

# Design for knowledge dissemination: towards Ecological Well-being, a design case with sea urchins

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# Abstract and Keywords

This document details the Design process undertaken to support the communication of the “Living Surfaces” project, carried out during a scientific experiment conducted at CETEMARES. “Living Surfaces” is a shared project between CETEMARES - Marine Sciences R&D, Education, and Knowledge Dissemination Centre, and LiDA – Research Laboratory in Design and Arts, both research units from the Polytechnic of Leiria, and focuses on the preservation of the autochthonous species of sea urchin from the coast of Peniche, Portugal.

The primary goal of the present study is to reflect on the role of Design in the dissemination of the “Living Surfaces” project, which aims to repopulate an area that is being destroyed due to the capture of sea urchins, whose numbers are a cause for concern. This research explores the collaboration between Design and Marine Biology, emphasizing the importance of interdisciplinary approaches in addressing complex contemporary issues, such as biodiversity loss.

The project adopts an exploratory Design methodology centred on the concept of Ecological Well-being, prioritizing the health and sustainability of ecosystems over traditional human-centred approaches. By focusing on the species to be protected, rather than solely on human perspectives, this research aims for a deeper understanding of the ecological roles of sea urchins and seeks to foster empathy towards the species, through Design methods. This approach highlights the value of non-human life and considers the socio-economic implications of biodiversity loss and preservation. A crucial goal of this research is to understand Design’s role in the communication of scientific knowledge to a broader audience, making use of Design’s unique capacity to translate concepts, ideas,

and experiences. This document details the first phase of a broader study that aims to raise public awareness and foster empathy towards the preservation of sea urchins and their habitats, thereby contributing to a discourse on Ecological Well-being and sustainable environmental practices mediated by Design.

### **Keywords**

**ecological well-being, transition design, design methodology, design for knowledge dissemination, empathy**

## Resumo e Palavras-chave

Este documento narra o processo de Design desenvolvido para apoiar a comunicação do projeto “Living Surfaces”, levado a cabo durante uma experiência científica realizada no CETEMARES. “Living Surfaces” é um projeto do CETEMARES - Centro de I&D, Educação e Difusão do Conhecimento em Ciências do Mar e do LiDA - Laboratório de Investigação em Design e Artes, ambas unidades de investigação do Politécnico de Leiria, e centra-se na preservação da espécie autóctone de ouriço-do-mar da costa de Peniche, Portugal.

O objetivo principal deste estudo é refletir sobre o papel do Design na divulgação do projeto “Living Surfaces”, que visa repovoar uma área que está a ser destruída devido à captura de ouriços-do-mar, cuja população apresenta números preocupantes. Esta investigação explora a colaboração entre o Design e a Biologia Marinha, salientando a importância de abordagens interdisciplinares no tratamento de questões contemporâneas complexas, como a perda de biodiversidade.

O projeto adopta uma metodologia de Design exploratória centrada no conceito de Bem-estar Ecológico, dando prioridade à saúde e sustentabilidade dos ecossistemas em detrimento de perspetivas tradicionais centradas no ser humano. Ao focar-se na espécie a proteger, e não apenas em perspetivas humanas, esta investigação visa uma compreensão mais profunda dos papéis ecológicos dos ouriços-do-mar e procura fomentar a empatia para com a espécie, através de métodos de Design. Esta abordagem realça o valor da vida não humana e considera as implicações socioeconómicas da

perda e da preservação da biodiversidade. Um objetivo crucial desta investigação prende-se com a compreensão do papel do Design na comunicação de conhecimento científico a um público mais vasto, fazendo uso da capacidade única do Design para traduzir conceitos, ideias e experiências. Este documento narra uma primeira fase de um estudo mais amplo que visa sensibilizar o público e fomentar a empatia para com os ouriços-do-mar e o seu habitat, contribuindo assim para um discurso sobre o Bem-Estar Ecológico e práticas ambientais sustentáveis, mediados pelo Design.

### **Palavras-chave**

**bem-estar ecológico, design de transição, metodologia do design, design para disseminação de conhecimento, empatia**

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# Glossary

**Antimicrobial resistance:**

Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites no longer respond to antimicrobial medicines.

(<https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>)

**Biofilm:**

A thin layer that forms on top of some wet surfaces and consists of bacteria and other very small organisms.

(<https://dictionary.cambridge.org/dictionary/english/biofilm>)

**Ecological:**

Relating to the environments of living things or to the relationships between living things and their environments.

(<https://www.merriam-webster.com/dictionary/ecological>)

**Ecological Well-being:**

Ecological well-being refers to the harmonious relationship between people and their ecological system, which leads to a successful management, distribution, and sustainability of environmental resources for current and future generations.

([https://link.springer.com/referenceworkentry/10.1007/978-94-007-0753-5\\_3966](https://link.springer.com/referenceworkentry/10.1007/978-94-007-0753-5_3966))

**Ecosystem:**

All the plants, animals, and people living in an area considered together with their environment as a system of relationships. (<https://dictionary.cambridge.org/dictionary/english/ecosystem>)

**Empathy:**

The action of understanding, being aware of, being sensitive to, and vicariously experiencing the feelings, thoughts, and experience of another.

(<https://www.merriam-webster.com/dictionary/empathy>)

**Holocene:**

The Holocene is the name given to the last 11,700 years of the Earth's history — the time since the end of the last major glacial epoch, or "ice age."

(<https://ucmp.berkeley.edu/quaternary/holocene.php#:~:text=The%20Holocene%20is%20>

the%20name,the%20Holocene%20has%20been%20a)

### **Human-centered design (HCD):**

Practice where designers focus on people and their context. They seek to understand and solve the right problems, the root problems. They understand that everything is a complex system with interconnected parts.

(<https://www.interaction-design.org/literature/topics/human-centered-design>)

### **Intertidal zone:**

The intertidal zone is the area where the ocean meets the land between high and low tides.

(<https://oceanservice.noaa.gov/facts/intertidal-zone.html#:~:text=The%20intertidal%20zone%20is%20the,extend%20for%20hundreds%20of%20meters.>)

### **One Health:**

One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems.

([https://www.who.int/health-topics/one-health#tab=tab\\_1](https://www.who.int/health-topics/one-health#tab=tab_1))

### **Photomicroscopy (photomicrography):**

Art and science of taking photographs using a microscope to visualize an unseen world.

(<https://www.gslabs.com/photomicroscopy>)

### **Sustainable Development Goals (SDGs):**

The Sustainable Development Goals are a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere.

(<https://www.un.org/en/exhibits/page/sdgs-17-goals-transform-world>)

### **Transition Design:**

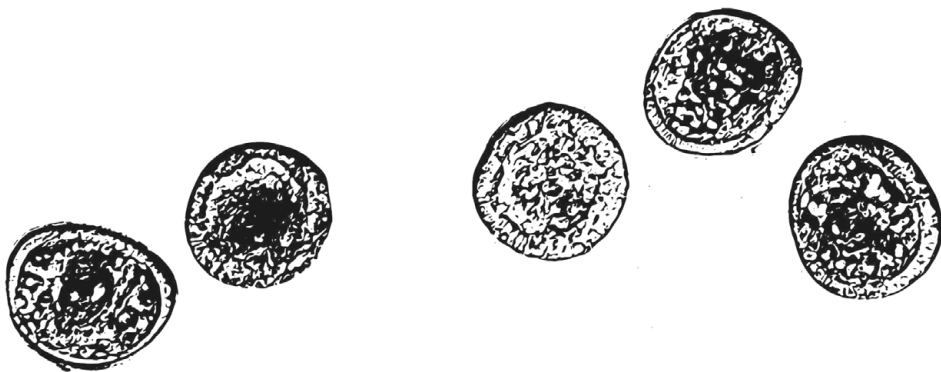
Transdisciplinary approach aimed at addressing the many 'wicked' problems confronting 21st century societies: climate change, forced migration, political and social polarization, global pandemics, lack of access to affordable housing/healthcare/education and many others.

(<https://transitiondesignseminarcmu.net>)

### **Zoonotic diseases (zoonosis):**

A zoonosis is an infectious disease that has jumped from a non-human animal to humans.

(<https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>)



# 1. Introduction

The affirmation that “the planet has entered the sixth mass extinction” of species is today a scientific fact (Strona & Bradshaw, 2022). Since the industrial revolution started, the human species provoked the end of the world’s most stable period, the Holocene (Fothergill et al., 2020). The part that designers played in this effect, with design practices historically promoting consumerism, waste, and unsustainable resource use, is massive and undisputable (Papanek, 1992; Wizinsky, 2022). The importance of interaction between species, and the role that human continues to play in alarming biodiversity loss are undeniable and claim for urgent action (Strona & Bradshaw, 2022). The equivalence that the human species has attributed to economic and emotional satisfaction with the concept of well-being has to be profoundly reframed and acted upon, recognizing the health and stability of ecosystems as fundamental to all life (Grouzet & Lee, 2014; Helne, 2021). Design can have a profound effect on the world and the quality of life of humans and non-humans (Papanek, 1992).

CETEMARES and LiDA, two research units from the Polytechnic of Leiria, have been combining efforts from Marine Biology and Design research, to repopulate the coast of Peniche with the common European sea urchin, under the project “Living Surfaces”. As the species constitutes a delicacy in some countries, this species population presents alarming numbers. The consumption of this luxury item, nowadays rebranded as “Portuguese caviar” (Marques, 2017) for a population that previously wasn’t attracted to its consumption, poses a threat to the marine ecosystem and consequentially to the human species.

When the author was presented with the opportunity to communicate

the “Living Surfaces” project, encountered an intricate web of complex issues that surround the species and are directly linked to human actions, rooted on a lack of empathy towards the species. This complexity calls for a design-led approach that moves beyond conventional solutions.

The unique capacity for Design to communicate and materialize ideas in a multitude of ways is intended to be used to instil empathy towards the species and promote human behaviours that respect and cater to biodiversity.

The complexity of Designing to pursue such goals demanded a reflection upon the contemporary **concept of well-being** – that led to the pursuit of the emergent concept of Ecological Well-being – upon **Design methodology** – what precipitated an exploratory methodology and the adoption of the emergent approach that is Transition Design – and upon the need for **Design to act in an interdisciplinary way**. As a consequence, the present document pertains to an initial approach to the issue, that will be carried into doctoral studies. This context is documented in part I.

The present document, in part II, accounts for the period during which the referred species of sea urchin was studied by the author, in a laboratory context during a scientific experiment, working alongside marine biologists. Phase III of part II exposes the reflection upon the knowledge and data acquired during the process, while trying to answer the prevailing question “how to foster empathy towards sea urchins?”.

This document serves as an initial exploration of these challenges, which will be expanded upon in doctoral studies with the continuity of the project and the author’s participation in it.

## 1.1 Goals

This work was carried out in a peculiar environment. As mentioned above, it has roots in a species preservation research project: “Living Surfaces”. Scientific research on the development and settlement of sea urchin larvae is being carried out at CETEMARES, where scientific experiments are conducted to create sea urchins in the laboratory, transport them to their natural habitats and regenerate marine communities. LIDA’s team of designers conducts research into materials to produce substrates where sea urchin larvae can settle and then be transported to their natural habitat. Within this context arose the problem of how to communicate this project, and foster knowledge and respect towards the species and its habitat.

The present work presents a report of the initial part of a bigger study, as during the research there was a realization that the problem of the project communication could be autonomized and an object of deep thought. The need for repopulation of this sea urchin species arises from harvesting and habitat destruction that cause biodiversity loss (which in turn has detrimental consequences for many species, including humans). More than science communication, it aims towards knowledge dissemination and change of behaviours that lead to species and habitat destruction. The current report materializes the option to segment the communication project into phases that accompany the Living Surfaces project. Hence, this report is framed within the temporal constraints of a scientific experiment conducted within laboratory settings and aims to expose the research conducted during this period, pertaining only to communication and abstaining from the specificities of material research being conducted at LiDA.

Above all, this research consists of a methodological reflection of an

exploratory design process based on values and how they affect design decisions.

These values - subjective and objective - find common ground for reflection in disciplines as apparently disparate as Philosophy, Anthropology, Psychology, Public Administration, Biology, and Design. In the present work, Design is viewed simultaneously as a discipline and binding element between areas of study.

Objectively, or at a societal level, these values manifest themselves under concepts such as Ecosystem, Humanity, Biodiversity, then Planet, Human, Animals, and disciplines such as Ecology, Design, and Biology. These are also the three main disciplines that influence this study, as can be seen by the selected precedents in part II. The presented precedents are paradigmatic examples of the interplay between science, design and art and were also selected for their relevance and unified essence despite being so chronologically distant. They all aim to disseminate knowledge in an empathic, systemic, and interdisciplinary way (to the point where it is difficult to categorize them into a single discipline).

The reflection upon the work that took place after the end of the scientific experiment brought the realization that to further develop this investigation there was a profound need to reflect on what informed this design process until then (the concept of ecological well-being and the role of design when pursuing it through knowledge dissemination) and its implications on design methodology.

As scientists in this project reflect on the findings and problems found during the scientific experiment, to prepare for a new one, in an iterative process, so it was decided that there was a need for Design to act in a similar way to communicate the project. Hence, before proceeding to another phase in the project, where a pre-defined structure can

eventually be used and the human relation towards sea urchins will be explored, was set the goal to elaborate a design case and try to answer some preliminary questions pertaining to the goal of translating the relevance of this project in relatable and enticing ways (in other words, fostering empathy towards sea urchins).

So, the main goal of the carried work is to find ways to communicate the project to the community to change the behavioural conditions that lead to species and habitat destruction, starting at the present phase of conveying empathy towards sea urchins. Design has a specific role to play in this aspect as it is able to translate ideas and concepts in a unique way (Bispo, 2019; Zingale, 2016) which can be especially powerful in the context of translating – or materializing - research findings and concepts to different publics.

Through this work, an understanding of the role that Design can have in knowledge dissemination was permanently sought and reflected upon. Because of Designs' innate ability to tackle “wicked problems”, there was also the goal to expose the reflection that was carried on the role design can play in tackling contemporary complex and interconnected issues, as is loss of biodiversity.

The main goals pursued can be summed up in the following topics:

- Fostering empathy towards a species;
- Exploratory study on decentralising the human (or changing perspectives) in the Design process;
- Study the role of design in knowledge dissemination (guided towards ecological well-being) within an interdisciplinary context.

## 1.2 Challenge

As mentioned above, this project started in a Marine Biology environment, and later transcended this area to request from Design another approach to a specific problem: “what material, structure, and form may be adequate for the settlement of sea urchin larvae and ulterior transportation?”. Scientists also felt the need to communicate this project but the way that can be done and the target audience of communication efforts are still being defined.

The author is a Research Assistant at LiDA, responsible for science communication, mainly through the management of LiDA’s website.

For communication of the project on the website, some photos were handed to the author (Annexes 1 and 2), who later used them to test alternative photographic techniques and showed the result of that exploration to the researcher responsible for the project at LiDA. In that sequence, the author was invited to communicate the project and follow up on a sea urchin larval settlement experiment. This invitation had the goal of immersing the author within the project at CETEMARES and getting to know the species development to be able later, in the project’s communication, understand and explore the factors that contribute to sea urchins’ population decrease and habitat destruction.

Many interesting questions arise from this context, that can motivate a variety of approaches by the Design field. Design has an immense potential to tackle societal and ecological issues and induce behavioural change, especially when informed by knowledge from other fields. Moreover, the interdisciplinary aspect of a problem that has designers and biologists working towards common goals and the collaborative aspects that this symbiotic relation between disciplines, demands

careful analysis and consideration. For that reason, phase II of part II of the present document hopes to present the reader with a vicarious experience of this collaboration.

The current study initially posed the following question: “How can design present these projects to people who aren’t actively interested in it?”. The search for an answer to this stated problem requested a broader approach and a reflection on Design itself. In this context, the first part of the present work reflects a pursuit of an answer to a broader question: “how can design contribute to the dissemination of scientific knowledge?”.

Amidst a climate crisis and an economic and social transition (Wizinski, 2022), as well as a shift in the concept of well-being to an ecological approach that recent literature points towards (Chaigneau et al., 2021; Helne, 2021), it’s necessary to learn and devise new ways to communicate knowledge, especially scientific knowledge, to a wider and diversified public.

These questions posed the necessity to reflect and elaborate on the ways design can interact with science (Dunne & Raby, 2013) and on a more contemporary concept of well-being that’s well-suited to tackle current problems (Helne, 2021).

This macro view of well-being puts in crisis the use of frameworks rooted in anthropocentric views of Design. That led to a reflection on the role of Design from a perspective that is not rooted in a human-centred framework. Questioning conventional frameworks also posed the inevitability of addressing Design from a methodological viewpoint. The context in which the present work was born, the implicated broader sense of well-being that is contemplated in this work, and its reflective essence on the role of Design and the Design process posed

the acknowledgement that the present research could have value as an instructional design case (Boling, 2010).

