional gap, makes it almost impossible for humans to perceive planktonic microorganisms through their senses.

For this reason, I decided to experiment with the development of haptic gloves ideally capable of recreating, when combined with a visual component, the sensation of physical contact with these organisms.

The experimentation began through the use of a coin motor synchronised with plankton movement, in order to under-

stand whether this combination could enhance their perception. By animating two daphnia within the visualisation and connecting only one of them to the vibration generated by the haptic motor, it became evident that the user’s attention focused almost exclusively on the organism enhanced through tactile feedback.

After understanding the potential of this effect, I began researching ways of translating this response into a distributed tactile feedback system across the sensitive areas of the hand. During this process, I encountered the project *Arduino Science Project: Build a Haptic Glove* by Science Buddies, which demonstrates how to construct a system of coin motors positioned on the fingertips and connected to an Arduino (Science Buddies 2025). Following this example, I developed an initial prototype by attaching one haptic motor to each fingertip of a cycling glove.

During testing, a particularly interesting feedback emerged near the minimum power threshold required to activate the motors. By applying a script that continuously oscillated the motor power around this threshold, the motors generated an almost organic effect, resembling the behaviour of a living organism.

The prototype was therefore built using six coin motors positioned on the fingertips and palm of the hand, sewn directly into the glove.

The haptic gloves, however, required a visual connection in order for the vibrations to be associated with physical contact to the planktonic life forms. For this reason, a second iteration of the live visualisation from the underwater microscope installed in the waters of Lake Greifensee was developed.

To avoid the issues encountered in the first version and to emphasise the morphological and behavioural diversity of planktonic organisms, illustrations and animations were created for all 46 plankton categories catalogued by the Aquascope research group at Eawag. Multiple variations were also developed for specific species in order to avoid visual repetition and increase the diversification of the represented ecosystem.

As highlighted during the research phase in fact, water can potentially function as a connective element between humans and other life forms within the natural environment (Neimanis 2017). This reflection led me to emphasise the physical properties of the water experimented in the first prototyping phase. Unlike plankton, human beings are familiar with water; they touch it, interact with it and drink it throughout their lives. For this reason, I believe that the simulation should be as true to life as possible so that it can serve as a conceptual bridge. To achieve this, a reactive script based on a vector field si-

mulating the dynamics of a was developed. This system formed the foundation of the visualisation, allowing the plankton to drift within a constantly changing environment and completing the user's visual stimulation.

Maintaining the positive aspects that emerged from the sound components of the first iteration was essential. Each plankton category whose movement could be considered as active, such as antenna movement or cilia rotation, was therefore associated with various sound responses reminiscent of the displacement of small masses of water. Additionally, a constant underwater ambient sound was introduced to further reinforce the immersive auditory experience.

To complete the embodied dimension of the installation, an infrared hand-tracking sensor was integrated together with the previously developed haptic glove.

The sensor captures the position and movement of the hands, which directly interact with the vector field underlying the fluid simulation, transforming water into an actual interactive bridge between the user and the represented plankton. The direction of the hand movement temporarily alters the vectors in the same direction, while the speed of the gesture accelerates the movement of the plankton and particles within the area of influence, which also increases proportionally with the speed of the hand. Just as in natural aquatic environments, in the visualization plankton are therefore also highly affected by anthropogenic activities, but always through the water simulation that constitutes their living environment.

But humans are not always disruptive towards other living beings. To encourage behaviours of care and coexistence aimed at bringing plankton closer to human society, when the user moves their hands very gently or keeps them still, the vectors within the area of influence converge toward the hand. This gesture enables prolonged contact and closeness based on empathy and respect for these microorganisms.

The haptic glove was designed to be worn during this interaction in order to add a further sensory layer by returning

vibrations synchronised with the movement and activity of the plankton. This would make the act of physical contact with the organisms tactilely perceptible, thus completing the multisensory stimulation enabled by the installation.

To strengthen the immersive underwater effect, already partially suggested by the ambient soundscape, an accompanying visual layer was developed to realistically represent the movement of the lake surface as seen from below.

Initially, the system was intended to update and transform in real time according to meteorological data, synchronised with the latest data coming from the underwater microscope. However, for the first prototype iteration, the system was simplified into a more basic configuration.

Hybrid Affections Exhibition

The Hybrid Affection Exhibition was held in the Kunstraum space within the ZHdK campus. On display were projects of students part of the Art&Science Minor program and of the Master Transdisciplinary Studies in the Arts, that developed their practice at the intersection with Art and Science.

Although most of the exhibition took place within the Kunstraum, my project was installed in a smaller adjacent room that, in my view, proved particularly suitable for enhancing its immersive and contemplative qualities.

Unlike the previous work in progress exhibition, no dedicated introductory artefact was provided apart from a panel displaying the project title and abstract. This decision was intentionally made to investigate how visitors would respond to an exhibition structure focused directly on the primary artefacts. Contrary to expectations, the absence of a more extensive introduction did not generate significant confusion among visitors, who were able to acquire the necessary context through the video essay presented as the first station of the exhibition.

As in the previous iteration, the video essay was appreciated for the spontaneity of the two scientists, the educational value of the scientific information presented, and the

effective connection between the interview content and the visual material collected during fieldwork activities and microscope observations.

The Reading the Sample video also received positive feedback. While it did not generate particularly strong reactions among the visitors I spoke with, it was generally perceived as engaging and refreshing. Although no visitor remained for the entire duration of the recording, both audiovisual pieces were viewed, at least partially, by the majority of attendees.

The main installation, presenting an early but functional version of the Real Time Plankton Bridge with the organisms of Lake Greifensee, attracted by far the greatest amount of attention. The immersive atmosphere generated through the combination of soundscape, underwater projections, and plankton visualisations played a significant role in this outcome. At the centre of the installation, the animated planktonic organisms and the accompanying haptic glove stimulated considerable curiosity and a strong willingness to engage directly with the experience.

Even visitors who chose not to interact physically with the installation often remained for extended periods observing the movement of the organisms. The unpredictability of the plankton appearances and the awareness that the data originated in almost real time from the lake, encouraged forms of patient and contemplative observation. In several cases, visitors waited for minutes before new organisms appeared, motivated by curiosity about what unexpected forms of life might emerge next.

The aesthetic and representational qualities of the visualisation played a key role in fostering this engagement. Notably, an experienced plankton researcher expressed surprise at the accuracy of the visual representations, initially assuming that the display consisted of authentic live microscopic footage rather than illustrated visualisations.

The hand-tracking system and haptic glove attracted numerous visitors interested in directly experiencing inte-

reaction with the represented organisms. Both the haptic feedback and the ability to influence plankton behaviour through hand movements contributed to generate a strong sense of connection with the visualised ecosystem.

Interestingly, these results were achieved despite several technical limitations. The positioning of the hand-tracking sensor did not facilitate intuitive interaction and occasionally made the effects difficult to perceive. Nevertheless, many participants spent several minutes experimenting with the interface, attempting to influence water flows and keep organisms visible in order to prolong the interaction.

The still-fragile construction of the haptic glove and its Arduino connections resulted in several failures by the second day of the exhibition, highlighting the need for a considerably more robust technical implementation. At the same time, this limitation provided an opportunity to observe different behavioural approaches among participants. Some visitors handled the device with great caution, performing slow and delicate movements that generated subtle effects within the simulation. Others, driven by enthusiasm and curiosity, interacted much more energetically and frequently pushed the system beyond its intended physical limits.

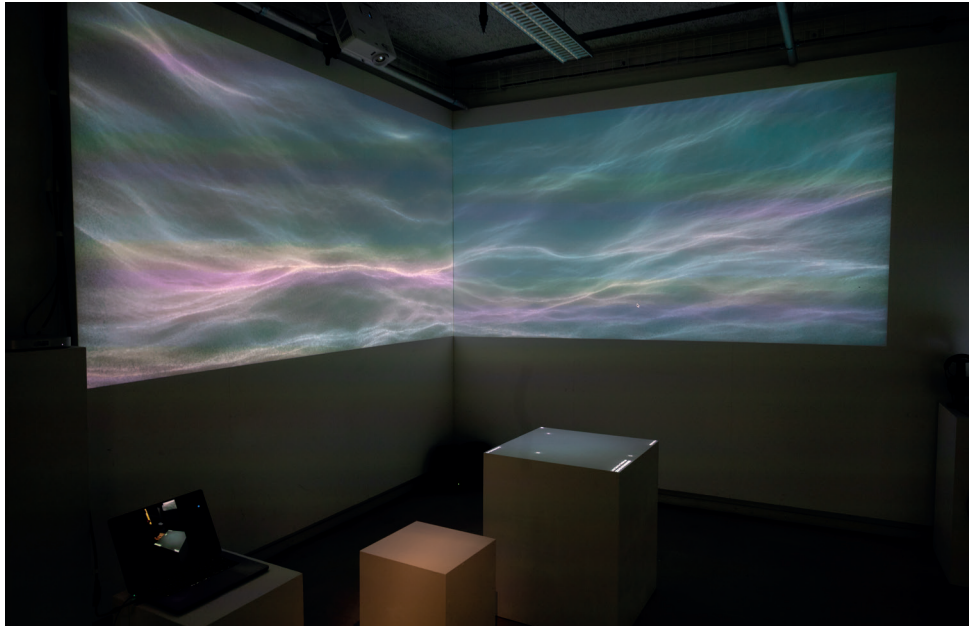
More broadly, the installation revealed the need for improved contextualisation and instructional support. Several visitors initially expressed uncertainty regarding what the installation represented and how they were expected to interact with it. Future iterations would therefore need to incorporate clearer explanatory and instructional elements capable of introducing the experience and guiding participants through its use.

Overall, the conclusion of the second prototyping phase proved highly productive, both in terms of validating the project's underlying assumptions and in generating constructive feedback. With only minor adjustments required, the two introductory videos appear largely complete. The feedback collected suggests that the mediation provided by the

two scientists effectively fosters forms of rational compassion toward plankton, preparing visitors for the central interactive experience.

The main installation already demonstrates promising results in terms of immersion and embodiment, although significant development remains necessary, particularly regarding technical robustness and system reliability.

An unexpectedly valuable outcome emerged from the feedback received from Marta and Stefanie throughout the process, and other scientists and researchers attending the exhibition. Their responses provided an important form of validation, suggesting that the installation may hold value not only for general audiences but also for experts within the field. Despite its speculative nature, the project offers researchers the opportunity to observe and engage with the subjects of their studies through perceptual and relational modes that differ from those typically available in scientific practice. This suggests the potential for the installation to function not only as a tool for public engagement and environmental awareness but also as a means of opening new interpretative perspectives within the scientific community itself.



[47] Exhibition setup
(29.4.2026)



[49] Exhibition with visitors
(Photo: Madeleine Hykes, 29.4.2026)



[48] Visitor interacting with the installation wearing the haptic glove
(Photo: Madeleine Hykes, 29.4.2026)



[50] Exhibition with visitors
(29.4.2026)

Final Outcomes

Following the two prototyping phases and the feedback collected throughout the exhibitions, the artefacts were refined through a final iteration, resulting in the outcomes presented in this chapter.

The following section introduces the final artefacts, describing their characteristics, modes of interaction, and intended contribution to the research. Supporting visual documentation is provided through images and videos accessible via the accompanying QR codes.

The artefacts build upon the theoretical foundations presented earlier. Central to the project is the recognition of the profound perceptual gap that separates human beings from planktonic microorganisms. Despite their continuous ecological interdependence, the vast differences in scale, sensory capabilities, and ways of experiencing the world make direct perception and understanding between the two forms of life extremely limited.

Within this context, water is considered both a material and conceptual medium capable of connecting bodies, environments, and living organisms. As the element shared by humans, plankton, and aquatic ecosystems, it provides the underlying framework through which new forms of relationship

and understanding can be explored.

Building upon this foundation, the project seeks to foster forms of rational compassion by combining emotional engagement with scientific knowledge and evidence-based understanding. Rather than relying solely on empathy, the artefacts aim to encourage informed and sustained concern for planktonic life and its ecological significance.

To support this objective, the final designs employ immersive and embodied forms of interaction. Beyond making planktonic life more accessible and perceptible, this strategy seeks to address the challenge of maintaining emotional engagement with large numbers of non-human organisms. By enabling visitors to engage with plankton through multiple sensory channels and direct forms of participation, the artefacts aim to counter tendencies towards compassion fade and foster more sustained forms of connection and care.

[2.8.1] Video Essay Current's Wanderers



With a final duration of 18 minutes and 18 seconds, the Video Essay serves as a key component of the communication pathway developed within this project. As evidenced by the feedback collected during previous iterations, the artefact plays a crucial role in introducing audiences to the topic of plankton and preparing them for the subsequent immersive and interactive experiences.

Through the communicative abilities of Marta Reyes and Stefanie Eyring, the video combines scientific knowledge, personal experiences, and reflections on their research practice, offering a perspective that helps audiences establish a closer relationship with planktonic organisms. In doing so, the artefact goes beyond the transmission of information, laying the groundwork for informed forms of emotional engagement consistent with the project's objective of fostering rational compassion towards these forms of life.

The narrative structure opens with an introductory sequence presenting the context of Lake Greifensee, the practice of microscopic observation, and the two scientists at the centre of the story.

The first chapter, *Why Plankton?*, introduces the ecological relevance and unique characteristics of planktonic micro-

[2.8.1] Final Outcomes: Video Essay *Current's Wanderers*

organisms while exploring the motivations that led the two scientists to dedicate their research to this field.

The second chapter, *Going to the Lake*, focuses on fieldwork activities, illustrating the work carried out at the monitoring station and highlighting the importance of directly experiencing the study environment in order to understand its complexity and constant transformations.

The third chapter, *The Laboratory*, examines the role of laboratory work and microscopic observation, emphasising not only their scientific value but also the perceptual and emotional dimensions that accompany the analytical process.

The fourth chapter, *The Real-Time Data*, addresses the collection of data through the underwater microscope, highlighting both the possibilities and limitations of the information obtained as well as the integration alongside multiple modes of observation in order to achieve a more comprehensive understanding of the ecosystem.

Finally, the fifth chapter, *Plankton's Importance*, presents the ecological significance of plankton and proposes practical actions that visitors can undertake to contribute to the protection of aquatic ecosystems, providing a sense of agency regarding an issue that is often perceived as distant and abstract.

Through this narrative structure, the video highlights the three interconnected dimensions that define the study of plankton in Lake Greifensee: the lake, the laboratory, and the data. Together, these elements provide a more comprehensive understanding of the scientific process and of the continuous exchange of knowledge that emerges through their interaction.

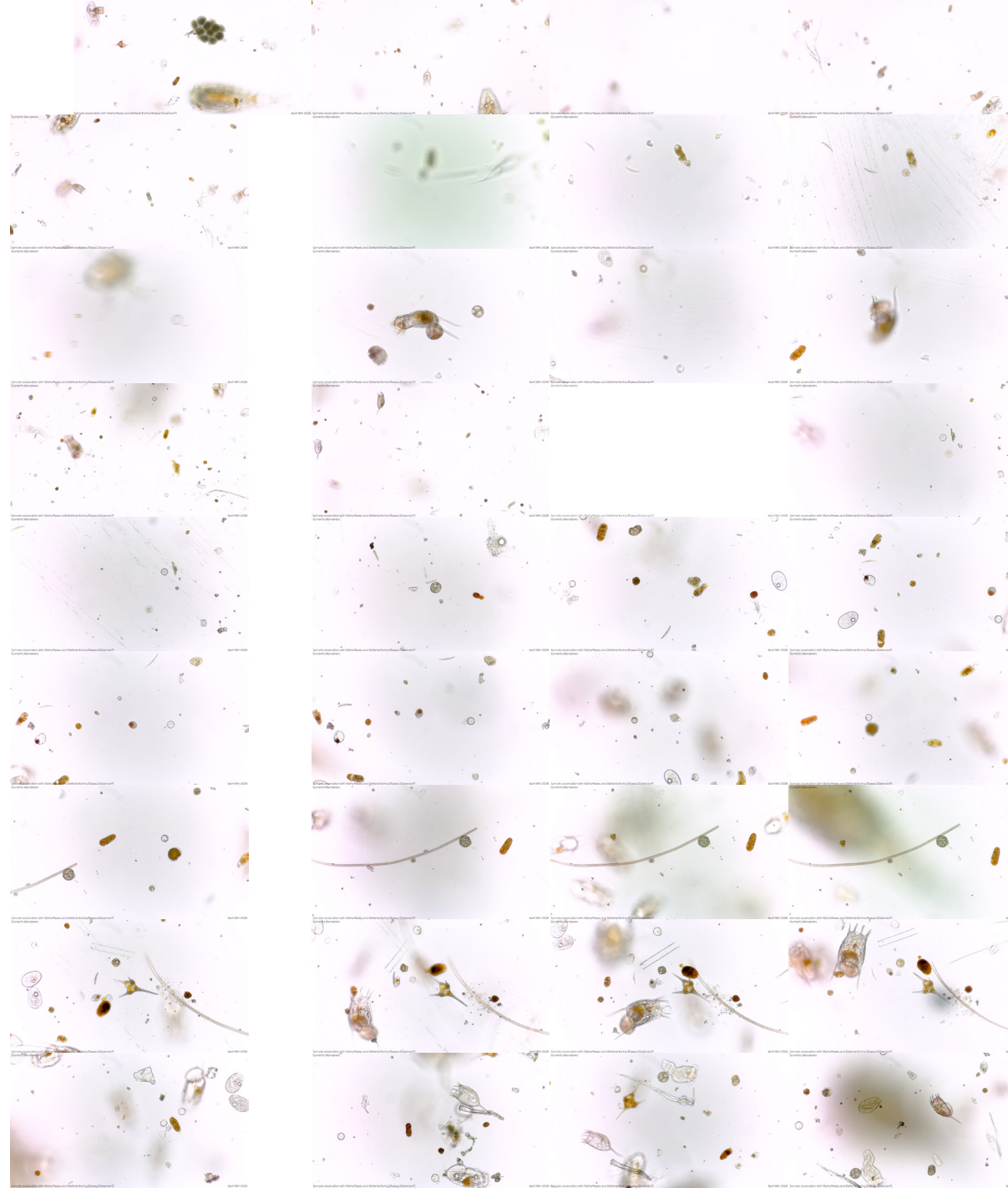
[2.8.2] Reading the Sample



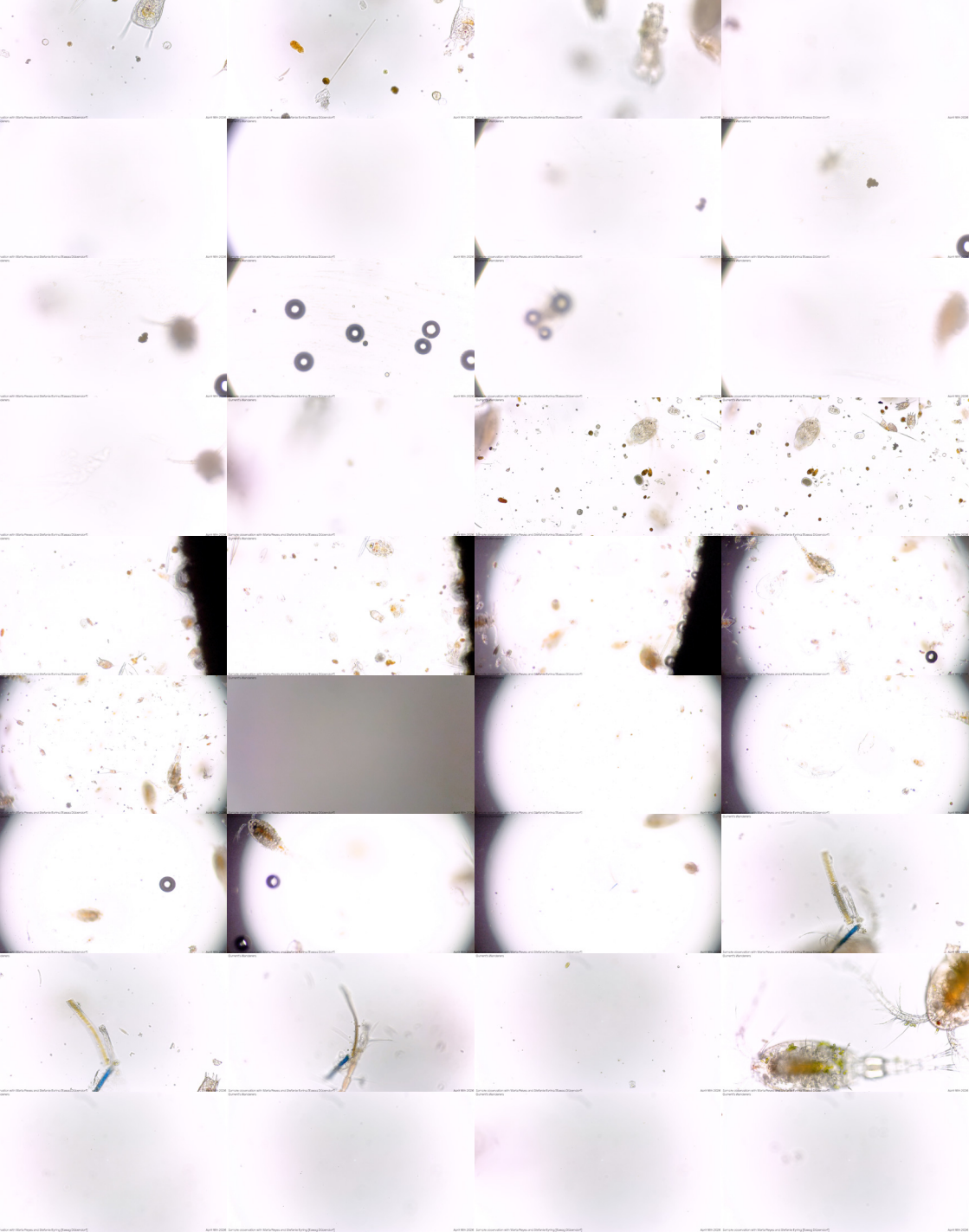
Serving as either a complementary or alternative entry point to the Video Essay, Reading the Sample pursues the same overarching objective while focusing specifically on the practice of microscopic observation. Throughout the research process, microscope analysis emerged as the scientific activity most capable of generating emotional engagement, both among the scientists themselves and among participants involved in the various user testing sessions.