The work is developed within a Transition Design approach. This gave rise to a reflection and need to demonstrate its coherence and aptitude to be used when confronting ecological well-being problems, and to explain how this approach or mindset isn't characterized as a methodology.

Upon reflection on the various problems the proposed challenge presented, it was decided that the present work should focus on answering a small and introductory part of a bigger problem, so the third phase of the report is bounded to the initial step of making sea urchins relevant to more people (Figure 1).

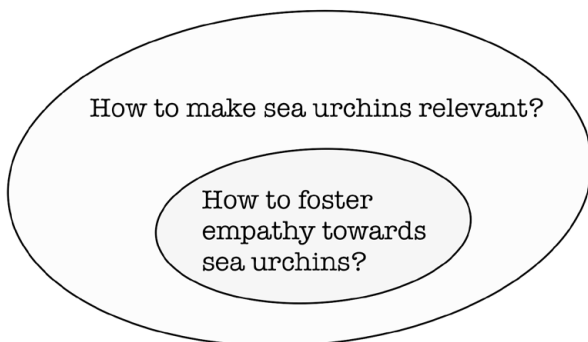


Figure 1. Defining a question. Diagram elaborated by the author

In other words, it was decided to focus on the inner stated problem (Figure 1) within the frame of the information collected during the period comprehended between the first visual explorations and the end of the scientific experiment of sea urchin development.

Thus, the present work narrates the research that was carried out until the end of a larval settlement experiment, pertaining solely to communication. Even though there was material research being conducted at LiDA, it's not reflected within the present document, as

it is focused on the research on knowing the species in a laboratory context and reflecting on the role Design can have in instilling empathy towards these beings.

### 1.3 Structure of the document

The present document is divided into two parts, one that frames and contextualizes the work on a conceptual level and the other that constitutes the report of the first phase of a larger investigation, that is intended to be carried into future doctoral studies.

The first part explores the concept of ecological well-being, the idea of the interplay between Science and Design and exhibits a perfunctory approach to an emerging Design field (Transition Design), to set the context and mindset within which the project is developed.

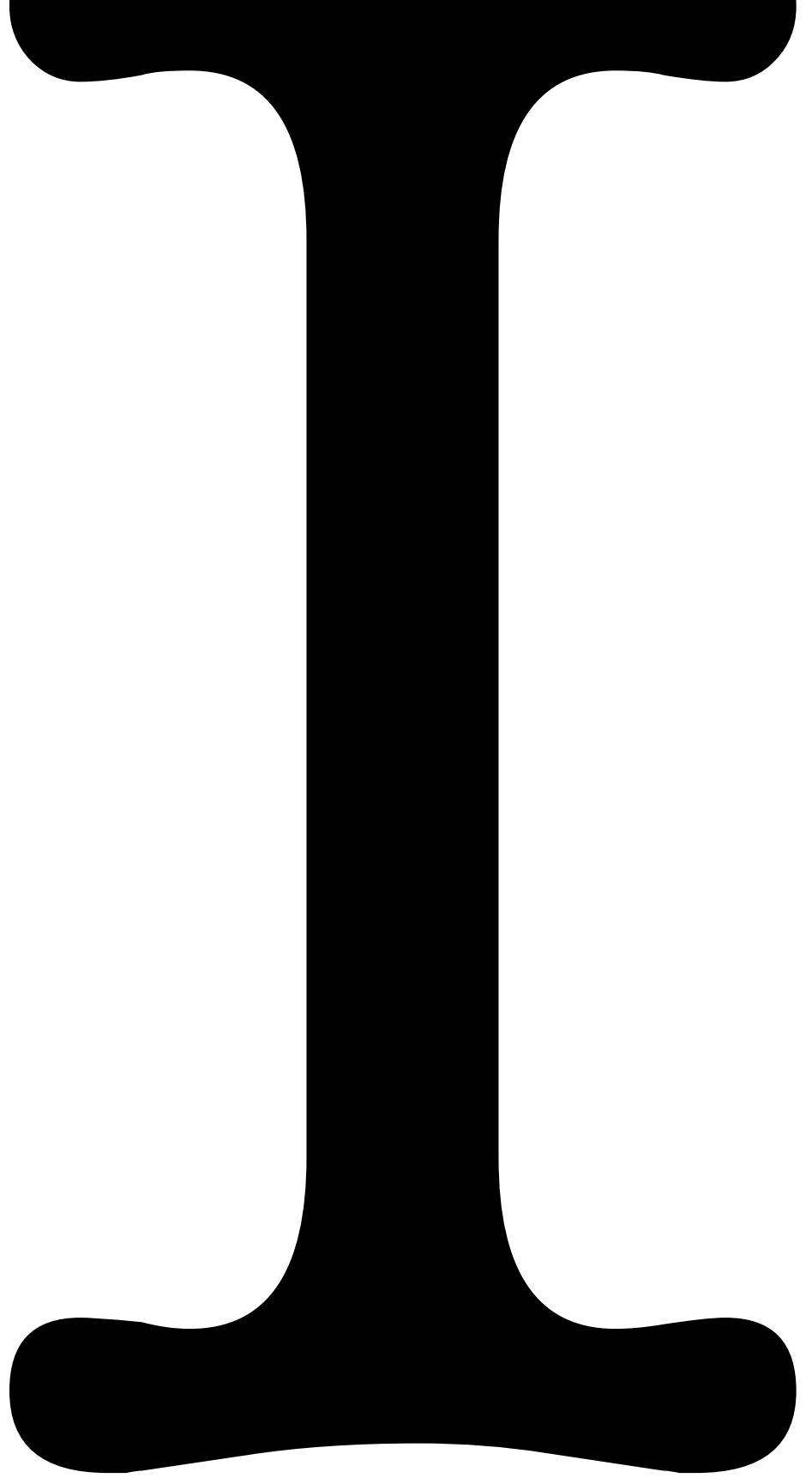
The second part starts by giving some examples of cases (that greatly influenced this work) where design played an important role in science and knowledge dissemination while also advancing scientific knowledge. It then narrates the design process that was developed in the period between being set the challenge of communicating the “Living Surfaces” project and the end of a scientific experiment within that project. This second part comprises three phases: the first phase of the project describes a photographic exploration that ended with a prototype for an instant book. The second phase depicts the process of collaborating with biologists and accompanying an experience of the development and settlement of sea urchin lava, through visual investigation. The third phase reports the process of reflecting upon the produced and collected visual information along with the experiments of translating scientific knowledge and findings through design methods.



Part

Context

Ecological Well-being  
Design and Science  
Transition Design



## 2. Context of the study

### 2.1 Ecological Well-being

“We have been brainwashed by the advertising industry into being the most dissatisfied people in the world. We are told we must all be handsome or beautiful, sexually devastating, and owners of a staggering amount of recreational gadgetry or doomed to frustration. The result is that most of us are frustrated.”

Strait, Guy (Kornbluth, 1968, p. 203)

In 2022, the World Health Organization, the Food and Agriculture Organization of the United Nations, the World Organization for Animal Health, and the UN Environment Programme signed a Memorandum of Understanding for collaboration towards “One Health” (Figure 2). It provides “a legal and formal framework for the four organizations to tackle the challenges at the human, animal, plant and ecosystem interface using a more integrated and coordinated approach” (Memorandum of Understanding (MoU), 2022). This memorandum proposes an integrated, holistic and ecological perspective of health, recognizing that challenges posed today require “multi-sectoral approaches to complex health challenges at the animal-human-ecosystem interface”. The recognition of interconnectedness between multi-sectoral challenges poses the need to reflect and act in an interdisciplinary and collaborative approach. This memorandum focuses primarily on antimicrobial resistance, emerging zoonotic diseases and the strengthening of health systems, as these are seen as initial areas of cooperation, given their

extreme urgency. Nonetheless, it also raises questions about other facets of health, such as well-being and mental health.

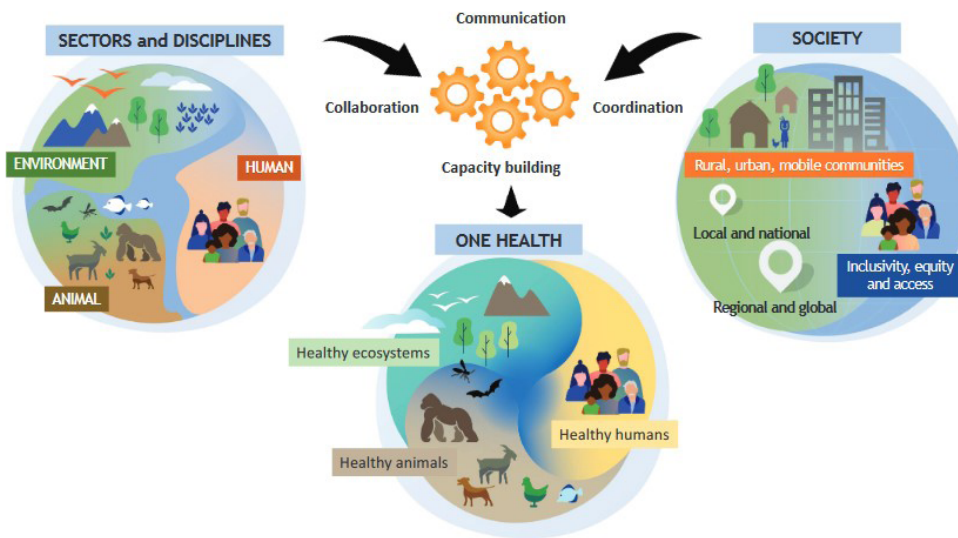


Figure 2. One Health approach [Illustration], by the One Health High-Level Expert Panel (OHHLEP). (One Health – Geneva Environment Network, <https://www.nevaenvironmentnetwork.org/resources/updates/one-health/>)

Ecosystems' health has a direct influence on our physical and mental health. With this realization comes the need to encompass climate change, build resilience, and foster biodiversity when addressing health issues (Barbosa & Cardoso, 2023; Biosafety Unit, 2024; Cunsolo et al., 2017). These global preoccupations are manifested in the United Nations Sustainable Development Goals for 2030 whose vision comprehends a “world with equitable and universal access to quality education at all levels, to health care and social protection, where physical, mental and social well-being are assured” (Transforming Our World: The 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs, n.d.).

The goals for global Sustainable Development request holistic problem-solving approaches to global issues. As it will be later explained, this holistic perspective is intrinsically connected to the adopted Design approach in this research – Transition Design (Irwin et al., 2022). These contemporary complex challenges constitute “wicked-problems”, a concept derived from Policy Sciences (Rittel & Webber, 1973) to describe societal ill-defined problems. In the last decades, this concept has been

used in the Design field to describe complex, open-ended problems that designers face (Cross, 2001; Lawson, 2005; Wizinsky, 2022). Some of the goals that are related to environmental resilience, have also well-being targets, indicating the need to surpass the traditional framing of well-being – more rooted in economic and emotional well-being (Helne, 2021) – to one that places humans within an ecosystem and encompasses “the complex multi-dimensional natures of wellbeing and resilience” (Chaigneau et al., 2021).

When exploring the meaning of well-being under this framework, the concept of **Ecological Well-being** arose (Helne, 2021; Jurjonas et al., 2024). This multidisciplinary term, also referred to as “Planetary Well-being”, is defined in the Encyclopedia of Quality of Life and Well-being in the following terms: “Ecological well-being refers to the harmonious relationship between people and their ecological system, which leads to a successful management, distribution, and sustainability of environmental resources for current and future generations.” (Grouzet & Lee, 2014). As it is explained in this entry, “affective connection to nature (or biophilia) is an important component of ecological well-being”. Other authors, reflect on “the importance of a nature-inclusive (that is, radically relational) conception of well-being” (Helne, 2021). The relevance of reframing the concept of well-being has been identified in different areas, such as psychology and political sciences (Helne, 2021). The present research and work developed explore these affective or relational dimensions through Design.

The exploration of the concept of ecological well-being identifies feedback loops in ecological systems. Human actions (individual and societal) impact the well-being of ecological systems which, in return, impact human quality of life, for current and future human populations (Angelique, 2014). Nonetheless, multiple barriers to pro-environmental

behaviour, that seem to be rooted in the way humans live, have been identified at the individual level – “including time, money, low efficacy, and lack of education about environmental issues” – and they appear to be rooted in lack of connection to nature (Quimby & Angelique, as referenced by Angelique, 2011). According to Helne, “The current economic order (...) sets in motion a vicious circle because unhappy people cannot create a happy society, and an unhappy society cannot beget optimal conditions for fostering balanced individuals” (Helne, 2021). Within a perspective that behavioural changes have the potential to benefit human health and restore the well-being of the planet, it’s possible to sustain that Design can play a crucial role in fomenting behavioural changes, directly related to the way people live, on an individual level and to ecosystems, on a societal level.

Researchers have found that three main factors could foster pro-environmental behaviours: “(1) level of awareness; (2) emotions, feelings, and perceptions; (3) situational and community factors” (Pruneau, Doyon, Langis, and Vasseur as referenced in Angelique, 2014). The present work focuses on the first and second dimensions. In further investigation, there is the intention to explore also the third dimension, which means researching and reaching the community level of the “wicked problem”.

Despite education being identified as a main catalyst to increase pro-environmental behaviour, most programmes aren’t being met with the expected success (Angelique, 2014). Nonetheless, social marketing programs and techniques appear to have good results in promoting individual behaviour changes (Angelique, 2014). This can be because it renders a good way to promote social norms and may “help to overcome the personal conflict between being green and being normal” (Connoly, as referenced in Angelique, 2014). As Helne explains, “The

prerequisites of well-being are social and ecological, beyond solely individual responsibility. Each of us, nevertheless, answers for our part in the collective responsibility, in doing right by other beings and the planet”. This relationship between humans at individual and social levels constitutes a complex part of the web of relations that is intended to be explored in future research.

Gaining on this knowledge, the present work is intended to take a first step within an exploratory approach, decentralizing humans from the design process (at an initial stage) and starting the design process by focusing on an endangered species and exploring affective relational dimensions towards that species.

## 2.2 Interplay Between Design and Science

“They called him Philos. The nickname did not imply that Darwin was a lofty thinker, prone to idle reveries or flights of fancy. At the time, natural philosophy was a surprisingly active, physical pursuit.

When the word “scientist” replaced “natural philosopher”, the shift marked a change in the way people thought about studying the natural world. It was more than mere semantics. In decades before “scientist” was coined, there was no clear separation between the arts and the sciences; after “scientist” was proposed as a parallel to “artist”, these realms began to divide. Until then, Romantic poets and philosophers (who were often one and the same) tended to think of pursuits that we would now call artistic (writing poems, sketching landscapes, making botanical drawings) as empirical investigations into the natural world.” (Bergland, 2024)

Some authors defend that new trends indicate that design is importing knowledge from other fields, such as social sciences, environmental studies, and business management (Muratovski, 2016), and that it now engulfs a multitude of actions (Latour, 2008). This doesn't constitute an entirely new perspective within the Design field but is gaining force. Victor Papanek had already argued that Design should cross its own discipline frontiers, "Design must become an innovative, highly creative, cross-disciplinary tool responsive to the true needs of men" (Papanek, 1992). The necessity of bridging the gaps to other disciplines, while collaborating with other professionals, is a task for current designers. As Bruno Latour stated, "bringing in scientists and engineers is quickly becoming another way of asking: How can it be better redesigned?" (Latour, 2008).

Going back in time and learning from the history of science, is also possible to sustain that designers, when working with scientists, can occupy a place that was somehow lost in history. Designers are well equipped to conduct their empirical research in a reminiscent way scientists used to, before the term "scientist" was coined, and before art and science became estranged and even seen as opposed areas (to the point that scientific validity was questioned if a work presented an artistic dimension (Figure 3)). As the author Renée Bergland (2024) states, "In the course of the nineteenth century, scientific objectivity replaced more subjective emotional approaches to the natural world. Science distanced itself from wonder. The German sociologist Max Weber would describe this process as the 'disenchanting of the world'".