Given the consistently positive responses received during previous exhibitions, and the demonstrated effectiveness of the format in communicating both scientific knowledge and emotional involvement, the decision was made to present the artefact in its existing form without substantial modifications.

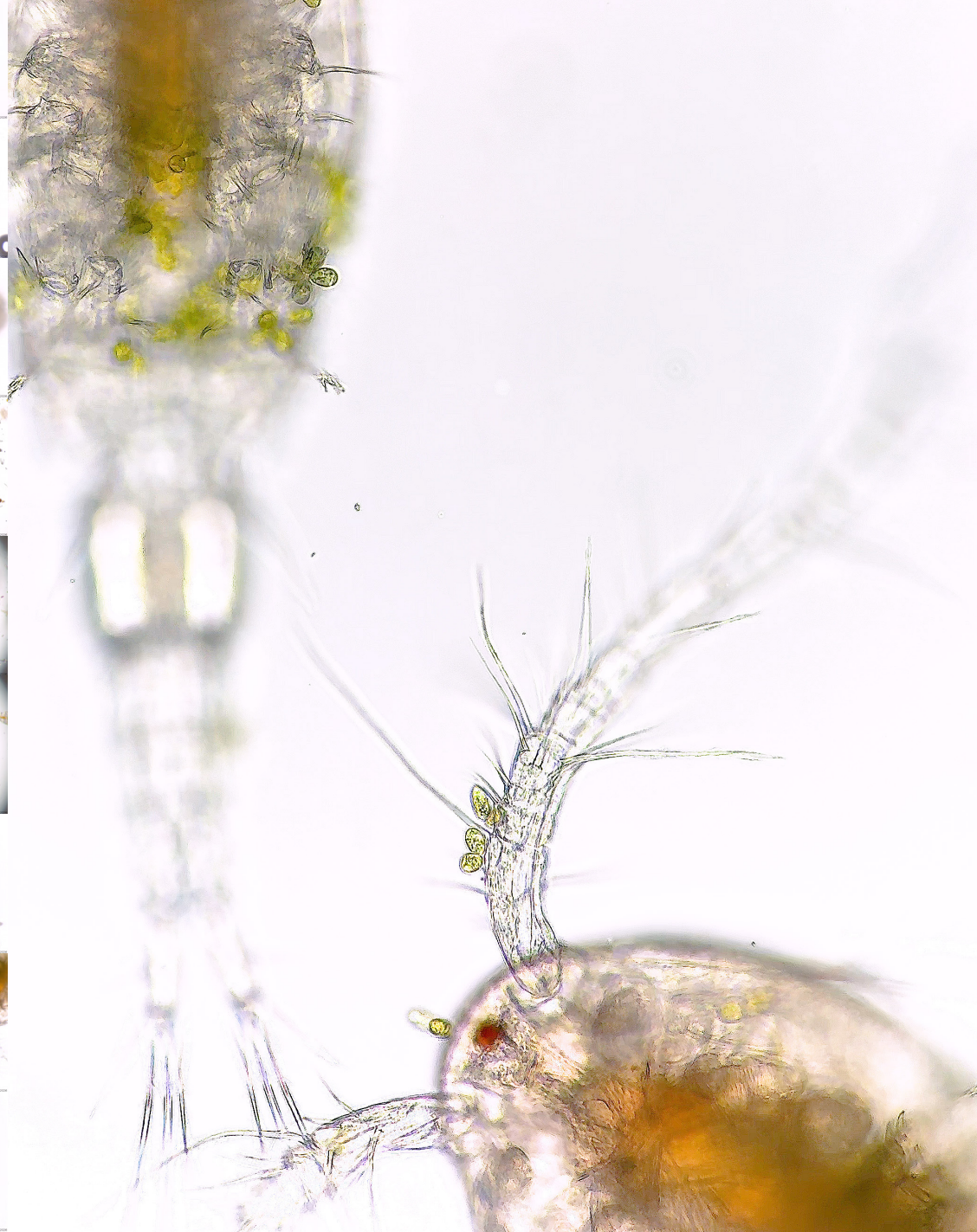
With a duration of 24 minutes and 9 seconds, the artefact consists of an audiovisual recording of a microscope observation session conducted on 16 April 2026 using a water sample collected from Lake Greifensee earlier that same day. The recording combines live microscope imagery with the spontaneous commentary, observations, and reactions of the scientists during the analysis, allowing visitors to experience both the scientific and affective dimensions of the practice.



[53] Stills from the Reading the Sample Video
(Date Undefined)



[54] Stills from the Reading the Sample Video
(Date Undefined)



[55] Stills from the Reading the Sample Video
(Date Undefined)





Building upon the highly positive reception of the second prototype iteration presented during the Hybrid Affections exhibition, the installation was further refined and developed into its final form.

Based on observations and feedback collected during user testing, the primary design objective was to improve the installation's structural robustness, usability, and overall sense of immersion. The resulting artefact takes the form of a $60 \times 60 \times 60$ cm cube representing the approximately one cubic centimetre volume of water continuously monitored by the underwater microscope installed in Lake Greifensee.

Drawing inspiration from scientific instruments and laboratory equipment, the installation was designed to resemble a research apparatus rather than a conventional media installation. This aesthetic choice seeks to communicate to visitors that they are not merely observers of scientific knowledge but active participants in both scientific observation and public engagement processes.

The structure consists of a framework made from 2×2 cm aluminium profiles, with side panels constructed from 4 mm frosted acrylic sheets and upper and lower surfaces made from painted MDF panels. Within the cube, the compu-

ter powering the installation, the hand-tracking sensor, LED lighting system, and electronic components remain concealed from view.

The upper surface, inspired by the interaction model of laboratory gloveboxes, features two circular openings connected to a pair of integrated haptic gloves extending into the interior of the structure. The idea of hiding the physical hands from the user's view stems from a desire to spark the imagination by transposing them onto a microscopic scale. A ceiling-mounted long-throw projector displays the visualisation directly onto the cube's upper surface, transforming it into the primary interaction area. Here, the user can see a digital representation of their hands, providing a visual reference for their movements and position.

To reinforce the immersive atmosphere, the installation is accompanied by the same environmental elements developed during the Hybrid Affections exhibition. Surrounding wall projections simulate the movement of the lake surface as viewed from below, creating the sensation of inhabiting an underwater environment, while a continuous aquatic soundscape reproduced through speakers further contributes to the immersive experience.

The haptic gloves were completely redesigned for the final version. Each glove integrates twelve vibration coin motors distributed across the fingers and palm, resulting in a total of twenty-four actuators. Particular attention was dedicated to improving the durability of the system and reducing the risk of technical failures during public interaction.

From a narrative perspective, the experience begins with an introductory interface displaying an animated body of water accompanied by contextual and instructional information. At the centre of the screen, visitors are informed that the cube represents one cubic centimetre of water from Lake Greifensee and that the lake itself consists of billions of such volumes. A one by one centimetre visual reference is displayed alongside this information to provide a tangible sense of scale.

Visitors are then invited to wear headphones and carefully insert their hands into the haptic gloves through the openings on the cube's surface. Once the system detects their presence, a transition sequence begins: the represented volume gradually scales up until the one-centimetre reference expands to occupy the entire projection area, visually transporting the user into the microscopic environment contained within the sampled volume of water.

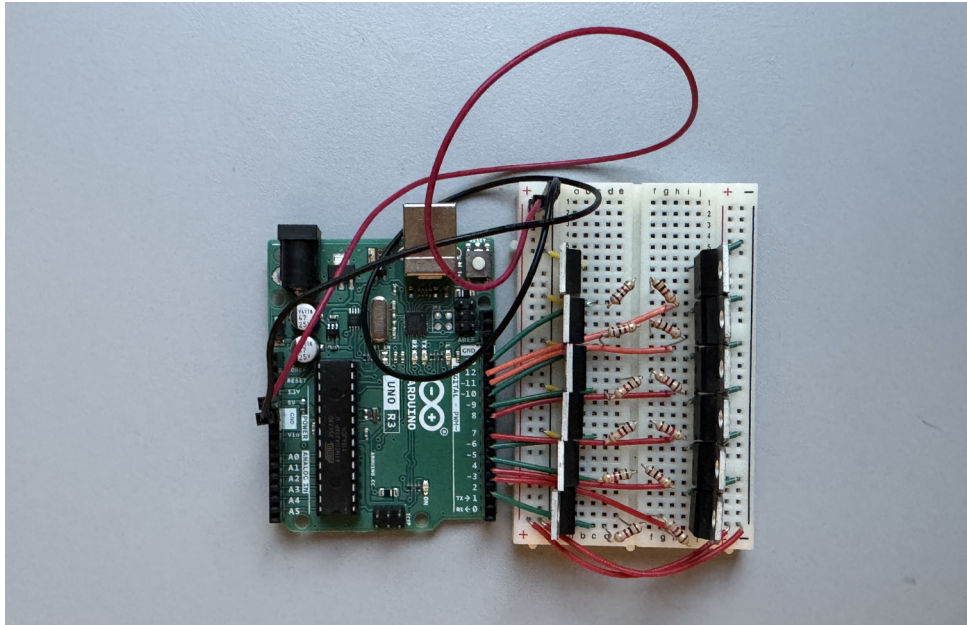
Simultaneously, the animated water background fades away and is replaced by the real-time visualisation connected to the underwater microscope. The visual language and interaction principles developed during the Hybrid Affections exhibition were largely maintained, with only minor refinements aimed at improving usability and amplifying the perceptual effects of hand movement.

As planktonic organisms enter the visualisation, visitors are provided with contextual information including the timestamp of the displayed data, the name of the observed organism, and additional dimensional references indicating its actual size. Through interaction with the fluid simulation and the haptic feedback system, users can influence the surrounding aquatic environment and establish a multisensory encounter with organisms that would otherwise remain inaccessible to direct human perception.

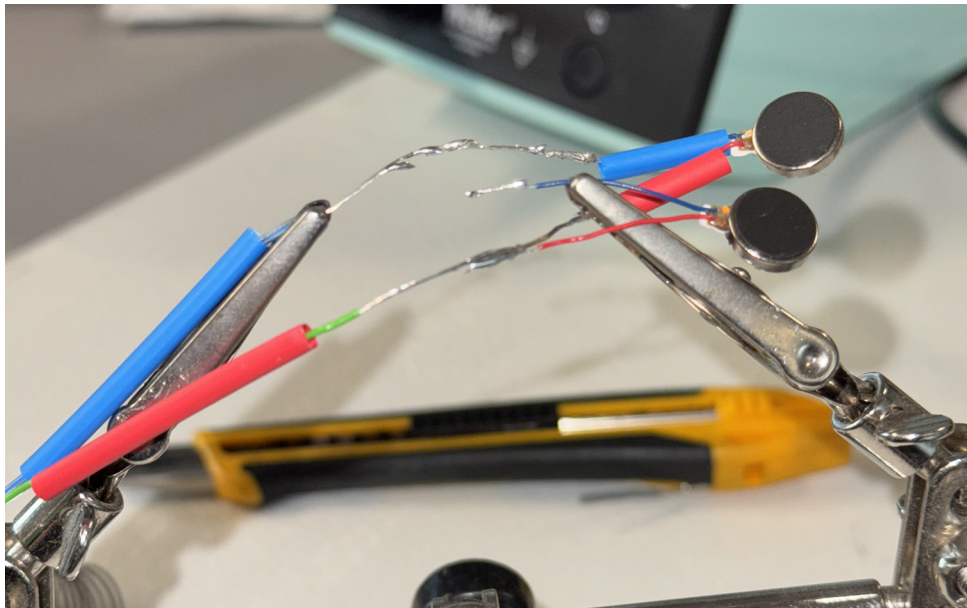
The installation functions as a bridge between two otherwise disconnected perceptual worlds: that of human visitors and that of planktonic microorganisms. By combining real-time ecological data, visual representation, sound, touch, and bodily interaction, it seeks to reduce the perceptual distance that normally separates humans from these microscopic forms of life.

The experience was intentionally designed as an immersive and strongly embodied encounter. Through the simultaneous stimulation of multiple sensory channels, including vision, hearing, touch, movement, and spatial presence, the installation encourages visitors to engage with plankton beyond

purely cognitive understanding. This multisensory approach aims not only to make the organisms more perceptible and relatable, but also to support more sustained forms of emotional engagement. By fostering a direct sense of connection with a multitude of planktonic organisms, the installation seeks to counteract the tendency towards compassion fade and promote forms of rational compassion grounded in both scientific understanding, emotional connection and embodied experience.



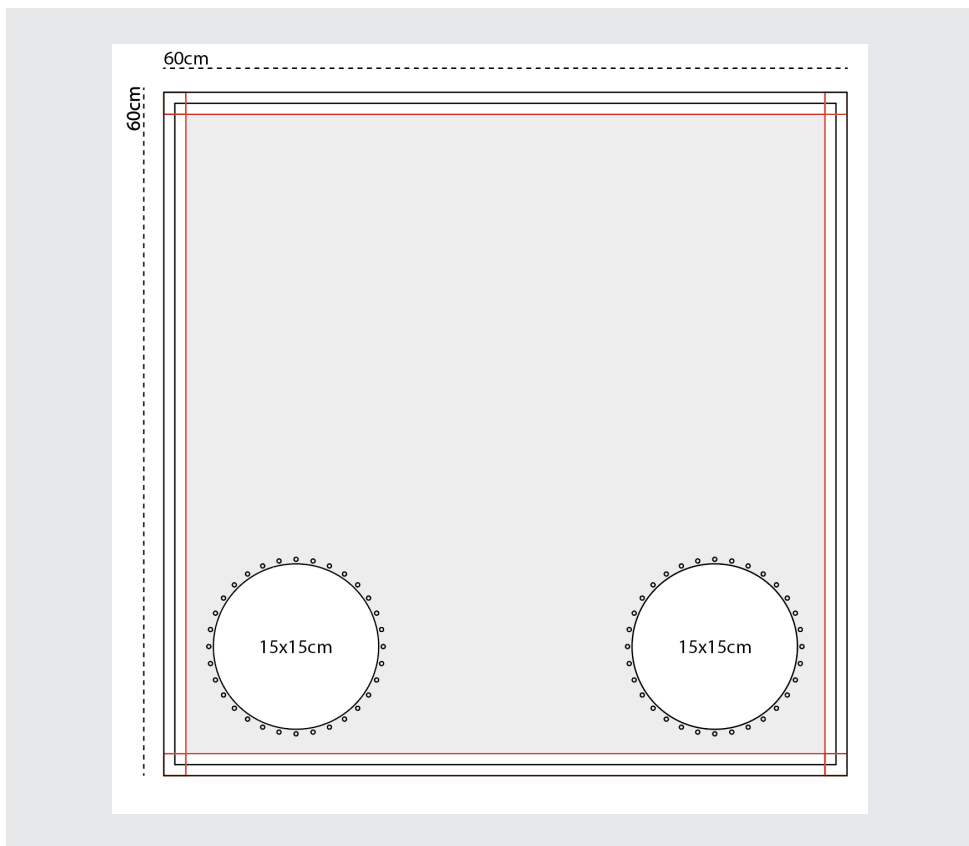
[57] Arduino with breadboard for the glove connection
(May 2026)



[58] Soldered coin motors
(May 2026)



[59] Haptic Gloves prototype
(May 2026)

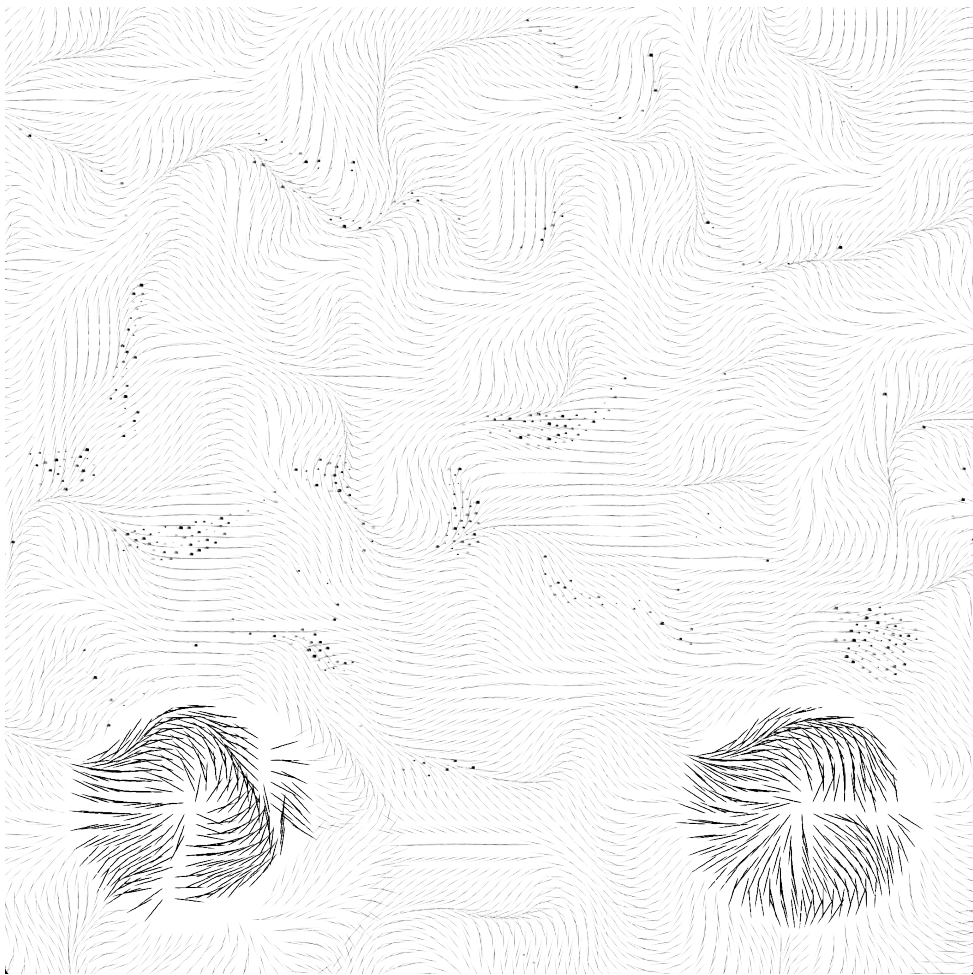


[60] Sketch for installation's upper surface
(May 2026)