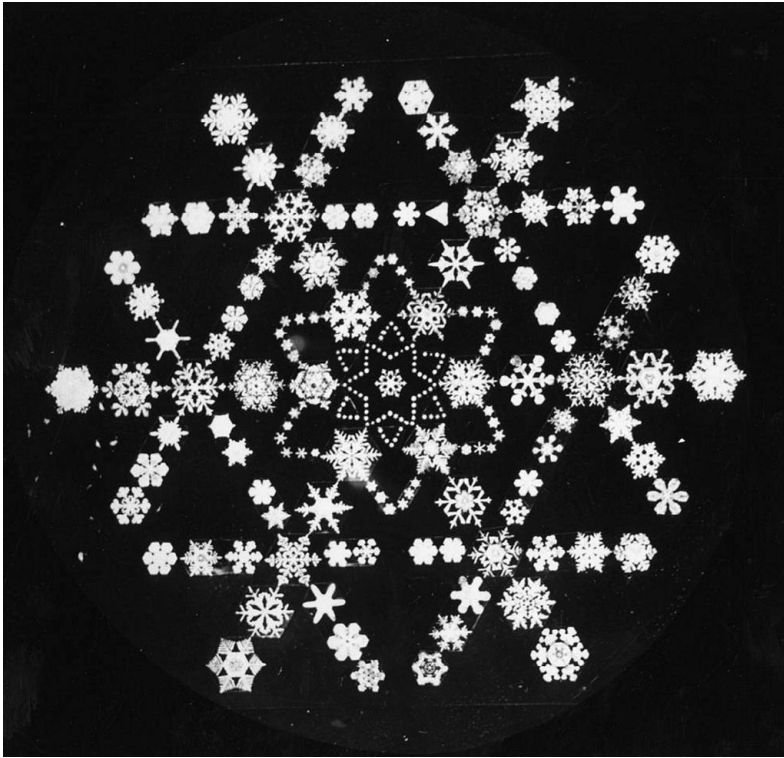


Figure 3. Collage of a snowflake consisting of various snow crystals [Collage of microphotographs], by Wilson Bentley, n.d. (<https://between-science-and-art.com/icy-hieroglyphics-wilson-bentleys-snow-crystals/>)

Note: Wilson Bentley (1865-1931) was a pioneer in photomicrography and is recognized today as one of the first atmospheric scientists. During his life, his work was doubted to have scientific validity because of its artistic presentation (Hemkendreis, 2021).

As designers play collaborative roles in interdisciplinary teams, their investigations remain free from the objectivity imposed by the scientific method in experimental sciences and can act in a reminiscent way natural philosophers did. As the author Müller states, “While scientific research obscures its own constructed character behind an ethos of objectivity, design ethnography can and should expose it. It does not need to strive for objectivity. Its methods are not applied dogmatically but playfully.” (2021, p. 3). It’s possible for designers to conduct their research adding another dimension (more experiential and emotional) to the research being conducted by scientists, without interfering with its objectivity. This dimension can become invaluable to disseminating knowledge and gaining insights from the domain of social sciences and humanities, adding to the possibilities of outcomes of a single experiment.

On the interplay between Design and Science, the authors Dunne & Raby propose four ways in which Design and Science can interact: “design for science, when design is used to communicate or illustrate

the research; design with science, when it is a true collaboration between designer and scientist; design through science, when the designer does some science; and design about science, when issues and implications arising from the research are explored through design” (Dunne & Raby, 2013). The author Joichi Ito proposes that Design works in a “antidisciplinary” way (that doesn’t fit into “any existing academic discipline”) to be able to tackle “wicked problems”, also adding that “our best chance for rapid breakthrough should come through a collaborative “One Science” (Ito, 2016).

Opting for a perspective on the ways Design and Science can interact may be limiting without fully knowing the scope of the whole project. As the science photographer Anand Varma says, “You don’t have to accept what the dictionary definition of a scientist or a photographer is, because there’s magic at the intersection” (Hutchison, 2023). As well as other questions that arose during this work, it was decided to relegate further study into this matter to a later moment (doctoral programme) when the societal dimensions of the present project will be explored.

As stated, the project occurs in an interdisciplinary context. This particularity, described in Part II, posed the design process to be time and constraint-bound to a scientific experiment with living beings, what deeply influenced decisions and outcomes.

## 2.3 Transition Design

“Design itself is synonymous with change. It is about materializing preferable states of the world and, in doing so, establishing preferable ways of being in the world.” (Wizinsky, 2022, p.10)

In recent years Design Discipline and Practice, as other disciplines, have become continuously more focused on addressing current issues like climate crisis and social disparities. The proliferation of recent proposals of design methodologies and frameworks like Ecological Design, Sustainable Design, Planet-centric Design, Life Centered Design, and Humanity-centered Design constitutes a result of the present context and the urgency to address the aforementioned issues (Acaroglu, 2017; Humble, n.d.; Norman, 2023; Spoelstra, 2023). These are some of the manifestations this mindset has been appearing under. Some appeared too restricted or unscaled, hanging too much on humans or lacking some aspects, so there was a necessity to investigate further into this issue.

These ideas are not new in Design Discipline and Practice. Designers like Buckminster Fuller, Vitor Papanek, Dieter Rams embedded in their practices and discourse ethical, societal, ecological, and material issues (Hustwit, 2009; Papanek, 1992).

Currently, is possible to propose that Design is being emancipated from a purely anthropocentric approach (Coops et al., 2022; Irwin et al., 2022; Kossoff et al., 2015; The Transition Design Framework – Transition Design Seminar CMU, n.d.; Wizinsky, 2022). This change currently presents various approaches with different degrees in which the human plays a more or less dominant role. As an example, the Human-Centered Design framework, maybe the most well-known Design approach, is proposed by Don Norman in “Design for a Better World” (2023), to make a shift into “Humanity-centered Design”. Some of the methodologies often don’t go far enough to navigate the complexities that designing for the XXI century entails, from a One Health perspective. As the author Mathew Wizinsky states “human-centered design and, later, design thinking became largely co-opted for

consumer-oriented design” (Wizinsky, 2022, p.151).

It is believed that the referred methodologies and toolkits can be valuable substitutes to current methodologies used in Design Practice and can help to reframe mindsets in the consumer market. They also offer great toolkits that can be used when communicating with non-designers, for they propose a common ground for communication that can yield relevant results.

There’s an inclination to believe they will nonetheless perpetuate a cycle of no real innovation on a truly transformative level if they continue to be used dogmatically by designers (Helne, 2021; Müller, 2021; Rittel & Webber, 1973). Their use as prescribed and inflexible sets of linear phases to go through contributes to the problem presented by Wizinsky (2022) in this statement: “Instead of creating visions for new ways of life on Earth, we flood the world – and the cosmos – with gadgets of minimal social value” (Figure 4).



Figure 4. Distribution of space debris around Earth [Frame from GIF], by the European Space Agency, 2020 ([https://www.esa.int/Space\\_Safety/Space\\_Debris/The\\_current\\_state\\_of\\_space\\_debris](https://www.esa.int/Space_Safety/Space_Debris/The_current_state_of_space_debris))

The problem with the use of “scientific methods” to approach design practice was already pointed out during the '70s by, nonetheless, authors who were pioneers in proposing and studying design as a methodology (Cross, 2001).

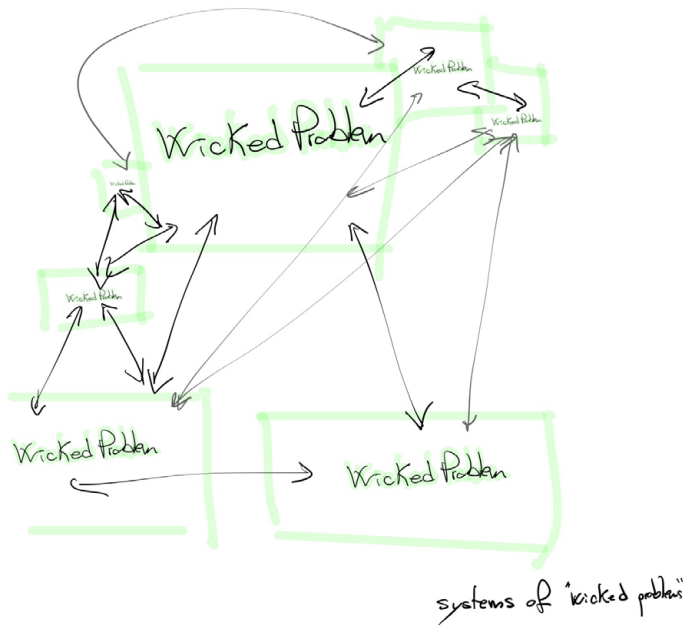
As a consequence, the present work is structured on a basis that adheres to an ecological and interdisciplinary approach. In a quest for a perspective that could be adequate to tackle the complexities of the current world, were discarded perspectives based on centric viewpoints, especially ones that are framed within a market-oriented social construct of the human, and that didn't regard the human being as a part of a complex system (thus opting to be oriented by positions stated by designers as Papanek (1992) and Wizinsky (2022)). On that note, the present work adheres to an approach that comprehends the idea of the necessity of Design to face systems of problems and recognize the presence of feedback loops, as the one identified when describing the Ecological Well-being concept (Irwin et al., 2022; Kossoff et al., 2015; Wizinsky, 2022). As Wizinsky states, "one of design's primary functions is to find new and "better" ways to operate within the given parameters of the situation, that design practice is itself institution making and affects both the world and the lives of countless humans and nonhumans well beyond the lived experiences of the involved designers, clients, and users" (Wizinsky, 2022, p.106)

When searching for a methodological approach adequate to the complexity of the Living Surfaces project, the Design Transition approach presented itself as capable of giving clues to address challenges embedded in complex systems with multiple "wicked-problems", within interdisciplinary contexts. Transition Design proposes an approach to address complex, diverse and urgent issues such as climate change, inequity and biodiversity loss – the latter explored within the Living Surfaces project (Irwin et al., 2022).

The current discourse about methodology started with pointing out the ability that design, and thus designers have, to establish "preferable ways of being in the world" (Wizinsky, 2022, p.10). This intertwined

complexity of “wicked problems” embedded in complex systems (Figure 5) should be, as previously stated, tackled in interdisciplinary ways, that connect designers to different disciplines and ways of thinking (Coops et al., 2022; Irwin et al., 2022; Kossoff et al., 2015; Müller, 2021; Papanek, 1992; Wizinsky, 2022). That doesn’t mean that design should necessarily try to adopt and adapt scientific methodologies, especially from “The Sciences”, that is, defined processes characterized by being empirical, objective and inductive (Archer, 1995). That should be done, if and when, it makes sense from a projectual needs standpoint and shouldn’t limit the contribution that design can have to tackle complex issues (Müller, 2021). The present research follows Wizinski’s (2022, p.18) position when he states that “the material-experiential expertise of design remains its critical distinction and is absolutely essential to creating a humane world”.

*Challenge :  
Design for the XXI century*



*Clusters of wicked problems?  
SDG 2030*

Figure 5. Systems of “wicked problems” [Sketch], elaborated by the author

Note: Reflection on the complexity that Systems of Wicked Problems pose for designers in the XXI century

That said, there's a belief that Design should be informed by Humanities, Social and Experimental Sciences alike, in other words, to operate in an interdisciplinary context (Irwin et al., 2022; Kossoff et al., 2015; Müller, 2021; Transition Design Seminar CMU, n.d.; Wizinsky, 2022). It is assumed that understanding the historical socio and political context in which design operates is essential, and understanding what science and technology have to offer to "design preferred futures" is also crucial - a discourse already embedded in the practices of some XX-century designers like Buckminster Fuller, Papanek and Enzo Mari (Irwin, 2015; Irwin et al., 2022; Kossoff et al., 2015; Mari, 2019; Papanek, 1992; Wizinsky, 2022). The role of the designer is difficult to define in this multifactorial and interdisciplinary context, but designers have the referred "material-experiential expertise" (Wizinsky, 2022) that is unique to the field.

In this respect makes sense to refer to the philosopher Slavoj Žižek, talking about ecology while pondering through piles of human-produced trash, and reflect upon the role of designers in recreating beauty and aesthetic dimensions when tackling "wicked problems" (Žižek, 2010).

"The difficult thing is to find poetry, spirituality, in this dimension. To recreate, if not beauty, the aesthetic dimension in things like this. In trash itself. That's the true love of the world. Because what is love? Love is not idealization. Every true lover knows that if you really love a woman or a man, that you don't idealize him or her. Love means that you accept a person, with all its failures, stupidities, ugly points, and nonetheless the person is absolute for you. Everything like that makes life worth living. But you see perfection in imperfection itself and that's how we should learn to love the world. True ecologists love all this."  
(Slavoj Žižek on ecology as religion)

The Transition Design approach proposes a shift in designers' mindset. Instead of using problems or necessities as a starting point, designers start the design process with preferred and desirable futures in mind (Irwin et al., 2022). In the present project, that could be envisioned as a future where sea urchins don't face an extinction problem, and they exist in peace in their natural habitats.

### 3. Methodology

The following considerations comprehend a theoretical analysis and context of the Design process. The term "methodology" is used in its primary sense of "analysis of the principles and procedures of inquiry" in the Design process. Here, the term "methodology" is not used in a procedural (a set of procedures - e.g. Design Thinking) sense (Methodology Definition & Meaning - Merriam-Webster, n.d.). Also, for clarification purposes, the word "method" refers to a concatenation of acts, and implies a procedure or process (a systematic way of doing, e.g. A/B testing) (Method Definition & Meaning - Merriam-Webster, n.d.).

Some authors claim that there seems to exist "areas of confusion" (Moore et al., 2023) in Design theory about methodology, both in academic research and research conducted within Design practice and several authors have been dedicating thought to this matter for some time (Archer, 1995; Boling, 2010; Cross, 2001; Lawson, 2005; Moore et al., 2023). Nonetheless, further research will be conducted in future studies to help clarify the distinction between a) methodology as an area of study of the principles and procedures used within Design Research and Design Practice, b) methodology as a set of procedures; c) Design methods; and d) Design tools.

### 3.1 Design case method

If (...) all cards can be put on the table, they can be turned, selected, triaged, rejected for ever, or indeed, accelerated forwards.” Latour, Bruno (Latour, 2020)

As Dieter Rams declared in the documentary *Objectified* (2009), “There’s a story attached to everything people do, that had to be told” (Hustwit, 2009). This premiss, the need to “tell the story” of the process, was subjacent to the structure and contextualization of the reported work.

At the outset of the communication challenge, there was no knowledge of the scientific experiment or the environment in which it took place. However, the design process had already begun with a **visual investigation** (as reported in Phase I of Part II of this document) of pre-existing photos (Appendix 1). When the brief was later introduced, the design process was already well underway through a photographic exploration that culminated in a prototype—an instant book depicting the first month of sea urchin larval development. This exploration was made without any knowledge of the context where the pre-existent photos had been taken. Only after elaborating the prototype, there was an invitation to photograph stages of larval development during a scientific experiment that would be made at the marine biology laboratory. At that stage, it was clear the design process had already started (it even had produced an output) when the brief appeared. Although what was developed in phase I of part II of the project, was a personal visual exploration of eight photos, a spontaneous activity, it could not be denied that the design process had already started when the brief appeared.

The stated fact posed an incompatibility with prescribed or determined

methodologies. Scientific honesty meant that this design process could not be conducted as a case study (Figure 6), because it didn't follow a path previously planned by the designer nor an adopted one (e.g. Design Thinking) (Yin, 2018). There hadn't been a conscious intent to start a Design process. Nonetheless, the truth was that the Design process had already started, and even though a methodology could be implemented at this stage, what had already been done couldn't be consciously dissociated from what in retrospect started with a prototype.