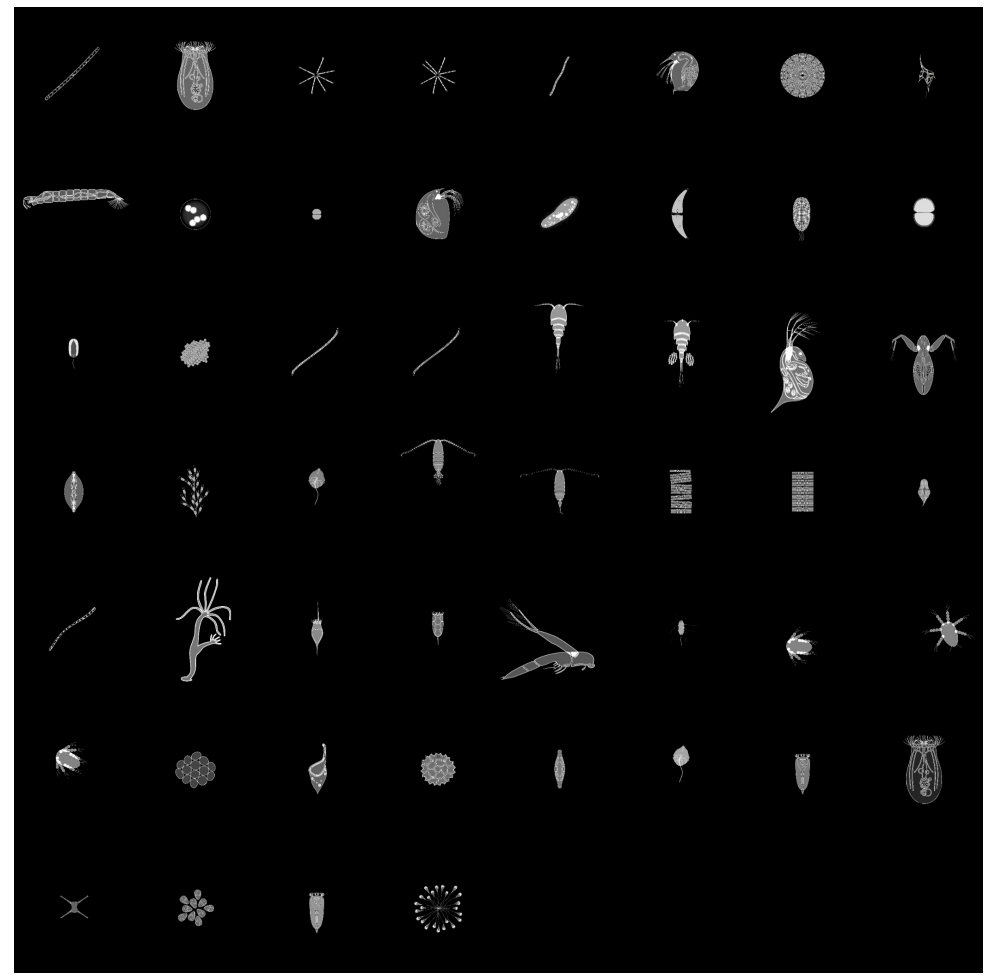


[61] Installation prototype
(May 2026)

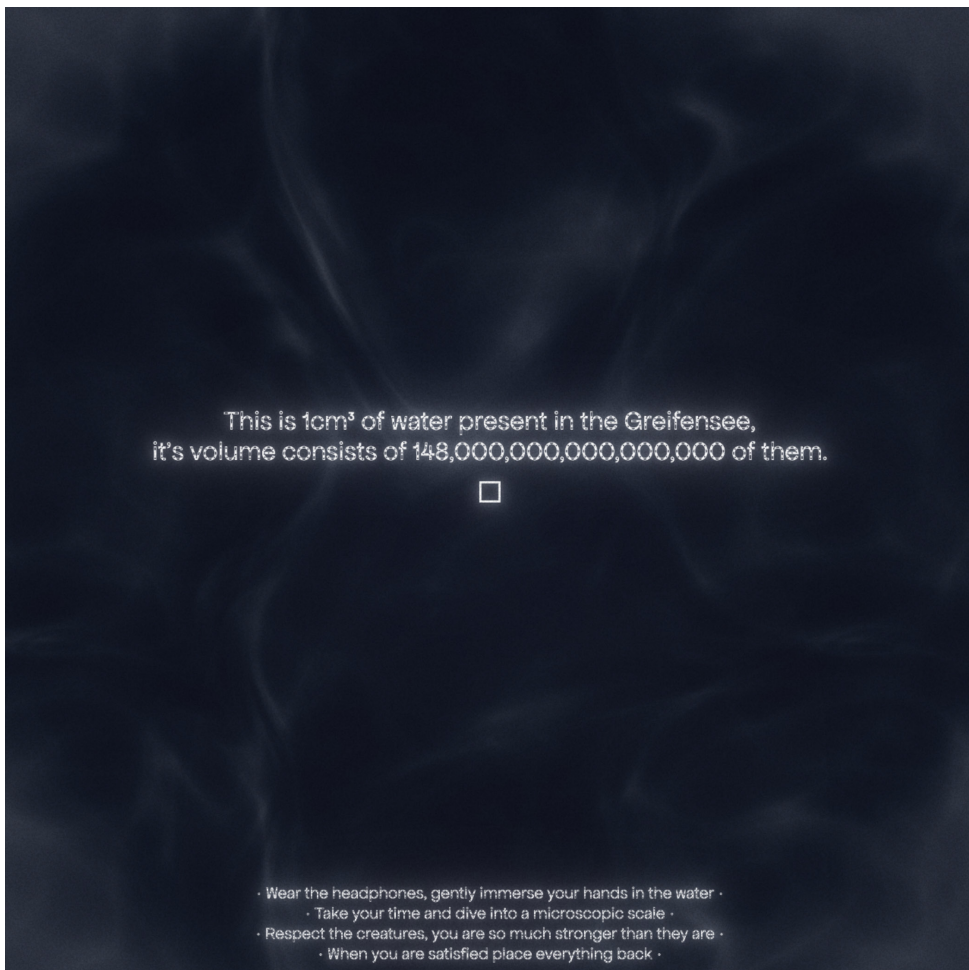




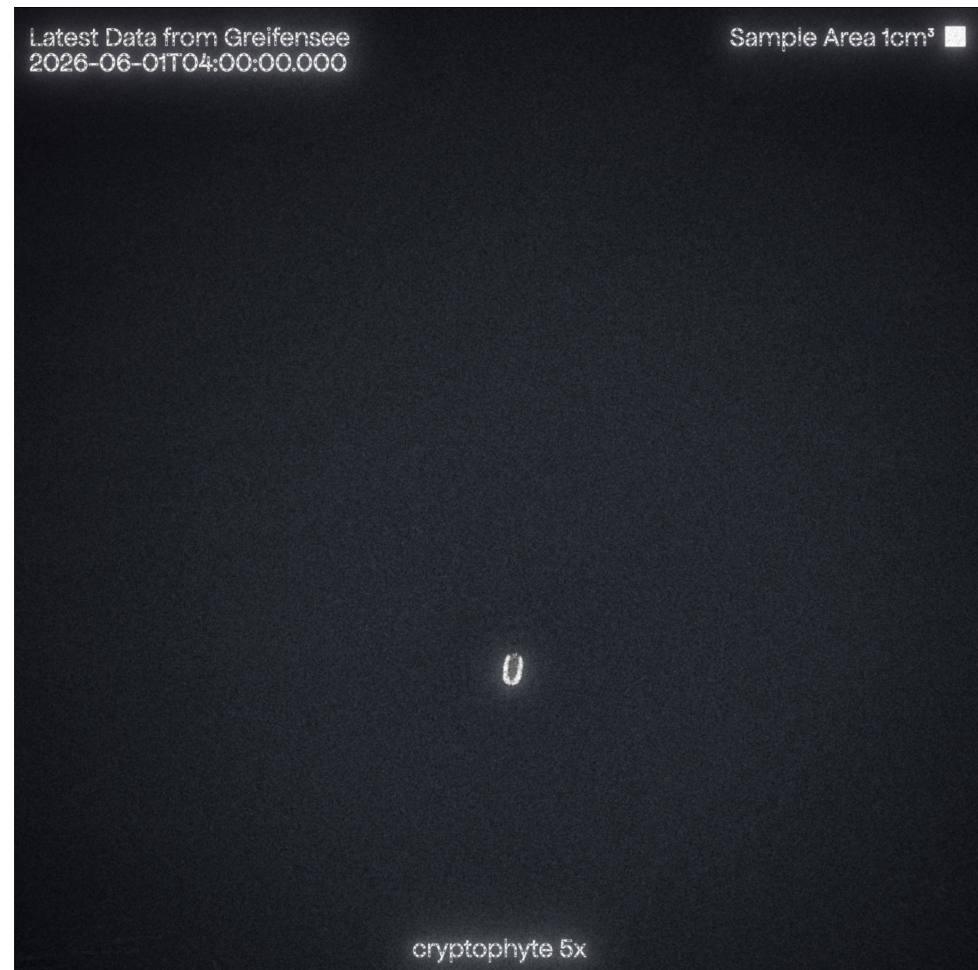
[63] Vector field for fluid simulator
(May 2026)



[64] Plankton illustration
(May 2026)



[65] Visualisation displayed before the interaction
(May 2026)



[66] Visualisation displayed during the interaction
(May 2026)

Findings and Conclusions

The relationship between human beings and planktonic life remains a largely unexplored field, offering numerous opportunities for future developments and alternative approaches. Based on the findings of this research project, the following conclusions summarise both the outcomes achieved and the insights that emerged throughout the process.

Beginning with the theoretical research phase, and motivated by the intention of reducing the profound differences in the ways humans and plankton perceive the world, a communication model was developed by drawing upon multiple strands of existing literature. While applied here to the specific case of planktonic microorganisms, the framework could potentially be adapted to address other ecological issues characterised by significant perceptual, cognitive, or experiential gaps, particularly when involving large numbers of non-human entities.

At the foundation of this model lies water and its potential to function as both a material and conceptual connector between human beings, nature, and other forms of life. Such connections can support environmental awareness through feelings of empathy and compassion. However, for these feelings to endure over time and avoid becoming fragile, superficial,

or ephemeral, they require the support of objective knowledge and reliable sources, fostering more stable forms of rational compassion. Furthermore, when engagement involves large numbers of entities, immersive experiences characterised by strong embodiment become particularly important in mitigating the effects of compassion fade. Throughout this project, these principles informed the design and development process and proved effective for the target audience involved in the various testing phases.

More specifically, the two audiovisual artefacts, Current's Wanderers Video Essay and Reading the Sample, demonstrated the value of combining scientific communication with personal narratives. Through the participation of Marta Reyes and Stefanie Eyring, both artefacts effectively communicate fundamental scientific knowledge about planktonic organisms while simultaneously establishing an emotional connection grounded in the scientists' long-term relationship with the organisms they study.

Current's Wanderers Video Essay highlights the interdependence of the three key dimensions that characterise plankton research within the Aquascope group: the lake as a living ecosystem, the laboratory as a site of observation and interpretation, and the data generated through monitoring technologies. Reading the Sample, by contrast, focuses on the laboratory practice that emerged as the most emotionally engaging and communicatively effective throughout the research process. The observation sessions revealed how scientific analysis is often accompanied by wonder, curiosity, surprise, and affection towards the organisms being studied. Through their transparency, enthusiasm, and scientific expertise, Marta and Stefanie act as scientific-emotional mediators, enabling audiences to perceive plankton not as an abstract ecological category but as diverse living organisms characterised by distinct behaviours, forms, and ecological roles.