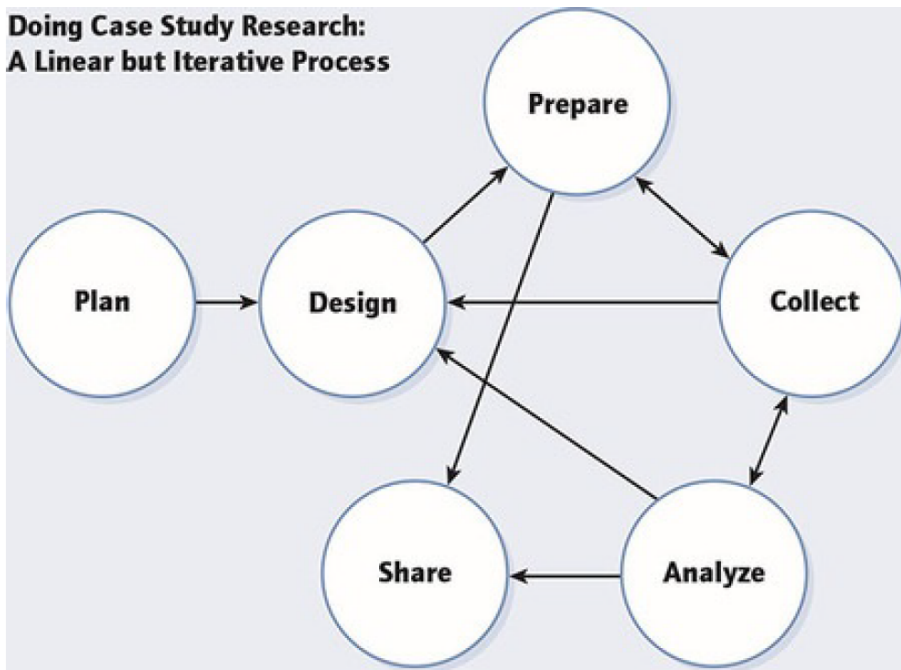


Figure 6. Doing Case Study Research [Diagram], adapted from Robert K. Yin, 2018, Case Study Research and Applications, p.30

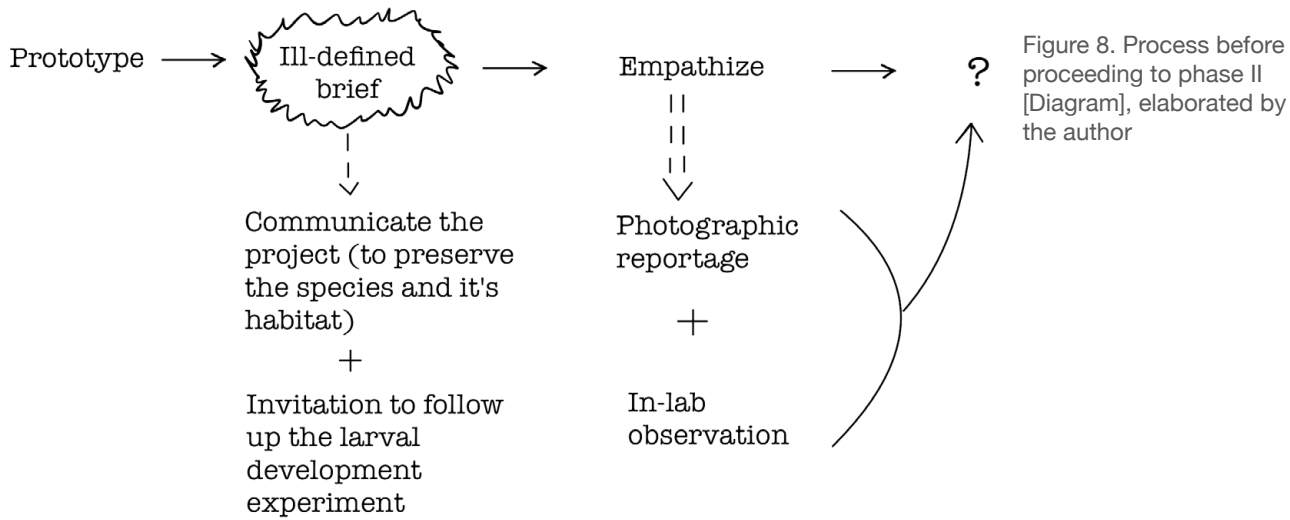
Adopting a framework also posed a challenge, in the face of the interdisciplinary context the project presents.

At this stage, what could be made during and after the accompaniment of the scientific experiment was incognito for several reasons - there was no empirical knowledge about the environment of a marine biology laboratory, there was no past knowledge of working in an experimental sciences context, there was no knowledge of photomicroscopy, and there was no way to know which challenges would arise (Figure 7).

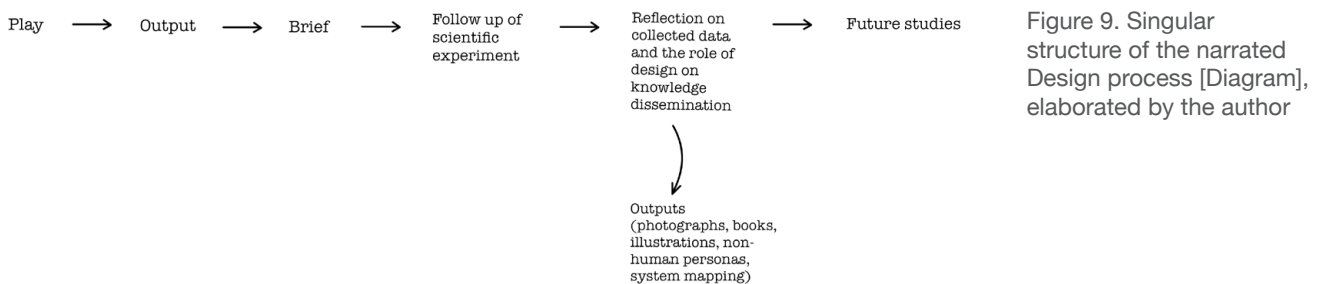


Figure 7. Design process upon brief proposition [Diagram], elaborated by the author

For the presented reasons, it was planned to conduct a photographic reportage and observe the work environment and activities taking place in the laboratories (Figure 8).



Only during the last stages of phase III, it was possible to start devising the future possibilities for the continuation of the communication project (Figure 9) (that is expected to continue with observation within the laboratory, observation of the habitat and research into human connection with sea urchins and their habitat).



This sequence of events presented a challenge to prescribed methodologies such as case studies or predetermined frameworks like Design Thinking (Yin, 2018). The process had begun spontaneously, without conscious intent or a pre-planned approach. However, it became evident that the Design Case Method would be the most appropriate approach to documenting this evolving process. While it did not follow

a rigid, pre-structured path, it allowed for the reflection, analysis, and contextual exploration necessary to provide a clear understanding of the design decisions made along the way.

Although it involves documenting the design process step-by-step, the Design Case Method functions here as more than a simple method. It operates as a methodology because it guides not just the procedural aspects of the design but also the overall framework for inquiry and reflection. As Moore et al. (2023) and Boling (2010) explain, the Design Case Methodology enables designers to convey a vicarious experience of the design process, offering insights that go beyond the final product to explore the complexities, challenges, and decisions encountered along the way.

The used structure was also found to be the most transparent way to communicate the implicated concepts, the context of the project and the activities that were conducted. There's an effort to present the design process in chronological terms, hence being the document (Part II) divided into three phases: phase I – where the initial visual investigation took place –, phase II – narrates the observation of the scientific experiment and also reports some ideas that weren't pursued and occurred in parallel –, and phase III. Phase III constitutes a reflection, analysis and management of the evidence and knowledge gathered during phase II, accompanied by idea generation mainly through drawing and mapping, and literature review on Biology, One Health, Ecological Well-being, Contemporary Philosophy, Transition Design and Design theory, some of which is indirectly reflected upon the report but wasn't used as reference.

As clarified in “Research methods for design knowledge: clarifying definitions, characteristics, and areas of confusion” (Moore et al., 2023), design cases are aimed at providing the reader with a “vicarious

experience of the design”. According to the referred authors, design cases share six characteristics. These characteristics, along with the authors’ explanations and their relation to this project are following explained:

- Unique and variable structure: “because within each design case there is inevitably a story” (Moore et al., 2023), the structure of a design case is a consequence of its unique context and process and should be presented in a way that conducts the reader through the design process. The current work was structured to present the reader with a narrative of what informed the design process and how it was conducted;

- A stated vantage point: the explanation of the role of the designer in the design process is fundamental, and theoretical contextualization serves the purpose of describing “the rationale of the designer or how the designer approached the design” (Moore et al., 2023). In a interdisciplinary context as this one, the design case is especially suited to reflect upon the role of design when collaborating with other disciplines;

- Representation of the design: more than describing the results of the present work, the goal was to communicate the process and the reflections that took place and led to the results. To explain this characteristic of design cases the authors refer to a case where “the real value of the case lay in the interrogation of the communicative strategies of the designer, who via reflection, mined the experience for insights” (Moore et al., 2023);

- Significance of case selection: the conducted work is set within a peculiar context that elicits reflection on the role of design in interdisciplinary contexts and is based on a broader approach to “wicked problems”. There are aspects of the process and its context

that may be of use to other designers (as the authors state, aspects “the author most wants to tell a colleague” (Moore et al., 2023));

- Orientation of all elements toward the design itself: being a narrative of a design process, there’s an emphasis on considerations, actions, and choices that were most preponderant for the process and the outcomes. Through this report, there’s a preoccupation with stating “the connection of each element in the design case to its impact on the design” (Moore et al., 2023);

- Transparency and trustworthiness: the authors explain that “cases must include frank and straightforward discussion of failures, including the unforeseen obstacles encountered in the creation of a design” (Moore et al., 2023). This work aims to report unexpected technical challenges and how they were confronted. It’s thought that there’s a special relevance in reporting these contingencies because of the constraints that working in an interdisciplinary context poses, the main ones being the time frame of the design being dictated by a scientific experiment (in reality, by the uncontrollable rhythm of the development of life forms) and by the possible unrepeatability of the process. The realization that, in this kind of context, the designer is not able to replicate the scientific experiment and that the experiment may not be repeated by the scientists was a crucial factor in the Design process.

For the explained reasons, the Design Case method is considered to be the most adequate for the present Design process, especially because of the unique and variable structure it allows for, as it admits a design process that started with a prototype, where the brief was given after some exploration and planning had to be reflexive and adaptable to unforeseen circumstances. Nonetheless, the choice of this methodology has to be carefully considered, as it can pose a degree of unpredictability and it’s not adequate when replicability is intended.

The present work was mostly, as previously said, of a reflective essence (Lawson, 2005; Müller, 2021). The mindset with which the problem was addressed - from an ecological well-being standpoint – posed an incompatibility with pre-defined structures of the design process which place the human being at the centre of the process. The Transition Design approach emerged as fully adequate to such a context.

The first phase of the project started with learning and experimenting with some alternative photographic processes and developing a prototype for an instant book. During this period, photographs captured by biologists were used (Annex 1).

Photography was the main medium used in this Design case, in the first moment under alternative photographic processes and later in digital photography. It was not only a medium to think, explore, comprehend, observe, and analyse, but also to communicate.

After being challenged to think about the project's communication, the research, in a second phase, was conducted by observation of sea urchin larvae, and through dialogue with marine biologists, always mediated by photography. The reflection upon what was being conducted at CETEMARES was facilitated by digital and analogic experimentation, through idea mapping, and drawing.

The third phase of the present work started with a reflection upon the project since its very beginning. In this phase, there was observation and tinkering with the collected and produced results, along with the analysis of literature about sea urchins. This reflective act was mediated by photographic exploration and drawing, with the defined goal of disseminating knowledge (in an empathic way) about the sea urchin, to a broader public.

## 3.2 Tools

“A imaginação é o meio para visualizar, para tornar visível o que pensa a fantasia, a invenção e a criatividade. (...) Os meios que substituem a imaginação são, portanto, o desenho, a pintura, a escultura, o cinema, a arte cénica, etc.”  
 [Imagination is the means to visualise, to make visible what fantasy, invention and creativity think (...) The means that replace imagination are therefore, drawing, painting, sculpture, cinema, stage art, etc.] (Munari, 1997, p. 24)

The “visual investigation” – a term used by Bruno Munari when he refers to investigations “where all the technical and scientific means can be used” (Munari, 1978, p. 40) -, was mainly conducted through photography, drawing, and mapping. These tools also became the main mediums to translate and communicate findings, ideas, and concepts.

### Photography

Photography was the most prominent tool. It was primarily used to comprehend, in empirical terms, the sea urchin development and the way laboratory research was conducted, and then used as a means of conveying results and translating ideas and findings. Photomicroscopy opened the possibility of observing and registering what can only be accessed by the human eye through a device. It exposed the necessity to think about ways to make the microscopic beings visible, so people can engage with them, even if they can't access their microscopic world.

Alternative photographic processes also consisted of visual and haptic

mediums to initially understand the subject and the context of the project, understanding the first month of life of a sea urchin. Using photographic outputs from scientific research was the first step - an introduction - to the natural sciences context. To an extent, these first pictures were the means of communication, or the first common language, tools between Marine Biology and Design. As will be explained later in this work, the photographic outputs of scientific research were the starting point of the development of this work.

The materiality was here important from a methodological point of view. Alternative photographic processes were used to explore the sense of touch, which digital photography is unable to impose.

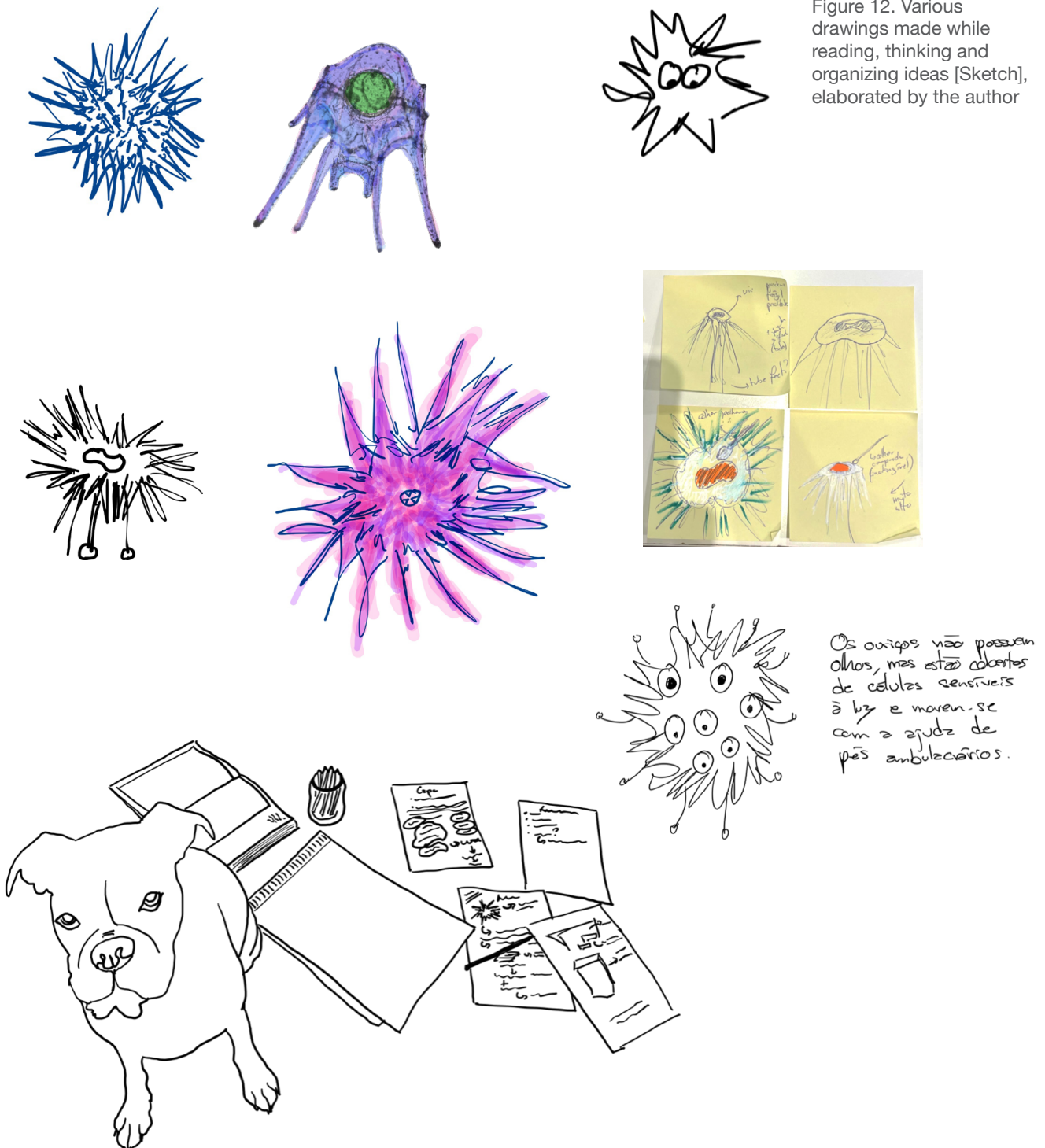
## Mapping

Mapping was extensively used as an idea organization tool, to make choices and explore potential paths. As explained by the author James Corner “mapping is perhaps the most formative and creative act of any design process, first disclosing and then staging the conditions for the emergence of new realities” (Corner, 1999, p. 216). Mapping assumed digital and physical formats. In earlier stages, where more determinant choices had to be made, there was natural steering to physical means, mainly with pencils and coloured markers. This was an indispensable tool throughout the process. Often maps were more serious, rigorous, and monochromatic (Figure 10), and other times they would contain humorous thoughts or little reminders (Figure 11). This dichotomy might have been inspired by designer Corita Kent’s Ten Rules (Annex 3), in particular by Rule 8 – “Don’t try to create and analyse at the same time. They’re different processes.” –, whose work was encountered during this project and became a reference. More formally, Lawson also describes this dichotomy in the design process under the terms



## Drawing

Drawing done through physical and digital media, was used to think visually, to generate ideas, to materialize an internal dialogue, and as a tool to translate – as in “to materialize”, to “give form” (Bispo, 2019; Zingale, 2016) - and communicate concepts that were apprehended but couldn’t be fully communicated in another way (Figure 12).



## 4. Photography Precedents

1912: Arthur Clarence Pillsbury - Photography and motion picture to advocate for nature

“One of the first reactions of seeing a reel of flowers growing and opening was to instill a love for them, a realization of their life struggles so similar to ours, and a wish to do something to stop the ruthless destruction of them which was fast causing them to become extinct.”