The main installation, Real Time Plankton Bridge, completes the communication model by transforming these in-

sights into a multisensory experience. While drawing upon elements introduced through the audiovisual artefacts, it creates space for visitors to develop their own relationship with planktonic life through direct interaction and embodied engagement.

The installation successfully integrates the three dimensions identified as central to plankton research. The lake is represented through the immersive underwater projections and soundscape, while the laboratory and data dimensions are translated through a near real-time visualisation of plankton activity inspired by microscopic observation practices and embedded within a laboratory-inspired physical structure. By combining visual, auditory, haptic, kinaesthetic, and spatial forms of stimulation, the installation creates an immersive and strongly embodied experience that, according to the user testing sessions, appears capable of mitigating the effects of compassion fade. This outcome seems to be reinforced by two additional factors: the geographical proximity of the represented ecosystem, which allows visitors to relate the experience to a familiar place, and the real-time nature of the data, whose unpredictability, dynamism, and authenticity encourage sustained attention and curiosity.

An additional finding emerged from the multisensory nature of the installation. While the visualisation and soundscape proved essential in contextualising the experience and communicating the dynamics of the planktonic ecosystem, the haptic component consistently generated the strongest reactions among participants.

This response may be explained by the relative unfamiliarity of tactile interaction within environmental communication experiences. Whereas visitors could easily anticipate seeing or hearing representations of plankton, the possibility of physically feeling contact with microscopic forms of life was often perceived as unexpected and, at times, difficult to imagine before experiencing it firsthand. The haptic feedback therefore contributed not only to the immersive qualities of the in-

stallation but also to making the existence of these otherwise inaccessible organisms more tangible and immediate.

This suggests that touch may hold particular potential as a medium for bridging perceptual distance between humans and microscopic life forms. By transforming an abstract ecological relationship into a bodily experience, the tactile dimension appeared to strengthen participants' sense of presence, connection, and engagement with the organisms represented within the installation.

Beyond validating the proposed communication model, the project also generated several unexpected insights. One of the most significant findings concerns the role of scientists as mediators between society and ecological phenomena. Rather than functioning solely as providers of expert knowledge, the scientists involved demonstrated how personal experiences, emotions, and forms of care can become powerful tools for communicating complex environmental issues without compromising scientific rigour.

A second insight emerged from the observation of laboratory practices. Contrary to common representations of science as detached and purely objective, microscope observation revealed itself to be a deeply affective activity, characterised by moments of surprise, fascination, and emotional investment. This suggests that the emotional dimensions of scientific practice may represent an explorable resource for environmental communication and public engagement.

Finally, the project revealed that the proposed artefacts may hold value not only for general audiences but also for researchers themselves. Feedback from scientists attending the exhibitions suggested that the installation offered new ways of perceiving and engaging with the organisms they study, opening alternative perspectives on familiar research subjects. While speculative in nature, the project therefore demonstrates the potential of design not only to mediate scientific knowledge for broader audiences, but also to create novel forms of reflection and understanding within

scientific communities themselves.

The research also addressed ethical questions arising at the intersection of science, society, and planktonic microorganisms. Rather than advocating for identical forms of ethical consideration across all living beings, the research supports a position of measured and systemic ethical responsibility. From this perspective, microorganisms should not necessarily be approached as individual entities requiring the same forms of care attributed to larger organisms, but rather as living communities and ecological systems whose wellbeing is fundamental to the functioning of broader ecosystems. The goal is therefore not individual-level equality among all forms of life, but the cultivation of greater awareness, respect, and responsibility towards the ecological networks upon which both human and non-human life depend.

Ultimately, this research does not seek to eliminate the perceptual distance separating humans from plankton. Rather, it suggests that through scientific mediation, immersive interaction, and embodied experience, it is possible to build meaningful bridges across that distance, fostering more informed, sustained, and caring relationships with forms of life that remain largely invisible, yet are fundamental to the ecological systems upon which we depend.

Future Developments

Several opportunities for future development emerged throughout the research process.

The first concerns the further refinement of the haptic interaction system. While the haptic gloves proved highly effective in creating a sense of connection with planktonic life, the exhibitions and testing sessions also revealed limitations related to durability, ergonomics, and the precision of tactile feedback. Future iterations could focus on developing a more robust and comfortable wearable system capable of delivering increasingly nuanced sensory stimulation. Such improvements would not only enhance usability but could also strengthen the perception of physical contact with microscopic organisms, further reducing the perceptual distance between humans and plankton.

A second area for future research, concerns the long-term impact of the proposed communication model. The current project primarily evaluated immediate reactions and experiences during exhibitions and testing sessions. Future studies could investigate whether the combination of scientific mediation, rational compassion, and immersive embodied interaction produces lasting effects on visitors' perceptions, attitudes, and behaviours towards aquatic ecosystems and

environmental conservation.

Finally, the project presents opportunities for implementation beyond exhibition contexts. One possible development would involve installing the experience in situ near Lake Greifensee, allowing local residents and visitors to establish a more direct relationship with the ecological activity taking place within the lake. By connecting real-time plankton dynamics to a familiar and geographically proximate environment, the installation could further strengthen place-based forms of environmental awareness and engagement.

A parallel implementation within the Eawag research facilities could also provide valuable insights. While the project was primarily conceived for public audiences, feedback from scientists suggested that the installation may also offer novel ways of perceiving and engaging with familiar research subjects. Future investigations could therefore explore how immersive and embodied representations of ecological data influence the perspectives and practices of researchers themselves, extending the project's contribution beyond science communication into scientific reflection and knowledge production.

Glossary

All definitions provided below are taken in their entirety from Dictionary.com.

Autotroph

Any organism capable of self-nourishment by using inorganic materials as a source of nutrients and using photosynthesis or chemosynthesis as a source of energy, as most plants and certain bacteria and protists.

Biogeochemical Cycles

The flow of chemical elements and compounds between living organisms and the physical environment. Chemicals absorbed or ingested by organisms are passed through the food chain and returned to the soil, air, and water by such mechanisms as respiration, excretion, and decomposition. As an element moves through this cycle, it often forms compounds with other elements as a result of metabolic processes in living tissues and of natural reactions in the atmosphere, hydrosphere, or lithosphere.

Deep Learning

An advanced type of machine learning that uses multilayered neural networks to establish nested hierarchical models for data processing and analysis, as in image recognition or natural language processing, with the goal of self-directed information processing.

Eutrophication

A process by which pollution from such sources as sewage effluent or leachate from fertilized fields causes a lake, pond, or fen to become overrich in organic and mineral nutrients, so that algae and cyanobacteria grow rapidly and deplete the oxygen supply.

Cytometry

The counting and measuring of cells, especially the counting and analysis of cell size, morphology, and other characteristics, traditionally performed using a standardized glass slide or small glass chamber of known volume.

Heterotroph

An organism requiring organic compounds for its principal source of food.

Mixotroph

Any organism capable of existing as either an autotroph or heterotroph.

Phylogeny

The development or evolution of a particular group of organisms.

Taxonomy

In biology, the science dealing with the description, identification, naming, and classification of organisms.

[6] Timeline

4.3.2025
First Meeting with Eawag Researchers
First Visit at Eawag Research Center

6.3.2025
Sampling at Greifensee Part 1
First Visit at Aquascope Laboratory

7.3.2025
Microscope Observation Part 1

6.3.2025 – 16.9.2025
Initial concept development

16.9.2025 - 1.12.2025
First Prototype Iteration

24.11.2025
Interview with Marta Reyes and Stefanie Eyring

26.11.2025
Limmat Sampling

[6] Timeline

26.11.2025 – 27.11.2025
Work in Progress Exhibition

27.11.2025 – 29.4.2026
Second Prototype Iteration

17.12.2025
Sampling at Greifensee Part 2

16.4.2026
Microscope Observation Part 2

29.4.2026 – 6.5.2026
Hybrid Affections Exhibitions

7.5.2026 – 11.6.2026
Project Finalization

11.6.2026 – 27.6.2026
Final Exhibition

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[8]

Appendix

INTERVIEW WITH MARTA REYES AND STEFANIE EYRING
[Eawag, November 24th, 2025]

Massimo

To start I'll ask you to present yourself by saying what's your job and what do you do here.

Marta

My name is Marta Reyes. I work as a research technician at the Department of Aquatic Ecology. I'm a biologist, environmental scientist by training, and I am a plankton lover. I've been working here for 15 years. I do a lot of field work, some lab work, and some research on top of that.

Stefanie

I'm Steffi. I am also an ecologist. I studied at the University of Zurich. I did my master's with Francesco and Marta and then that's where I got in love with plankton and the group. So I've been at Eawag as a research assistant for four years now. And then now, since May, I also work for the canton of Bern in the Water Protection Agency, also broadening my perspective in

other aquatic things as well, not just plankton.

Massimo

And why Plankton? Why did you decide to dedicate a lot of time of your life to these organisms?

Marta and Stefanie

Why not, no? Why not, exactly.

Marta

I actually started working at Eawag working with fish. Then I moved to micro invertebrates, and for the last 9-10 years, I've been working on plankton and there's no reason to stop focusing on plankton.

Massimo

And what are the reasons to keep going? There must be something that pushes you a little bit.

Marta

Their importance, their beauty.

Stefanie

Their beauty, their diversity, how interesting the crazy dynamics they have. They're so unpredictable. You will never stop studying them, ever. They're fascinating and they're so diverse and dynamic that you'll always find another question to ask.

Marta

Their geometry, the beautiful colonies they can build.

Stefanie

Shapes, colours, sizes, movements, ...

Massimo

Going beyond the classic definition, based on your daily

experiences, what is a plankton for you?

Marta

Phytoplankton. Let's start with phytoplankton. Phytoplankton are the creatures that are capable of producing oxygen so that we can actually breathe. For me, that's one of the main forces of these creatures.

Stefanie

Yeah. It's a very scientific definition, I think. It's like, they are what they are. And they're just fascinating of what they are. I think it starts being interesting when we have debates of like what group to put things in. So I'd be like, oh, I see cyanobacteria. They're technically bacteria, but they're also kind of phytoplankton, or some people call them algae and then you start debating of like technicalities. I think that's when it starts being interesting and very emotional as well. But they are like this, or like a thing that is in theory a phytoplankton, but then it doesn't produce oxygen and it doesn't do photosynthesis, but it only eats. How can it be a plant? So, super interesting.

Marta

And if it can do both, mixotrophs? Still a plankton.

Massimo

Do you consider them a little bit like co-workers?

Marta

Well, at least during experimental times they are co-workers. They decide if they want to crash and stop growing or not. No, I still think we do still look at them through the microscope with some kind of perspective of us observing them. I don't feel observed by them, but we do observe them.

Massimo

Do you have to deal, for example, with their needs "personalities" so to say?

Marta

Yeah, light and nutrients and temperature. I mean, in the lab we do need to deal with their needs totally.

Stefanie

When you culture them they're your babies. So you have to make sure that they grow, that they're happy, that they are good and it's really frustrating when you just want to grow something and it doesn't grow. You can also hold them as a pet, like daphnias you can keep them in a jar as your pet at home like in an aquarium, it's a great pet.

Marta

They need less love than a dog or a cat.

Massimo

Do they communicate to you in a certain way?

Marta

I would say on a binary way, like dying or growing. That's the best way they can communicate.

Massimo

What's the one thing about plankton that blows your mind?

Marta

I can think of many things. I mean, for me, it's fascinating cyanobacteria that without any flagella, or any arms like animals, like such a simple organism can move through the water column up and down just by like getting some gas in their gas back walls to get the light, for example. Another fascinating thing might be the beautiful colonies that they

build, the geometry is fantastic, it's perfect.

Stefanie

I think that's also like when you start learning about them, you have an identification course and you're like, oh, all of that is down there in the water?! Like you had no idea. And I think that's the first connection point you get to plankton or like at least phytoplankton and zooplankton. It's like, you see them and you're like, all of that is in there. So I think that's the first fascination, just the shape and the colours. They all come in, there's all kinds of greens. You learn about green, blue, green, yellow green, crayon green, ... So you even start distinguishing greens and that they come in so many colours and shapes and everything. And then their ecology and what they mean to the ecosystem, I think that comes second when you like, like learn about them when it's more like an entire thing, but less abstract.

Massimo

It's like when you know a person, you know, they're single traits, they're single characteristic and abilities; then the connection between you and them grows a little bit more deep.

Stefanie

The longer you're in, the more emotional you are to them, for sure.

Marta

I think another thing that I find fascinating is when, cyanobacteria build these akinetes, because the conditions are not appropriate for them to live in the lake, and they decide to release these cells that are like resting stages and they just go to the sediment and wait for better moments.

Stefanie

And they just know when the better moment is.

Marta

Yeah, when the conditions are appropriate and they can grow again.

Stefanie

They live in the first 5, 8 meters of the water column and then they might be at 30, 40, 50, 100 meters depth just resting and then they know when time is right up there. It's incredible!

Massimo

We talked about the characteristics that you find incredible. Is there a moment during your daily practices, when you observe them for example, in which you feel closer to them?

Marta

When watching them under the microscope on Thursdays afternoon.

Stefanie

Or watching them on the live updates, the images on the website. A lot of times I do a lot of data management. So they're just numbers. So it's like, it's a bit more abstract, you're a bit more distant from them. But when you sort images, for example, where you will look at what's right now in the lake, or when we once a week look at the actual samples under the microscope.

Marta

Living samples and then we see how they try to eat things that are like three times bigger than theirs.

Stefanie

Then it's for sure that the spark of love that comes back and it's less abstract again.

Massimo

So basically it's when you see them?

Stefanie

Yes. Because we can't hear them, we can't smell them or touch them.

Massimo

How different is it for you looking at the sample under a microscope and receiving the data from the underwater microscope? What's the difference in feelings for you?

Stefanie

Under the microscope, it's much more dynamic because they're alive. So they swim around, they all have different like, one that is like, flops around, the other one swirls around, the third one, the other one just like, whirs around, the other one stays there. And then the images, it's like, it's a momentary, like, imagine about snap shots or so. So it's obviously more exciting when you see things alive.

Massimo

Does it make a difference when you're in the same room with them or not really?

Stefanie

I don't think so.

Massimo

If the underwater microscope could stream you videos and not just images, would it then be kind of the same?

Marta

I think it is a different feeling like having the living sample under the microscope and watching it than if just our camera would just send us the videos from the platform, because there's still some distance. Well, yeah, I thought first I would answer no when you asked if being in the same room makes a difference, but actually you know you're moving the chamber as you want, and you're focusing as well on what you want to follow, maybe there is a tiny difference. Yes.

Stefanie

I think it's also the object, the way they look under the microscope in the lab, you have much more depth. Things become 3D and the colours are much more intense than from the images from the dark field microscopy. And you can see many more details. You can start seeing the flagella. So I think that makes a difference too, not necessarily that they're in the same room, but the depth of detail you gain.

Massimo

Let's move a little bit away from the lab and images, let's try to simulate we're going on a field work on the boat and we're going to the station at the lake. How does that moment make you feel when you're leaving the lab and going to the field?

Stefanie

Best part of the week.

Marta

Yeah it's a highlight.

Stefanie

It's fun, you can air your brain out, you're just like out there you feel free, it's fun, you're less stuck in the computer.

Marta

And then we only don't see the data from the sensors and the camera, but we actually are in there. No, I do think it's much different. It's a fantastic moment of the day.

Stefanie

You learn about the environment that you study. So what does the lake look like today? How did it look last week? What's the weather like? How does all this dynamics and the entire ecosystem, not just like the data that we collect, but also the lake itself, how does that change and how does that vary? I think it's part of what makes us a valuable member of the team, that we understand the system. Because you've been out there so much, and we're like, oh yeah. Then we have this, and then maybe it was more warmer, and then we can see the difference, like we can see the difference in transparency. That gives you more insight as well to the overall picture, I think.

Marta

Totally. And I also like, even if we go every week, every day is different. I mean, one day is sunny, the other not. One day the lake is transparent, the other one is rain. Or it's foggy, and you don't find a platform.

Massimo

Yeah, it's not always the same. For example, I remember when we went in march and you saw those cyanobacteria and it was not normal, you wouldn't have known unless you would go there, I think.

Marta

Totally

Stefanie

Absolutely, yeah.

Massimo

About the practices and the actions you do when you're at the lake, what's your favourite one?

Marta

I think either taking the sample of phytoplankton because we know that we're going to spend some minutes with that sample under the microscope a couple of hours later.

Stefanie

You see them swim around in the bottle. So you see it's like, oh, you collected a shit.

Marta

And there's going to be things to watch under the microscope.

Stefanie

And you can see them swim around in the bottle, the little zooplankton. So I think that's fun.

Marta

Maybe taking care of the camera and cleaning the ports is a way to appreciate, be thankful to the camera. Keep doing your work, I'll clean you. It's another moment.

Massimo

It has a name as well, right?

Stefanie

Oh yeah, it's called Ariel.

Massimo

You answered already a bit but why do you think it's important for you to go on the field and not just stay in the lab?

Marta

To understand how things are. First, the limitations of each system, the limitations of the data set we could have, to also experience how the lake can change so much within a day, even just it rained a lot yesterday and then it's totally different today and then you can really see it.

Stefanie

Otherwise, the things are just numbers. If they're just numbers, you don't really understand the depth of the thing. It's like the more you understand that, like how the samples are taken, like all the instruments, the lake, how the lake looks, how it changes. It gives you scientific background knowledge that you need to understand the results of your models. Otherwise, it's just numbers and anyone could do it. AI could do it. But we need the experience and the knowledge to interpret the results. And that gives you so much more know-how if you go there and understand what they actually mean.

Massimo

That, I think, can also be translated to when we work in the lab and you observe them under the microscope and you see stuff that you are not expecting or that you couldn't see from the data.

Marta

Totally! I mean, we also try to understand for example how this dinoflagellate is going to eat this huge diatom when I've never thought a small dinoflagellate could eat a diatom that is so big. But then when you see under the microscope that it's inside of the dinoflagellate, it's like, wow, that actually happens. It's a cool moment, actually.

Stefanie

Yeah, I think so, too.

Massimo

Let's move back to the lab. We said that the microscope is probably the moment in which you feel closer to them. I feel that this moment carries a lot of emotions, like excitement and surprise. Can you describe it a little bit?

Stefanie

Every week is different. Their dynamics change so much. You can have one species that dominates everything and the week later they're gone. And you're like, where did you go? So you have something new and you never know what to expect, but it's also just exciting to see the pretty things.

Marta

Yeah, I think it's exciting to see different species or things changing. Or our latest highlight is to look at the poo. So that we know what the zooplankton eat. Trying to identify things from the poo. It's so funny to me.

Massimo

How would you describe the change in your relationship with plankton when you started receiving data from the microscope?

Marta

It's much more connected. I mean, until we installed the camera, the connection to the lake and the phytoplankton was once a month, an if, once a month, because maybe you go to the lake and take the sample, but you don't ID it until who knows when. And now we can know every day what's in there if we want. So that's, I find that fantastic.

Stefanie

But not only us, everyone can check all the time. And it's also a great communicator to other people, people that di-

dn't know plankton exist in the freshwater systems and you're like, actually you can check it in Greifensee and they're like, no shit, what? So it's really cool that you can just convey that so easily and it's so much more graspable, the images and the live updates and it's like something close to your home then some latin or some report with some pictures and a list of taxa.

Massimo

What about the moment you in which you were training the model? How was the process?

Stefanie

Slow, tiring because some of the pictures get very small for blurring so it's a good distraction but it's also tiring when you have to annotate thousands and thousands of pictures and you don't have the details of a lab microscope, you just have one picture and that's it. And then you'll be like, I think you look like that. Sometimes we would look at the same picture and be like, I think if you close one eye, you might see that and be like, but do you see this? And I see that.

Massimo

How many pictures did you analyse?

Marta

For the training set, I remember, I don't know, around...

Stefanie

A thousand, maybe?

Marta

No, no, more. Many more. I mean, we have 80'000 for the Zoocam, right?

Stefanie (post interview)

We annotated roughly 75'000 images across the 2 magnifications (72'871) with a total of 125 categories.

Stefanie

I think you spent weeks in front of the computer. You have to change your computer to dark mode because the pictures are black and the contrast with the white background of the computer is too much. Your eyes just stop working. But it's worth it.

Massimo

How does it feel that underwater microscope is working based on what you did?

Marta

If it does errors, it's our fault. Oops. It's good.

Stefanie

It's fun.

Marta

I think we did a pretty good job.

Stefanie

I'd be proud of the work and also the thing that it's the best data set in the world.

Massimo

We kind of talked about three environments: the lab, the lake and the data is are kind of in between the two. How would you describe the different feelings that you feel between the three fields?