Arthur Clarence Pillsbury (1937, p. 25)

Arthur Clarence Pillsbury (1870-1946) labelled engineer, photographer, inventor, and filmmaker, was succinctly defined as “a man who solved problems with whatever tools were at hand or that he could invent.” (Pillsbury-Foster, n.d.; Williamson, 2022). Having for his graduation project in Mechanical Engineering at Stanford built the first circuit panorama camera, he pursued his visions by tinkering with engineering, botany, and photography. He would use apparatus like microscopes and x-ray machines, and tinker with and design equipment that would fulfil his need to study life above and underwater (Figures 13 and 14 contain pages of the book “Picturing Miracles of Plant and Animal Life”, from 1937, depicting biological processes of plants and life below water) (Pillsbury, 1937; Pillsbury-Foster, n.d.; Williamson, 2022).

The main idea brought from this precedent was, as Pillsbury did, to focus on the visual aspect of the outputs, to the detriment of a more scientific perspective, to hold the interest of the viewer.

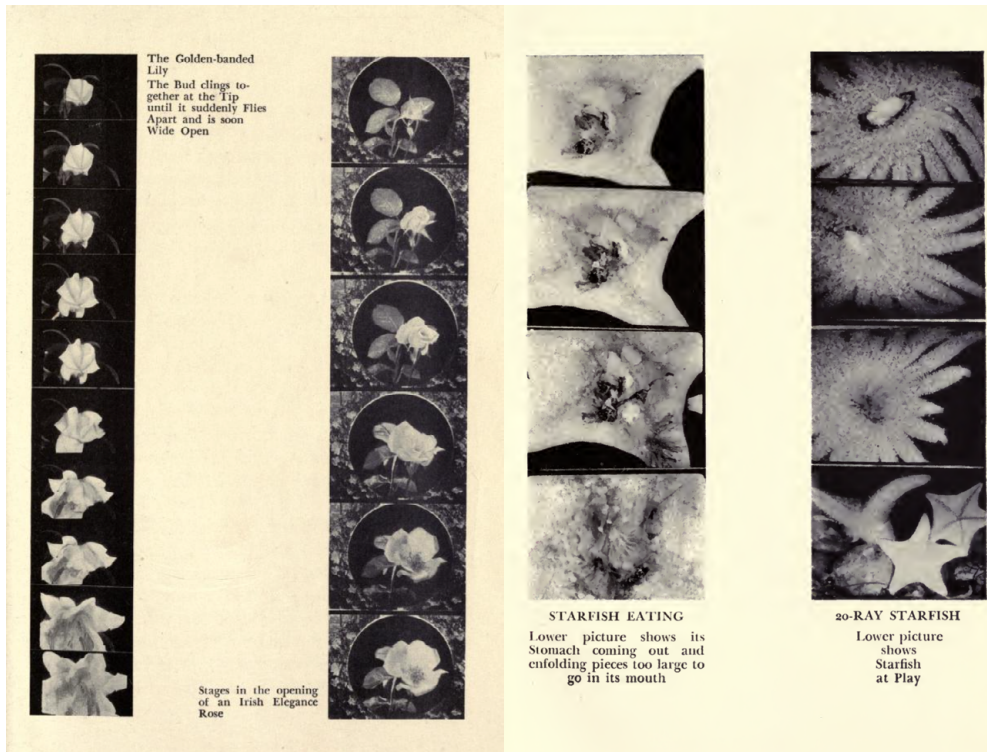


Figure 13. The Golden-banded Lily; Stages in the opening of an Irish Elegance Rose [Photographs], by Arthur C. Pillsbury, 1937, *Picturing miracles of plant and animal life*, p. 23

Figure 14. Starfish eating; Ray Starfish at Play [Photographs], by Arthur C. Pillsbury, 1937, *Picturing miracles of plant and animal life*, p. 165

As Pillsbury thought he could “instill a love for” (1937, p. 25) nature through photography while using photography to study the subject. In this work there was a strove to convey the emotion of empathy towards sea urchins through photography and drawing.

Through his work is possible to understand that alongside a great preoccupation in technical terms relating to the study of plants and marine life, the outputs of his work were destined to inform the wider public and comprehended carefully thought ways to reach that audience. In his book “*Picturing Miracles of Plant and Animal Life*”, while describing the calculations and the process of motion image making, Pillsbury reported he “realized a scene had to be very dramatic to hold the interest for over thirty seconds” (Pillsbury, 1937, pp. 22, 23), curiously, a time frame still explored today in social media for engagement purposes.

This precedent posed an inspiration on the possibility of bridging the gap between natural sciences and photography, and showed the timeless need to foster empathy towards the natural world.

## 1982: Powers of ten – 1977 – Philip and Phylis Morrison & The Office of Charles and Ray Eames

The book “Powers of Ten”, by Philip and Phylis Morrison and The Office of Charles and Ray Eames, published in 1982, constitutes a classic of scientific dissemination literature (Fiolhais, 2002; Morrison et al., 1982). It integrates scientific knowledge and visual media for communication purposes, contributing to the viewer’s notion and perception of scale and the mathematical concept of powers. The book constitutes an extension of the well-known film “Powers of Ten”, made by The Office of Charles and Ray Eames (1977). Besides creating a visual narrative of scientific facts about the universe, it constitutes a detailed account of the extensive research that went into making the film. The book draws inspiration from the illustration book “Cosmic View - The Universe in 40 Jumps” (Boeke, 1957), which depicts the macro and micro scales of the universe. The book uses a reference photo throughout the book, to maintain the perception of scale. The book provides a sense of connection to scales too abstract to be easily comprehended by humans, providing a basis for relational connection to microscopic beings and visual perception of the larvae scale (Figures 15, 16, 17).

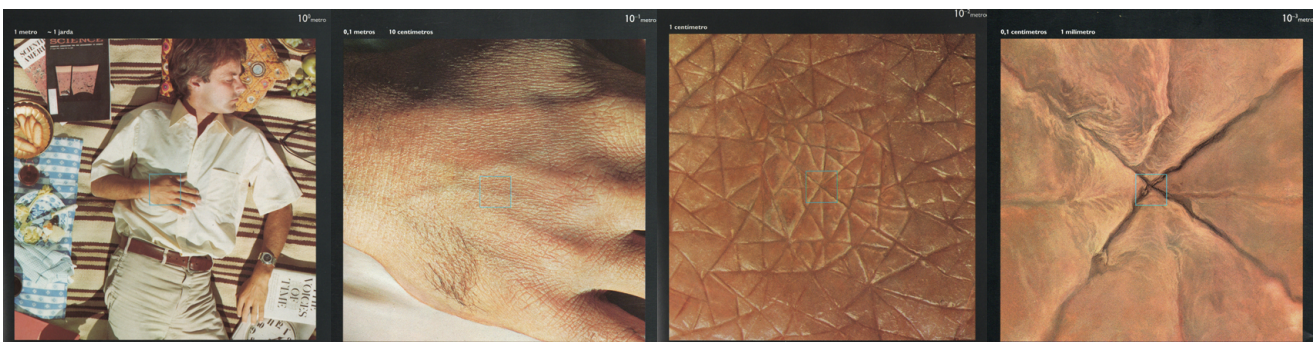


Figure 15.  $1^0\text{m}$ ,  $1^{-1}\text{m}$ ,  $1^{-2}\text{m}$ ,  $1^{-3}\text{m}$  [Photographs], by The Office of Charles and Ray Eames, 1977, Powers of Ten, pp. 81, 83, 85, 87

Note: These pages depict the reference photo, respectively, at scales of 1m, 1dm, 1cm, and 1mm

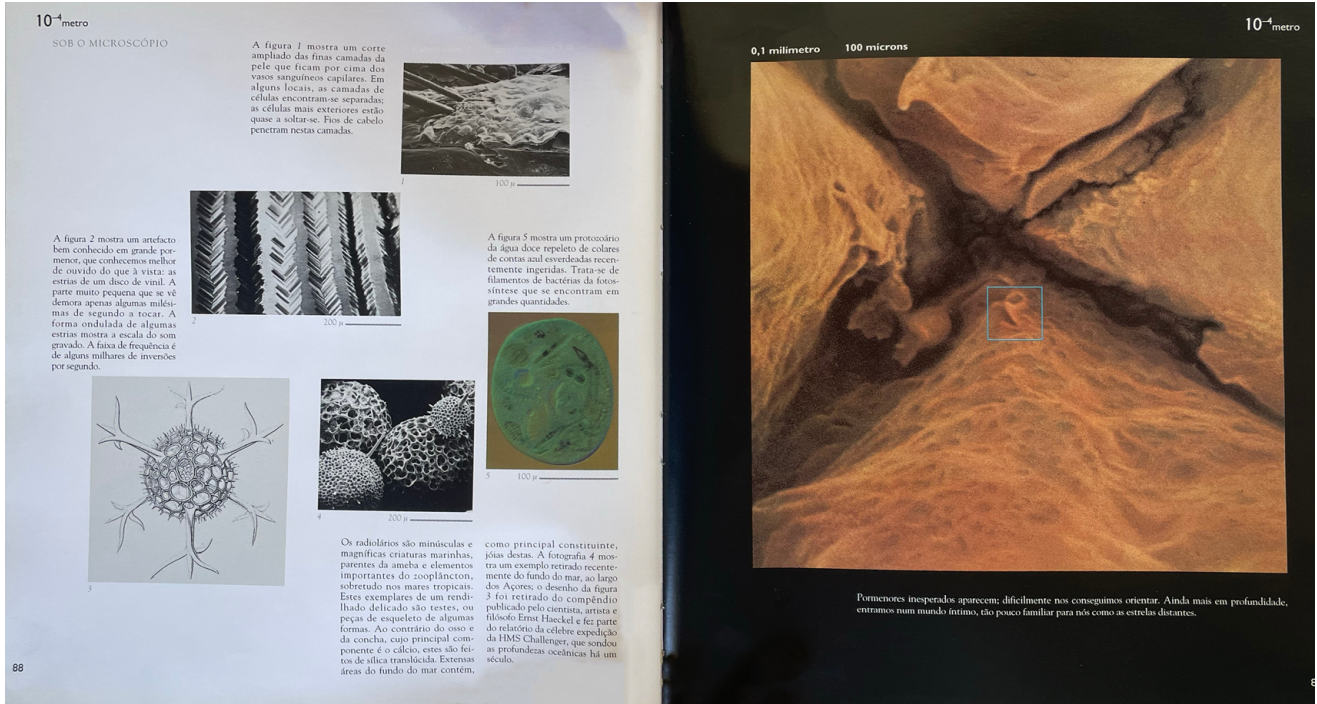


Figure 16. 1<sup>-4</sup>m [Photocopy], by Philip and Phyllis Morrison & The Office of Charles and Ray Eames, 1982, Powers of Ten, pp. 88-89

Note: Pages of the book depicting the 0,1mm scale and explaining what is possible to see at this scale.

Figure 17. Larva de ouriço com 16 dias, by Ana Gomes, 2023, Annex 1

Note: Photograph of a sea urchin larva at the scale of 0,1mm.

The book, through its narrative format, aims to use visual storytelling to communicate to the public scientific knowledge. As Pillsbury's work, "Powers of Ten" has an inherent purpose to bridge the gap between scientific knowledge and public understanding of things not perceivable by the human eye. In Pillsbury's case, the perception of time, and in "Powers of Ten", the perception of scale.

This precedent was especially important to acknowledge the importance of bringing microscopic phenomena into the human scale.

## Anand Varma – Science and photography: instilling a sense of wonder

“We tend to relate best to beings our own size. Photography can break this barrier by magnifying the subject and creating new perspectives we aren’t able to experience on our own.” Anand Varma (2023, p. 21)

Anand Varma stands out in contemporary photography when discussing the possibilities of merging Science and Photography for the purpose of knowledge dissemination. He leverages his knowledge of Biology and Photography to draw attention to the invisible wonders of the natural world, using photography as a “vehicle for creating a sense of wonder”, while providing scientists with new insights and data about various species (as an example, the documentation of developmental stages of a bee from larva to adulthood) (Hutchison, 2023). A great part of his work comprehends designing artefacts collaboratively that enable biological experiments to take place and enable new ways to photograph (Figure 18). When showing his work, he reveals an honest process of continuous trial, error and iteration, that sometimes takes many years to yield results (Curry, 2024; Hutchison, 2023; Nat Geo Live, 2015).

In his book “Invisible Wonders” (Varma, 2023), he shows how photography can explore size, time, light and focus to reveal what’s mostly invisible to the naked eye, while revealing techniques and works of various scientists and artists (Figure 18). Incorporating storytelling, his narrative style enables the wider public to relate to scientific phenomena emotionally. Through connecting people and science, he hopes to redefine people’s relation to nature, fostering a childlike sense of wonder towards the natural world (Hutchison, 2023).

Anand Varma poses a contemporary and ideal example of how science and art can co-exist in a symbiotic relationship while reaching towards a human connection to nature. This precedent greatly influenced the strive to navigate in different fields of knowledge.

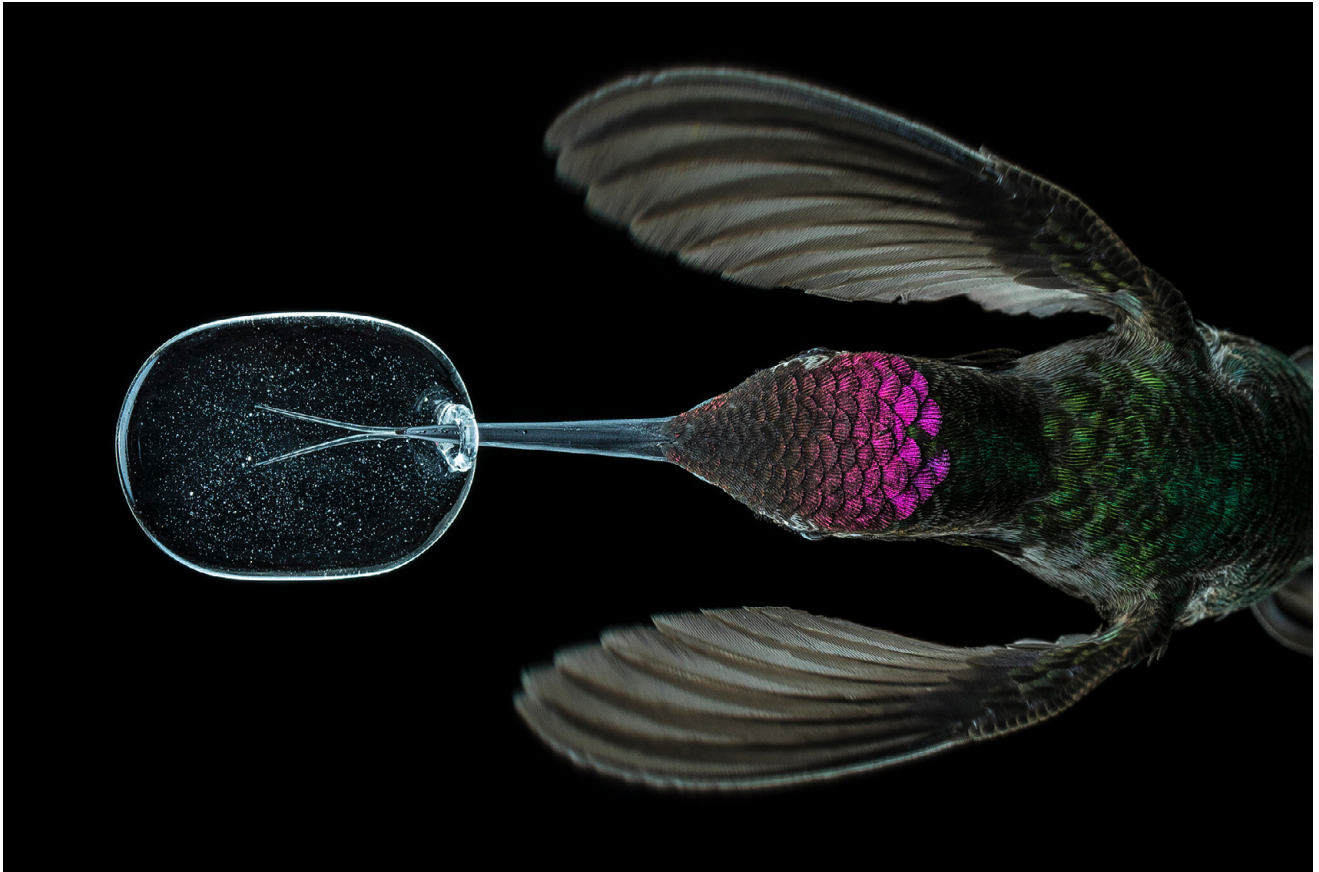


Figure 18. Hummingbirds [Photograph], by Anand Varma, n.d. (<https://www.varmaphoto.com/hummingbirds>)

Note: Hummingbird feeding of a glass vessel designed by Anand Varma collaboratively with a glassblower. The photograph registers for the first time the forked physiology of a hummingbird's tongue while feeding on artificial nectar. The photograph is one of the results from a 10-year collaborative project with a biologist studying hummingbirds (Varma, 2023, pp. 280-283).



Part

Design case

## 5. Living Surfaces

“Translation, especially in design, is Play, both intended as a game with rules to be followed and as a performance, but above all as a place for the free movement and mutual influence of the elements at stake” (Zingale, 2016, p.1071)

### 5.1 Project Description

Sea urchins of the species *Paracentrotus lividus* are the common sea urchins that can be found on the coast of Portugal. Sea urchins are key species in the coastal ecosystem “and can be considered bio-engineers of intertidal and shallow habitats” (Living Surfaces, 2024, Annex 2). They control the growth of macroalgae and by grazing, they excavate holes in the rocks, creating habitats for other species. They eat essentially photosynthetic organisms – they are basically herbivorous when food resources are not limited –, and are prey to teleosts, crustaceans, and molluscs. Even though the human species doesn’t describe itself as a predator of *P. lividus* in the literature (Boudouresque & Verlaque, 2020), they face an alarming decline in their population numbers due to intense harvesting for consumption. In fact, sea urchins are marine resources of high commercial value. Their roe is a gastronomic delicacy appreciated in some regions of the world. The common European sea urchin, *Paracentrotus lividus*, is the species with the highest commercial value and for this reason the most susceptible to overfishing, with several populations already practically decimated along the Mediterranean (Boudouresque & Verlaque, 2020; Correia et al., 2023; Gomes, 2019). For this matter, understanding what could be sustainable consumption,

will be a central question in future studies, as research into the human-sea-urchin relation moves forward.

In response to the declining numbers of *P. lividus* on the coast of Peniche, marine biologists in CETEMARES, are trying to create sea-urchins in the laboratory and settle sea-urchin larvae in substrates that can later be taken to *P. lividus* natural habitat to repopulate it. These substrates are being developed at LiDA by designers conducting research in materials where algae and microalgae can develop biofilm adequate for larval settlement. The substrates also have to be adequate for transportation into the wild and remain as shelters for the juvenile sea urchins.

The author manages LiDA's website and to communicate the project some content was delivered for that effect (Annex 1 and 2).

The visual content included some photographs of the microscopic sea urchin larvae, along with their natural habitat and some material experiences conducted at LiDA (Figures 19-21 and Annex 1). The uniqueness of the photographs of the microscopic beings instilled in the author a sense of wonder that led her to ask if they could be used for the exploration of alternative photographic processes from the 19th century, in a workshop she would be undertaking.



Figure 19. Sea urchin larva with around three weeks [Photomicrograph], by Ana Gomes, 2023

Figure 20. Sea urchin larva after one month [Photomicrograph], by Ana Gomes, 2023

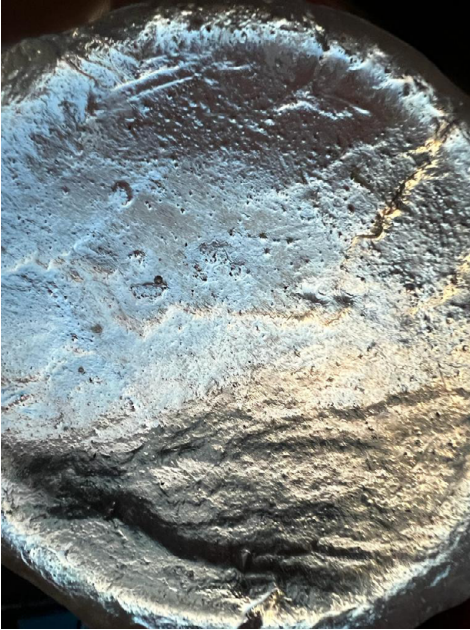


Figure 21. Substrate  
in poured glass  
[Photograph], by Diogo  
Saldanha, 2023

It was only after the materialization of this exploration into a prototype for an instant book (conducted during a workshop on alternative photographic processes), that the challenge of communicating the project surfaced. In the workshop was solely conducted a playful exploration of photographs relating to an ongoing research project, without any design brief.

When the challenge of communicating the project was set, it was explained that for this project to succeed, people would have to abstain from destroying the natural habitat of the sea urchin.

In order to communicate the project, the starting point was to understand its context and there was one question that recurrently surfaced: “How to communicate the project to people who aren’t interested in sea urchins?”.

The pursuit for an answer was greatly influenced by the book “The Art of Relevance” (Simon, 2016), which caused a reformulation of the previous question to “How to make sea urchins relevant?”.

Some of the doubts and ideas that emerged in this context could be

formulated in the following questions:

“How to foster empathy towards **microscopic animals** that are seen commonly as **food**?”

“How to **make people care** for little marine animals that look like sticky pompoms and “just stay there”?”

“How can the pretty shells found on the beach be seen as remains of dead animals we should **care** for?”

It seemed the prevailing factor to suggest the relevance of sea urchins to the community would be **empathy**. At this point, the main question was once again reframed, arriving at the central question during the time frame of the present work: “**How to foster empathy towards sea urchins?**”

In this context, arose the supposition that education, especially of the consumers and local population, will play an important role in resolving this puzzle. Also, that education conveyed through a communication project, could play an effective part within a complex solution for the detected system of problems.

Before proceeding to a path where the envisioned public for the message is studied (that research was relegated to further research, to be pursued in doctoral studies), it was decided to carry on the study of sea urchins and the production of visual outputs about them to act as communicational tools. It's understood that this choice was a consequence of the option of exploring a design approach instead of using a human-centred design process, thus making the sea urchin the prevailing object of study throughout the work narrated in the present report. This option made it possible to arrive at different outputs that

most probably wouldn't have been produced using a human-centred framework.

## 6. Phase I

### 6.1 Visual exploration through alternative photographic processes

The photographic investigation, documented in part II of the present report, is divided into two parts. On the first, the work started with images gathered by researchers who were already in the project (Figures 19-21 and Annex 1). This first visual investigation was made using alternative photographic processes. The author enrolled in the Photographic Workshop "Alternative Dreams" at Imagerie – Casa de Imagens, where the alternative photographic processes Cyanotype, Gum Bichromate, Gumoil and Van Dyck Brown were taught. In the midst of marvel and curiosity for the photos used for communication of the project "Living Surfaces" on LiDA's website (Annex 1), as mentioned earlier, the author asked if she could use them to experiment with alternative photographic processes.

The author chose to use three photographs of the project to learn the techniques of cyanotype, cyanotype toning and gum bichromate as the aesthetical value produced by these techniques seemed adequate to portray the larvae and their maritime environment.

### 6.2 Cyanotype

## What is

Cyanotype is an alternative photographic process with history calls for some notes, especially due to its use as a photographic medium to document and disseminate scientific knowledge.

Atkins was a scientist who used a photographic system for the first time to document scientific findings and through the use of the cyanotype technique, produced the first book ever published illustrated with photography, "Photographs of British Algae: Cyanotype Impressions". Anna Atkins is also considered to be the first women photographer. It's possible that she learned the cyanotype process directly from its inventor, Sir John Herschel. Herschel discovered that the combination of ferric ammonium citrate and potassium ferricyanide produces a photosensitive emulsion that, when exposed to light, renders a deep blue, mostly known as Prussian Blue. Herschel invented this process in 1842, only three years after the invention of photography, and used it to copy his notes. The ease of use and low cost of the chemicals promoted the main use of the process throughout history as a copy machine. In consequence, the word "blueprints" is still often used to refer to technical drawings in architecture and engineering (Anderson, 2019; James, 2016).

## Technique

Albeit cyanotype constitutes a simple process that mixes two chemicals, ferric ammonium citrate and potassium ferricyanide, there's an immense variety of formulas that mix these chemicals in different proportions or add other chemicals (Anderson, 2019). In the photographic workshop

was used a traditional formula previously tried and tested in different papers by Magda Fernandes and José Domingos, the mentors of the workshop.

To yield the following results (Figures 22-25) were mixed in equal parts a solution of potassium ferricyanide with a concentration of 8% and a solution of ferric ammonium citrate with a concentration of 20%. The quantity of chemistry per paper used the reference of 3ml of mixed solution for an A4 watercolour paper.

The digital image was printed on acetate for photolithographs, to produce digital negatives. As cyanotype is a contact printing process, the negatives have to be printed on the desired scale for the result. The photosensitive emulsion was coated onto watercolour paper with a hake brush and after drying, exposed to UV light under the acetate with the digital negative. UV lamps render more consistent and precise results than natural light exposure (James, 2016, pp. 179-183).

The time of exposure for each negative is decided after conducting a test. Figure 22 shows the test made for the first cyanotype impression. On a watercolour paper, Fabriano 250gm, was conducted a test by sequentially exposing strips of the paper for 30 seconds. The preferred time of exposure (3 minutes) was then used to print the final cyanotype (Figure 23). After exposure, cyanotypes are washed in tap water and remain fixed in the paper. Instead of running water as widely done (Anderson, 2019; James, 2016), cyanotypes were washed in a sequence of three baths with small amounts of water. Only the first bath is discarded after one use and the second is used as the first bath of the next cyanotype, and so on. This method constitutes a sustainable practice, that greatly diminishes the amount of water used and yields good results and fixed images.

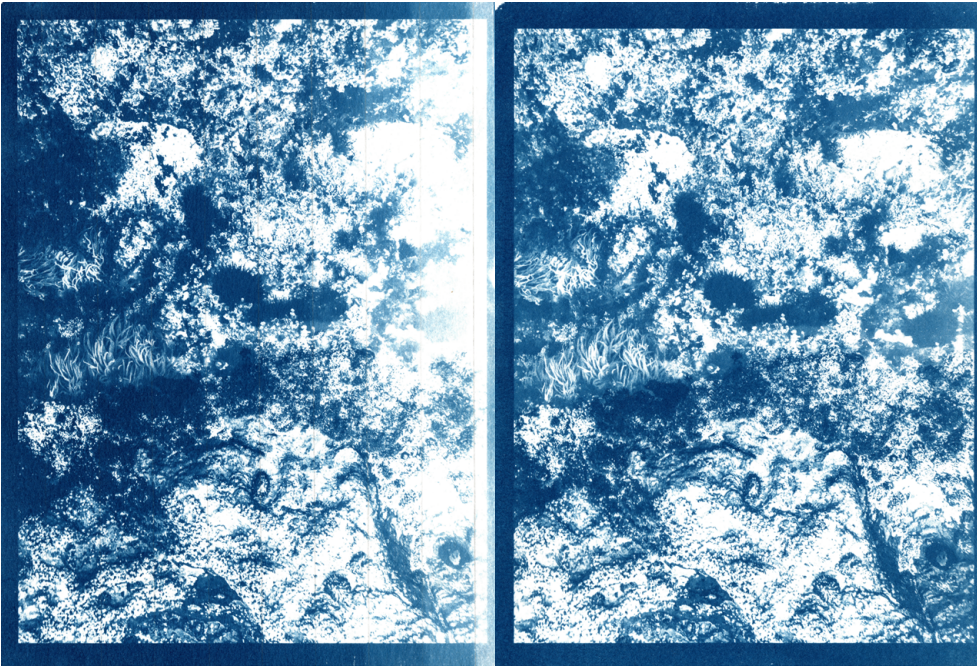


Figure 22. Cyanotype test for exposure time [Cyanotype], elaborated by the author

Figure 23. Cyanotype of shallow seabed area [Cyanotype], elaborated by the author

The described method is used to test each negative and each type of paper, and was later used for every cyanotype produced.

### 6.3 Cyanotype toning

When the colour blue is not the most indicated for the subject or the author of the work wants to convey some meaning through the use of colour, it's possible to tone cyanotypes into other colours.

To experiment with this method, were made two cyanotypes with an exposure time of two minutes, through the process described above (Figure 24). One of the photographs was then bleached in a solution of water with a small amount of sodium carbonate (an alkaline solution). This process turns the blue into yellow (on removing the yellow, James, 2016, p.191). The photograph is then immersed in a strong solution with a chemical reagent. Various agents can be used, such as wine, coffee, tea, oak apple, and onion skin (Anderson, 2019, pp. 107-108; James, 2016, pp. 189-191). The cyanotype was immersed overnight in a strong infusion of oak apple powder and then dried (Figure 25).

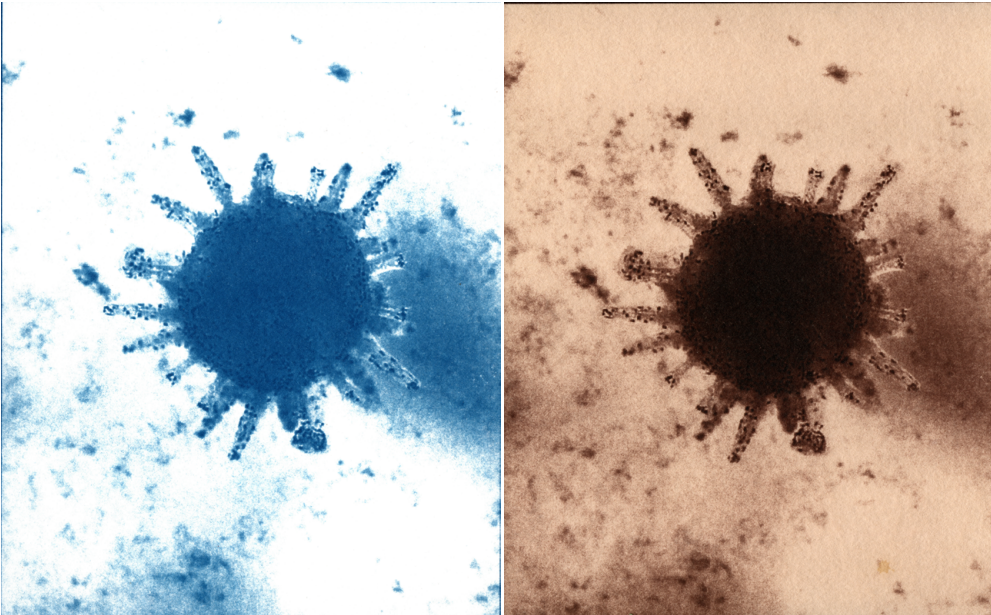


Figure 24. Cyanotype of a sea urchin recently settled [Cyanotype], elaborated by the author

Figure 25. Cyanotype toned with oak apple [Cyanotype], elaborated by the author

The result produced an earthy brown that wasn't suited to the subject, but some tests being conducted in the workshop with green tea showed some promise as they rendered a nice shade of brown that gave a sense of holding an old photograph of some bygone existence without the connotation of earth being so apparent. The option to use green tea on the prototype later described derived from this fact, as it conveys a nostalgic feeling appropriate for portraying an endangered species.

## 6.4 Gum bichromate

The gum bichromate process, as cyanotype, is developed solely in water, but uses different chemicals and the colour is not obtained from the reaction of chemicals, but from the use of watercolours. This provides an almost infinite palette that is possible as a consequence of the diversity of watercolour brands and their combination with different papers. The complexity of the process resides in the variability that a small change in any of the agents of the formulas of papers and watercolours can produce (James, 2016).

For this process, was used a combination of Hahnemule Platinum Rag

300g/m<sup>2</sup> paper and Talens Rembrandt watercolours. The formula used combined 0,7ml of Arabic gum, 0,65ml of a 10% solution of potassium bichromate and 0,42g of watercolour for A5 paper.

As the test showed that bigger times of exposure had to be set (Figure 26), to obtain a good result was needed a 15-minute exposure (Figure 27).

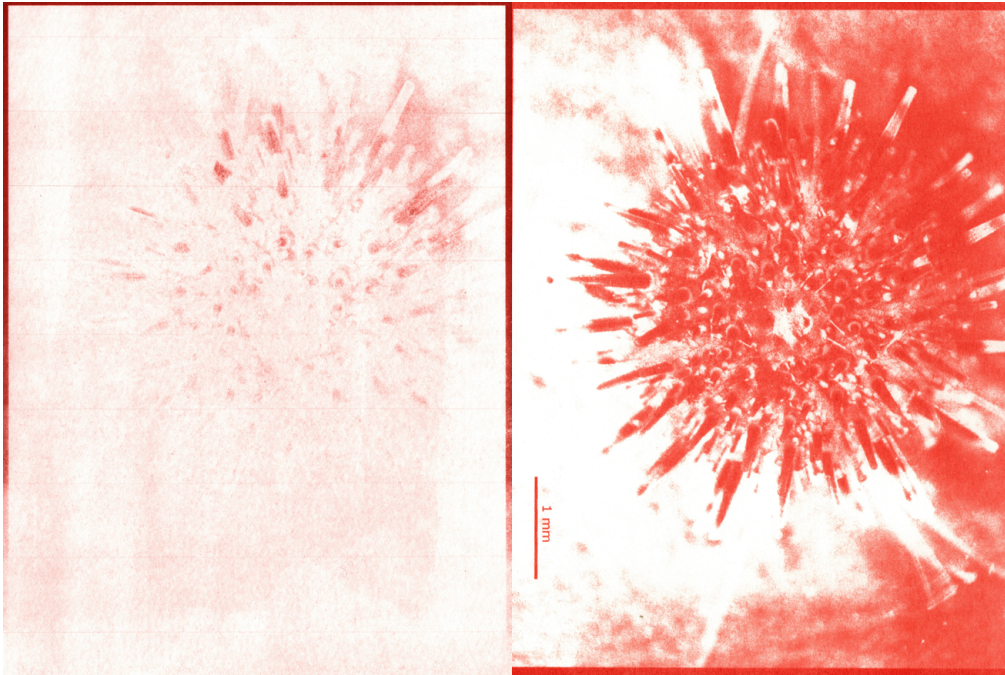


Figure 26. Gum bichromate test for exposure time [Gum bichromate print], elaborated by the author

Figure 27. Sea urchin after larval development [Gum bichromate print], elaborated by the author

300g/m<sup>2</sup> paper and Talens Rembrandt watercolours. The formula used combined 0,7ml of Arabic gum, 0,65ml of a 10% solution of potassium bichromate and 0,42g of watercolour for A5 paper.