Marta

It feels different, but you need this balance and I think you

need the three of them. You actually need to go and take a sample, watch it on the microscope to make sure that what you're identifying is the right balance, the right thing. Things are sometimes a bit small and you are hoping that it's category X and checking that it's really that species. Then the microscope, it gives you the look.

Stefanie

For the scientific practice, I think together they form like a perfect triangle, you need each of them. But I think emotionally, the lab obviously is the most fun. I think the computer and the data work is the most abstract, the most methodological one. Cause they're just numbers, you do some coding, you get more numbers and then you can make colourful graphs, but, yeah. Sometimes you run out of colors. And then I think the fields, they get good balance between the two of them. Connect the two.

Massimo

And for, let's talk about the society. I realized that a lot of people don't know a lot about plankton.

Marta

Poor them.

Massimo

Why do you think they should know at least a little bit more about the topic? Why is it important?

Marta

People think that the oxygen we breathe comes all from the Amazons.

Stefanie

Yes. which is wrong.

Marta

From those trees. But that's totally wrong. I mean, the plankton living in the ocean, obviously, the ocean is a tiny bit bigger than lakes, but it's the plankton who provides us with half or more than half of the oxygen, it comes from plankton, not from trees. People see the trees, but people don't see the plankton, so maybe they just don't appreciate it. Or are not aware.

Stefanie

But in the lakes they also provide us with fish, like up to up the food chain you'll have fish that are based on the food chain and the community that is underneath

--- Technical Problem ---

Stefanie

Okay let's do it again. People think that oxygen comes from the Amazon, from all the trees, but actually at least 50% or more come from plankton in the ocean. There's much more ocean than lakes. But this is the basis of what we breathe, what we live on. And it's completely unknown to many, many people. But also it provides us in lakes with a working ecosystem, with a basis for fish, we eat, a lot of people eat fish. Then depending on what species you have in the lake, like if you might have toxic cyanobacteria for example, you might have a problem for drinking water or recreation. So everything we do with the water and on the water, around the water, bases on plankton. We rely on them and they're really important for the entire ecosystem.

Massimo

Does that affect also what lives on the terrestrial ecosystem?

Marta

Yeah. I mean, marine toxic dinoflagellates kill huge populations of fish and then or like even seagulls or like yeah like at the end terrestrials as well because they can feed on fish their power is massive.

Massimo

What people might be aware of for example are these toxic blooms in the lake and then therefore they think oh they are bad or toxic for us.

Stefanie

I think a really small percentage are considerable dangerous or toxic. Better potentially dangerous! So even the ones that can produce toxins do not necessarily do it. So I think it's a fraction.

Marta

A small fraction.

Stefanie

That could be harmful to us. But they do their thing. And they're even the toxic ones, are part of the ecosystem. When we say, oh, they're bad, it means they're bad for us. It's a very anthropocentric point of view. Whenever we call something in nature bad, it's usually bad to us. Not necessarily bad for the ecosystem or nature. There's a big distinction, I think.

Massimo

What would you say it's most important for people to know about plankton?

Marta

Well, just not because they are microscopic, they are not important. They are like the basic for life and they are

everywhere.

Stefanie

Yeah, they are there. The transparent water doesn't mean there's nothing living. Just because we can't see them doesn't mean they're not there. I think that's the very basic message.

Massimo

For some people it's hard to understand what to do to help plankton since they can't see them. What actions would you recommend?

Marta

Taking care of the freshwater ecosystems, basically. Avoid pollution.

Stefanie

If you care about the water, you care about the plants too. So they don't like pesticides because they're plants, many of them, or they're animals, many of them. So if it harms the water and the other living beings in there, they also harm the plankton. If you have a lot of nutrients from agriculture, for example, a lot of runoff, it takes away the balance of the lake and then it can influence the composition or the abundance of the different species in the lake. So I think the general recommendations for protecting waters is protecting the living beings in there.

Massimo

How's the Greifensee health for example?

Marta

Nutrient rich. It gets anoxic in summer.

Massimo

That's due to what?

Stefanie

A lot of nutrients means a lot of growth, some species will like nutrients more than others, so they can grow faster than others. So it changes the balance between species and which ones can grow faster than others. And then when they die and they sink down, they get decomposed and that takes a lot of oxygen. So in summer we have a problem with oxygen in the lake.

Marta

And the fish use oxygen to survive in the waters.

Stefanie

The fish eat the other kinds of plankton, but if there's fish anymore because they died, it could alter the ecosystem as a whole. Temperature also makes a difference. Changing temperatures, increasing temperatures. The layer that separates the warm water and the cold water in the lake, that stretch gets longer. Then it mixes less, which changes the physics, which also changes the biology.

Massimo

If we think about politics or what is being done to help the ecosystem and ecology, do you think plankton are getting the right attention that they deserve?

Marta

For lakes until now, a bit less. They are not on the radar.

Stefanie

Generally, there is quite a bit of effort for rivers. There's very established methods, established action plans, things that you need, you have to do. And lakes have been conside-

red fixed because there's no more fossils.

Marta

It has improved, but it could be better.

Stefanie

But the problem is not fixed and we'll face different challenges in the future.

Massimo

When a lake's ecosystem loses its balance, does it take a lot of time to rebuild it?

Stefanie

I think it needs a lot for it to crash.

Marta

There's going to be another balance, other species or something. Maybe it's not what you had before originally. Maybe it's an invasive species, who knows.

Stefanie

But generally I think a crash of the ecosystem is unrealistic for the very bit lakes. Maybe for like small ponds it's more realistic because then like everything is like smaller volumes, dynamics are different. But they change and I think change in nature and composition, it's just different than we know and if we want to preserve what has been done naturally, without the human's impact, I think that's the thing. Do we want to take responsibility for changing things in a way that wouldn't change if it wasn't for us?

Massimo

Has there been a moment in your job or something you experienced that made you say "that's why I'm doing it"? Something that makes you feel fulfilled.

Stefanie

I think it comes back every once in a while again, when you have a really smart PhD or postdoc and then they find out some really cool things and we contributed to that. Or when you when we finish a training set that was hard work but it was worth it. When you see the outcome of it or when you have a day of open doors and you communicate to the public and then they see things and you're like oh my god this is actually really cool, yeah.

Marta

When you gain 10 enthusiasts for plankton in one day it's a nice moment.

Stefanie

If you convince someone to join plankton lover club it's always a feeling that makes you satisfied, I would say.

DECLARATION OF AUTONOMY MASTER-THESIS [ZHdK, June 1st, 2026]

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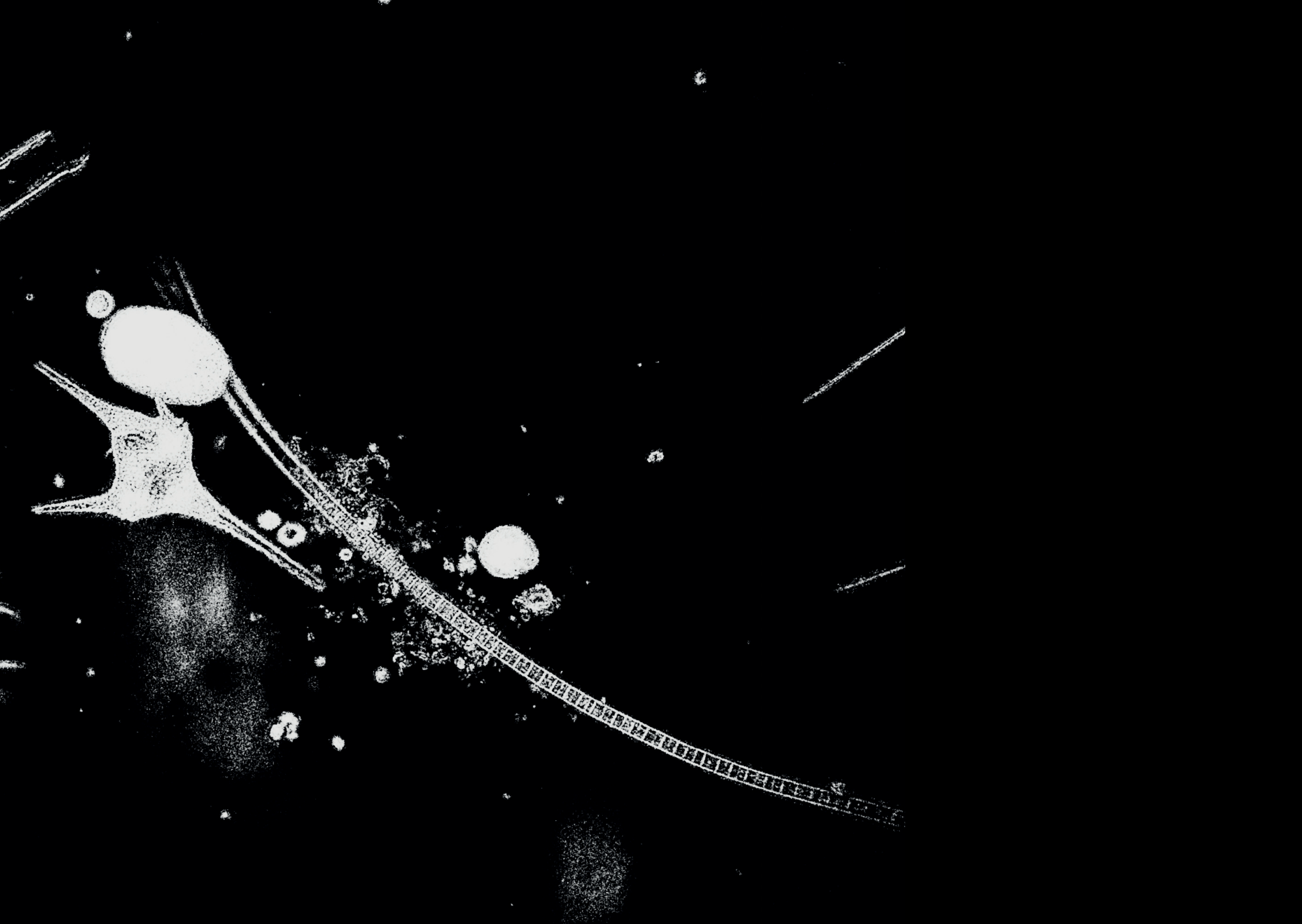


Printed in June 2026 by bookfactory.ch

Paper
Refutura

Typefaces
PP Kyoto, Apfel Grotezk

Videos and future developments will be
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A Real-Time Bridge to Plankton Life