As the test showed that bigger times of exposure had to be set (Figure 26), to obtain a good result was needed a 15-minute exposure (Figure 27).

This process showed promising results because of its diversified palette and was chosen to be used alongside cyanotype to produce a prototype for a book that showed the metamorphosis of a sea urchin larva during its first month of age.

## 6.4 Prototype for an instant book

After learning and experimenting with the techniques, the attendees were invited to do a project in the last three days of the workshop, using the techniques learned.

Inspired by Anna Atkins's book "Photographs of British algae: cyanotype impressions" (1843) (Figure 28) it was decided to produce a book that depicted the metamorphosis of sea urchin larvae, which happens during the first month of life.



Figure 28. Laminaria phyllitis [Cyanotype], by Anna Atkins, 1843, "Photographs of British Algae: Cyanotype Impressions".

Note: Page from the first book ever published illustrated with photography (Atkins, 1843; James, 2016).

This miniature book, was planned to be made with only one sheet of paper, printed on cyanotype and have slits to insert photos in gum bichromate, a detail reminiscent of sticker books with scientific illustrations given to children in the 90's.

The output of this first phase was an instant book that tells the first month of life of a sea urchin larva and shows its habitat.

The miniature book followed a design described by Esther K. Smith in “How to Make Books” (2007) as an “instant book”. It was decided to print the book in cyanotype (Figure 29) and then slide photographs in gum bichromate into the slits, which would add an interactive feature to the book. When printing the basis of the book it was also made a test of the photographs with cyanotype.

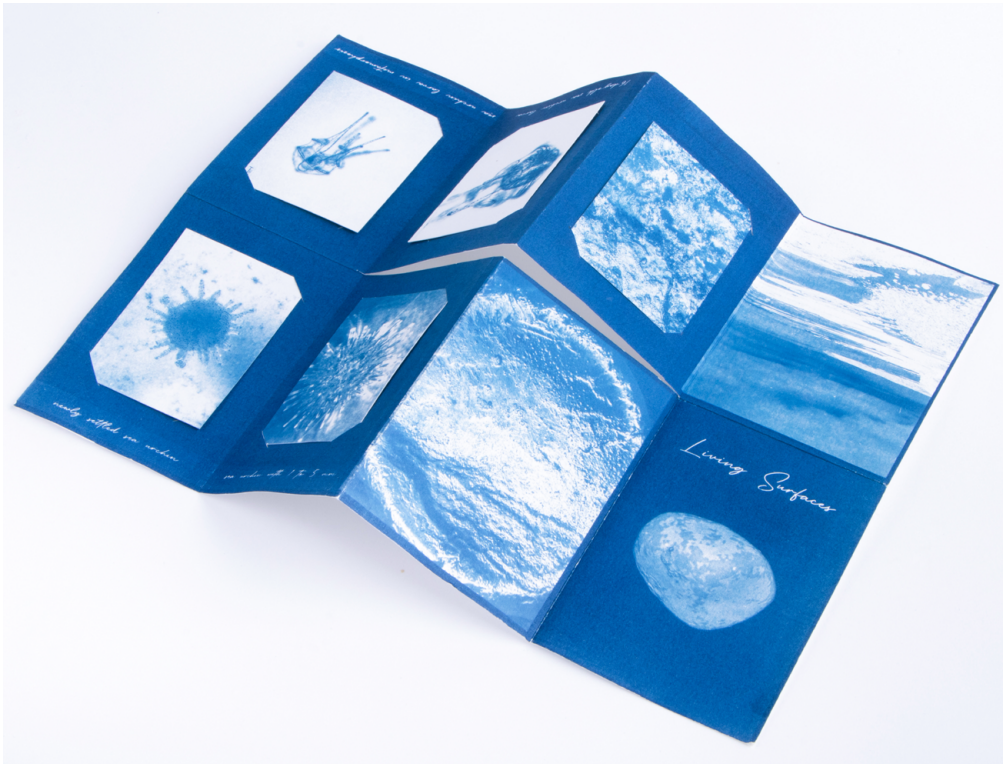


Figure 29. “Living Surfaces”, a book in cyanotype [Photograph], by Pedro Cá, 2024

The photographs were then printed in gum bichromate, using orange watercolour (Figure 30).

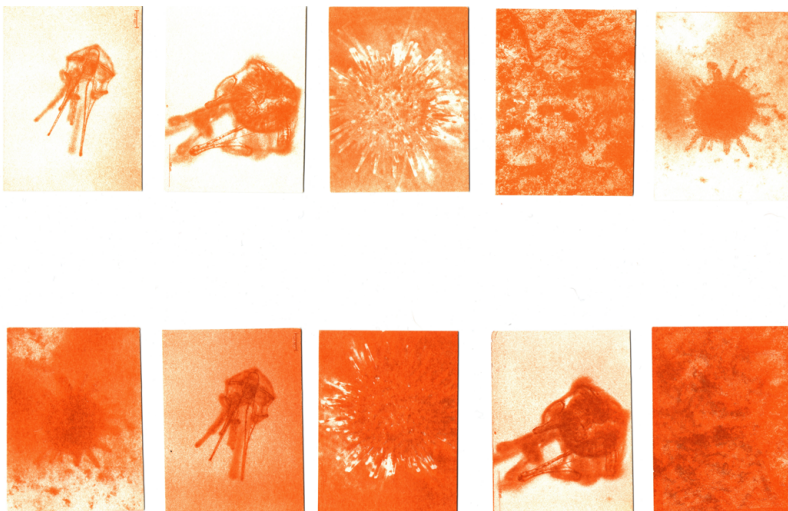


Figure 30. Movable photographs in gum bichromate [Gum bichromate prints], elaborated by the author

When testing the orange photographs in the book it was decided to make two more versions of the photographs so they could be swapped in the book according to preference of the viewer, which would make the book more interactive. As there were no more photographs, the versions could vary only in colour.

It was made a version of the movable photographs with cyanotype toned with green tea (Figure 31) and a version in gum bichromate with yellow watercolour (the colour was chosen for being complementary of the blue characteristic of cyanotypes, and the quantity of yellow would range about 1/3 of the area covered with blue, thus supposed to produce a contrast pleasing to the eye) (Figure 32).

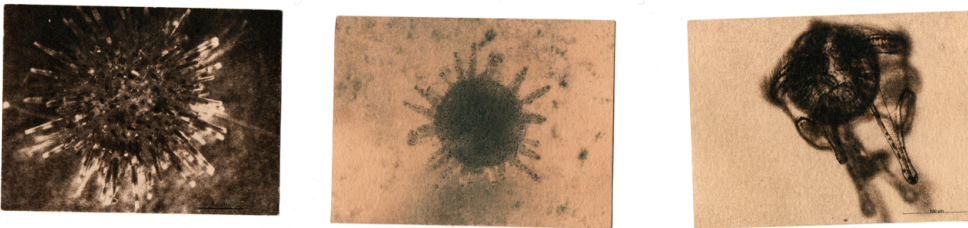


Figure 31. Movable photographs in cyanotype toned with green tea [Toned cyanotypes], elaborated by the author.



Figure 32. Living Surfaces instant book with movable photographs [Photograph], by Magda Fernandes, 2023

Note: Prototype for instant book Photo with movable photographs in cyanotype and gum bichromate with yellow watercolour

In the end, it was decided that the best results were attained using only cyanotype (Figure 33).

This book can be further explored, enabling to mix and match different photographs of the different stages sea urchin larvae go through. Making movable photographs could be also an activity to be explored as a pedagogical tool to communicate the project. This book, by depicting the first month of age of a microscopic animal in an interactive way is adequate to raise awareness and foster empathy towards sea urchins.



Figure 33. Living Surfaces instant book [Photographs], by Pedro Cá, 2024



## 7. Phase II

### 7.1 Larval development and settlement experiment

The present part of the report narrates the accompaniment of a larval development and settlement experiment at CETEMARES. The species followed was the purple common sea urchin (*Paracentrotus lividus*) the local species that has population in Peniche. This phase can't be truly described as an observation of the experiment. For this phase to take place, times for observation had to be carefully set up with the marine biologists. For that, the main researcher chose the best times for larval development showcase (larvae go through some paradigmatic stages during metamorphosis). At times microscope slides with selected samples had to be prepared especially to be photographed. Photographic sessions also had to be short, because larvae can die from the heat of the microscope lamp. Often, scientists were also analysing the samples, so photography had to be as unobtrusive as possible, for research to be conducted with minimal interference. This phase was crucial to decentralize the human from the Design process and study the role of Design in an interdisciplinary context.

#### Beginning of larval development experiment | 20.11.23

The beginning of larval development was initiated with an artificial spawning induction in a laboratory context. Even though it was not the spawning season, marine biologists tried to initiate the larval development experiment in November, to have time to repeat the experience, as natural spawning had occurred previously. The artificial

spawning induction experiment wasn't successful, so no larvae were born. The results revealed the laboratory would be a difficult place to photograph given the distribution of natural and artificial light and the refraction of light from the white countertops. The photographs collected that day were all overexposed (parts of the image had too much light) to be able to collect as much information from the sea urchins as possible (Figures 34-35).

One of the expected outcomes was to be able to produce cyanotypes as clear and crisp as possible to resemble 19th-century cyanotypes from Anna Atkins but show their potential nowadays with the technological possibility of digital negatives, and therefore of producing cyanotypes of microscopic beings.



Figure 34. Sea urchin showing its 5 teeth [Photograph], elaborated by the author

Figure 35. Marine biologist showing a gonad (roe) [Photograph], elaborated by the author

Note: Photographs showing technical difficulties in exposure and white balance.



## Visiting MARE | 1.03.24

On that day the main researcher showed the laboratories where experiments with sea urchins were being conducted, and the aquariums where the specimens were maintained (Figures 36-37).



Figure 36. Sea urchin munching on a corn-based preparation, holding it with his tube feet [Photograph], elaborated by the author

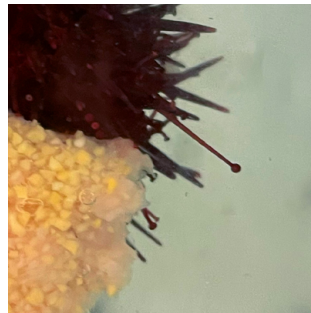


Figure 37. Detail showing a tube foot (these tube feet are spread through their whole body) [Photograph], elaborated by the author

It was not possible to collect photos because of technical difficulties with the size of the T-ring to microscope adapter and SD card problems. Only a photo of *Rhodomonas* microalgae was taken with a handheld smartphone through the microscope (Figure 38). These microalgae are commonly used in scientific research and aquaculture because of its nutritional value (Gomes et al., 2022).

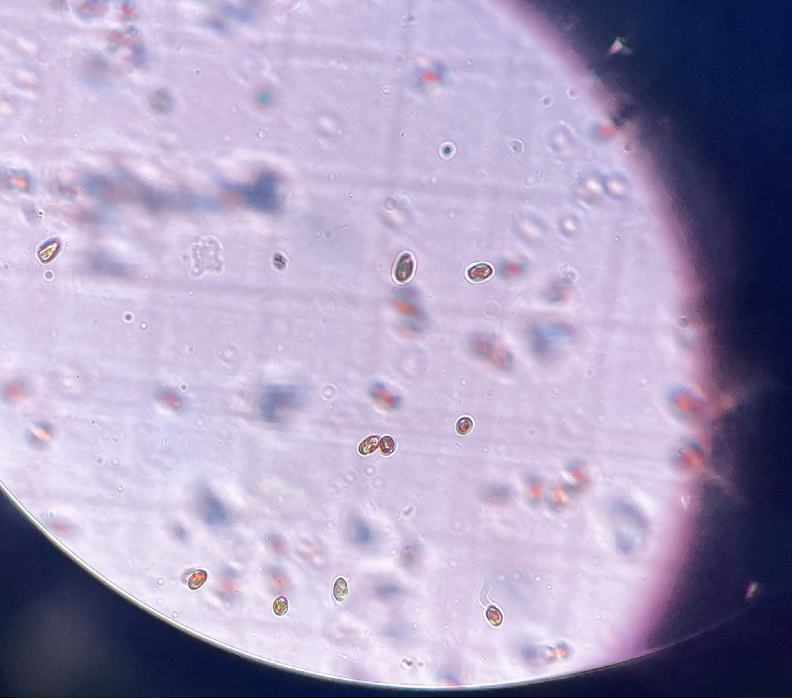


Figure 38. Rhodomonas [Photograph], elaborated by the author

Note: photograph taken with a smartphone through the microscope

On that day, some biological samples of sea urchins used in the artificial spawning induction and microalgae were preserved in a solution brought from the lab to study technical photographic issues that could arise and be equipped for them.

1st experiments | 2.03.24



Figure 39. Preparation for first autonomous study [Photograph], elaborated by the author

Note: Microscope, adaptor camera-microscope with Barlow lens and sea urchin specimens preserved in a solution of sodium hypochlorite (bleach).

Figure 40. Samples [Photograph], elaborated by the author

Note: Samples of Rhodomonas, sea urchin larvae, sea urchin shells and dried encrusting corallines (an alga that grows 2mm a year).

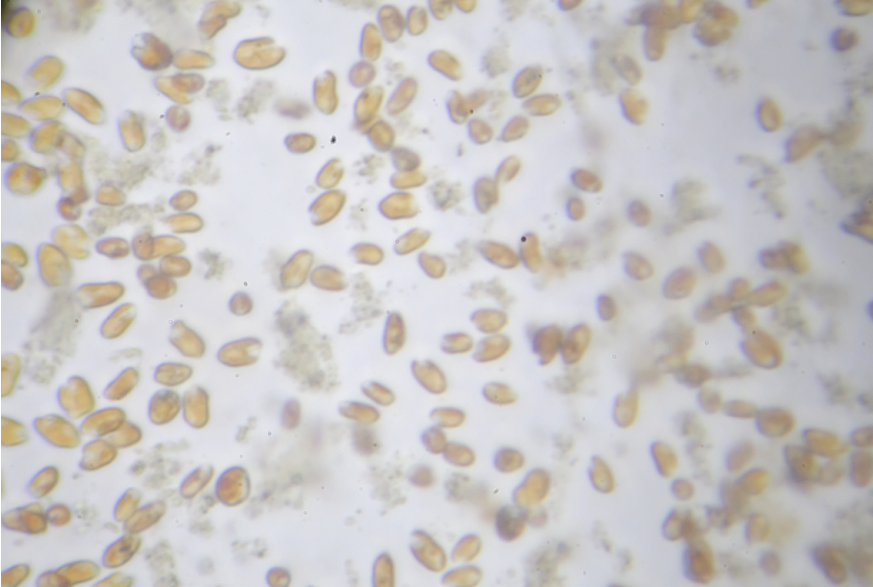


Figure 41. Rhodomonas on home microscope [Photograph], elaborated by the author

Note: Rhodomonas photographed with camera mounted on microscope with T-Ring mount and 2x Barlow Lens

In a domestic microscope, neither with a Fujifilm X-E3 camera, with the T-Ring mount, and a 2x Barlow Lens, nor with a microscope camera, the best results achieved didn't yield satisfying outcomes (the equipment and samples can be seen in Figures 39-43).

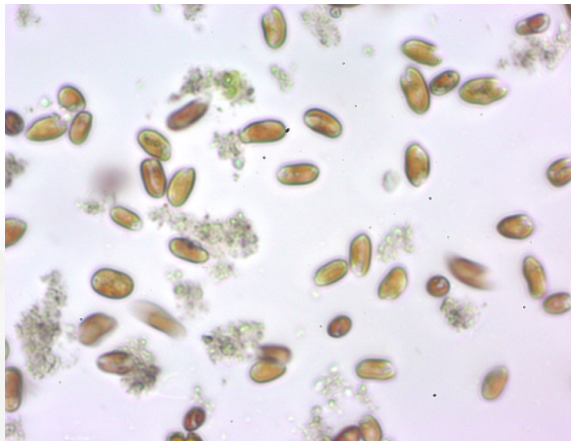


Figure 42. Microscope camera [Photograph], elaborated by the author

Figure 43. Rhodomonas [Photograph], elaborated by the author

When compared with the photograph taken with a handheld smartphone at the laboratory, it became clear that further experiences could not be pursued outside of the laboratory or with the equipment used.

To nonetheless be able to produce visual outputs, and to somehow respect the biological samples – in retrospect, a moment of empathy for the life of the sea urchin translated into a design decision –, it was

decided to explore visually the idea of sea urchins' consumption, or sea urchins as food. These images also constitute an aid to understanding the colour variability in this species (Figure 44).

The results of this visual exploration are better described in phase III and can be seen in the photographic narrative "To plate or not too plate" - Appendix 1.



Figure 44. Macarons or urchins at play? [Photograph], elaborated by the author

Note: This image was annexed to the page of the master's dissertation of Ana Gomes (Gomes, 2019), one of the marine biologists working on the project, to visually translate the range of colours the species, known as purple common sea urchin, can present.

## Urchins with two days | 11.04.24



Figure 45. Larva with less than three days [Photograph], elaborated by the author

Note: A cylindric shape shows the digestive system developing.

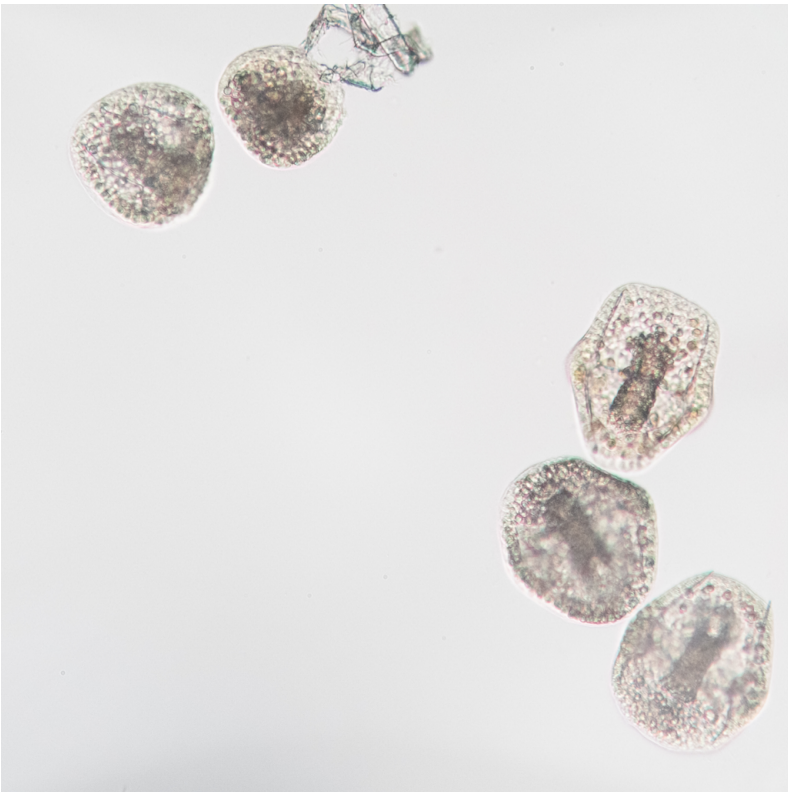


Figure 46. Larvae with less than three days show different forms [Photograph], elaborated by the author

In this session was registered the beginning of the larval development experiment that was followed up for a month. The larvae had less than three days (Figures 45-46), and parallel to the larval development, some substrates produced by LiDA's team were being tested for microalgae growth (Figure 47).

The photomicrographs were taken in live view mode - using Fujifilm's

Cam Remote mobile app -, to reduce the camera shake inherent to physical pressing of the shutter release button of the camera, and to have a better view of what was being captured. The 5MP microscopic camera was also tried and immediately discarded because the image gathered with the camera had more quality.



Figure 47. Red clay substrate with biofilm [Photograph], elaborated by the author

During this session, the researcher responsible for the project posed the challenge to participate in a photography contest promoted by MARE and the School of Tourism and Marine Technology of the Polytechnic Institute of Leiria (available at [https://www.mare-centre.pt/en/photo\\_competition](https://www.mare-centre.pt/en/photo_competition), at 24.07.24) with a photo taken during the experiment.

When analysing the photos afterwards it was clear that even parts in focus hadn't enough quality to achieve the envisioned results. It was also concluded that some images had only enough quality to be seen in very small formats. Facing this challenge, further study was conducted to prepare for the next session, with informal talks with schools' video and image technicians, colleagues and teachers, and internet browsing, without gaining any insight. It was decided to experiment in the next

session with a newer camera with a better sensor to acquire images that could at least reach an A5 dimension with good resolution when printed.

### Larva with 1 week | 19.04.24

In this session, it was brought another camera, with a better and newer sensor (Fujifilm X-T5), to be able to register more information and eventually have better results.

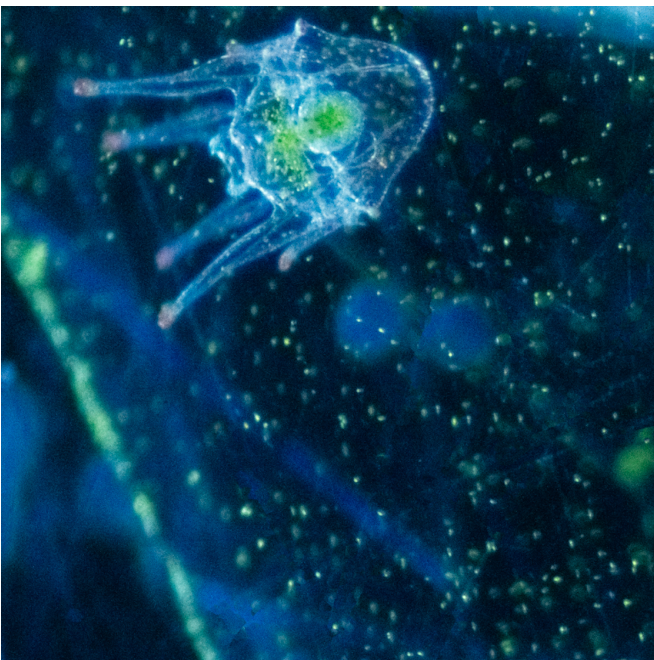


Figure 48. Sea urchin larva with a full stomach, surrounded by microalgae [Photograph], elaborated by the author

The samples of sea urchin larvae that were observed that day came from a pedagogical event where they were shown to students and had been fed a great amount of microalgae (Figure 48).

In this session the photographs were taken through a new acquisition software (XApp – Fujifilm’s remote-control app), in a smartphone, to reduce camera shake.

Considering the subsequent information arises the necessity to consider some aspects of photomicroscopy. The different focuses are manually adjusted on the microscope, which doesn’t yield the best results. In later

investigations to alleviate this technical problem it was also studied and discarded the possibility of setting aperture inside the camera to have a broader range of focus (in simplistic terms, aperture determines how much of the image is within focus). In photomicroscopy, the microscope acts like a manual lens, so it's not possible to adjust the aperture and focus is adjusted by manual rotation of a wheel that sets the studied object closer or farther from the lens.

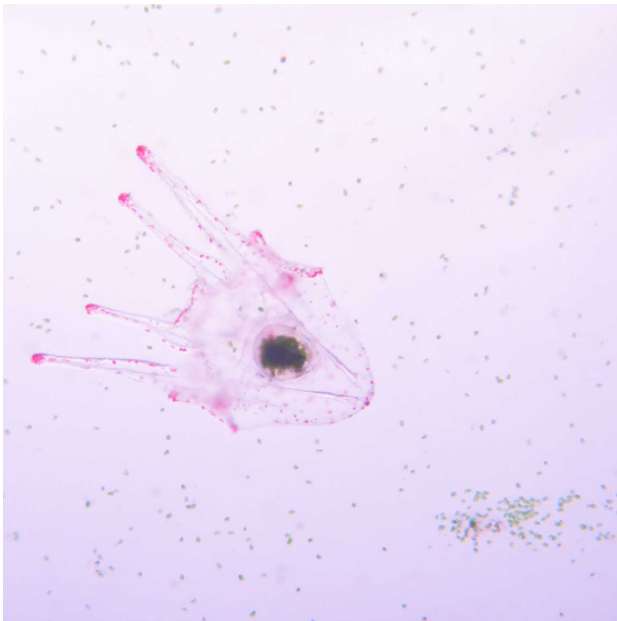


Figure 49. Example of focus stacking [Photograph], elaborated by the author

Note: The image comprised of five photographs taken with different focusing distances and stacked into one photograph on Photoshop. The photographs were taken moments after the camera malfunction.

During observation of a particular larva, it was possible to photograph a sea urchin defecating, which constitutes an event unlikely to be watched. Unfortunately, the camera malfunctioned and tried to save the photographs through tethering instead of in the SD Card, so the moment wasn't registered.

It was so exciting to watch such a biologically mundane act occurring at the scale of two hundred nanometres (1000000000 nanometres = 1 meter), that what was immediately recognized as a precious moment for communicating these beings and conveying empathy for them was lost due to technical malfunction.

When viewing the photographs on a bigger display, it became clear

that despite having better quality, they weren't enough to achieve the desired results. One of the equated possibilities was human error when manually focusing on the microscope, due to lack of knowledge.

Nonetheless, the photographs taken just a few moments later were posteriorly stacked into one photograph (Figure 49). The focus stacking technique was made in a semi-manual way. The focus stacking technique comprises taking multiple photos of the same scene, each with a different focus point (which was made manually), and then combining these images using Photoshop to create a final photo where all elements, from the nearest to the farthest, appear sharp and in focus. This method is especially useful in macro photography and landscape photography where it is often difficult to get everything in focus in a single shot.

Upon the difficulties faced, further study was conducted to prepare for the next session, with informal talks with schools' video and image technicians, colleagues and teachers, and internet and book browsing, without again gaining any insight or knowledge that could be immediately used.

Pertaining to the analysed information it was found that information is scattered and sparse, and technical information on photomicroscopy is essentially directed to scientists. It was considered that there was a need to also investigate more into Optics to understand for example how to surpass issues with chromatic aberrations (hence understanding and revising some more concepts from Physics). It was concluded that further study on various technical aspects should be conducted, but there was the necessity to accept that it wasn't possible within the given timeframe and that it would constitute too much of a deviation from what constituted a design project and not a photographic one.

## Larva with 2 weeks | 26.04.24

In the pursuit of images with better quality, it was taken the option to photograph on live view mode using an iPad (with XApp app) instead of a smartphone, so that the bigger display would facilitate the manual focus adjustments and hence enable the acquisition of better photographs.

In this session, there were marine biology trainees at the lab who became very interested in the work that was being done and demonstrated great curiosity in seeing the photographs that were being taken. During the session, the photographs were exhibited to the scientists who observed with curiosity while the photographs were being taken and revealed excitement for the possibilities that could derive from interdisciplinary collaborations.

Even though marine biologists demonstrated appreciation for the captured images, it could be seen in the tablet display that it still wasn't possible to capture photographs with the envisioned quality.

Previously it had been discussed the use of the laboratory's system of image acquisition, which was not possible with the lab's computer. It was taken a personal laptop to the lab with the software installed. As the necessary software is restricted to licensing that must be verified by the manufacturer and stated the motivation for use, it was not possible to use it.

While photographs were being captured, it was detected a protuberance in a larva. Upon detection, the Marine Biologist asked for a photo of the malformation (Figure 50) so she could discuss the finding with colleagues.

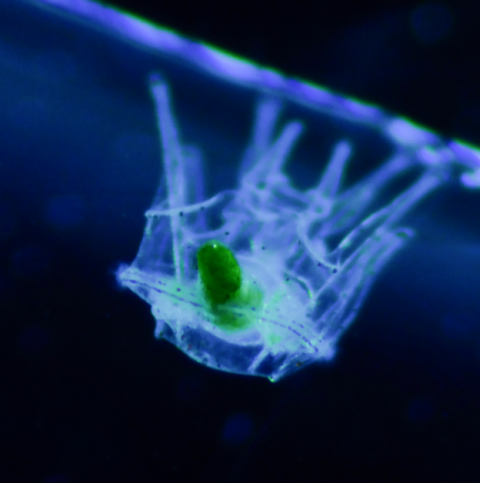


Figure 50. Photograph of a malformation detected during the photography session [Photograph], elaborated by the author

In an experimental approach, the only parameter that could be changed from the session of observation of sea urchins with 48h, which is suspected to cause issues, such as chromatic aberration, was the 2x Barlow Lens inserted in the camera-microscope adaptor. Due to unavailability and economic constraints, it was not possible to change this parameter.

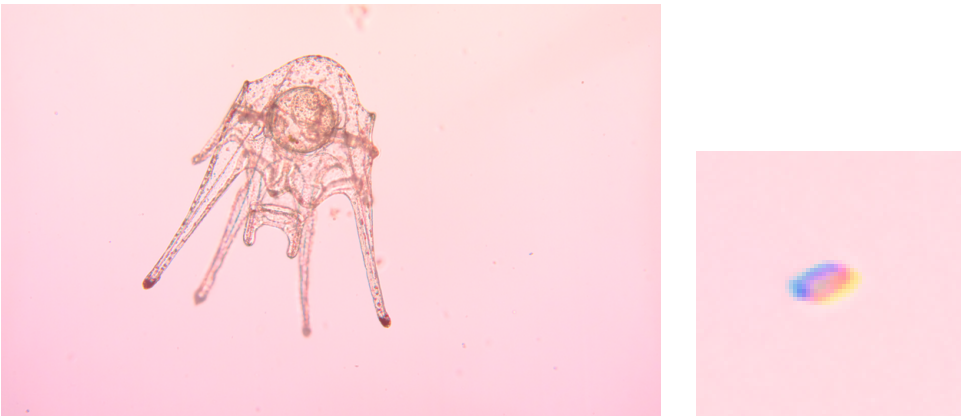


Figure 51. Larva with two weeks [Photograph], elaborated by the author

Note: Technical problems with detail, white balance and chromatic aberration. On the right, zoom of detail of the photo showcasing a particle suspended in the water.

The image as-is from the camera exposes some technical problems (Figure 51), in photomicroscopy, that were detected since the first images of sea urchin larvae were captured. The white balance is very difficult to control in camera and there was the necessity to adjust it within the camera and in later edition. In the showcased detail it's possible to understand the referred issues with chromatic aberration. There's the possibility of it being a consequence of low quality of the glass of the barrow lens.

Since the acquisition of the camera, there had been a feeling of “something wrong” with the image, despite contrary opinions from colleagues and technicians, who do not use the Fujifilm system. It was decided to conduct a test of the camera, placing it in a difficult technical situation.

Using a tripod, the same lens (16mm) and the long exposure technique, both cameras were used for astrophotography.

Upon results (Figures 52-54), it was possible to conclude the later camera, despite being more technologically capable, displayed the worst results.

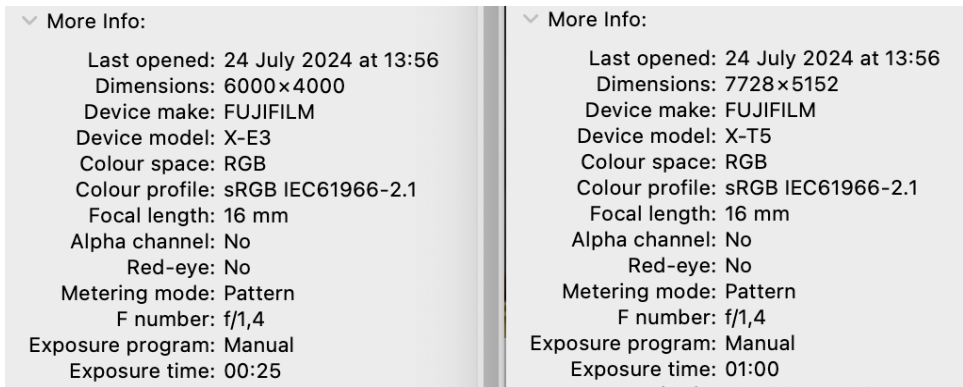


Figure 52. Characteristics of both cameras with a 16mm lens, reveal the necessity for longer time of exposure for the newer camera [Print screen], elaborated by the author



Figure 53. Fujifilm X-E3 with 16mm lens [Photograph], elaborated by the author



Figure 54. Fujifilm X-T5 with 16mm lens [Photograph], elaborated by the author

The problem was reported and observed by technicians from the brand and the camera was sent to warranty, where the problem was detected and the sensor remapped. It has since been tested on the same conditions. Even though the outputs appear good on normal conditions, and better than previously on the test conditions, the camera still performed badly when going through the same conditions used in the test and when compared with the previous model. Efforts are being developed to have fully functioning equipment on the next larval development trial.

Nonetheless, the best results, concerning image output, were attained in this session (Figures 55-56).

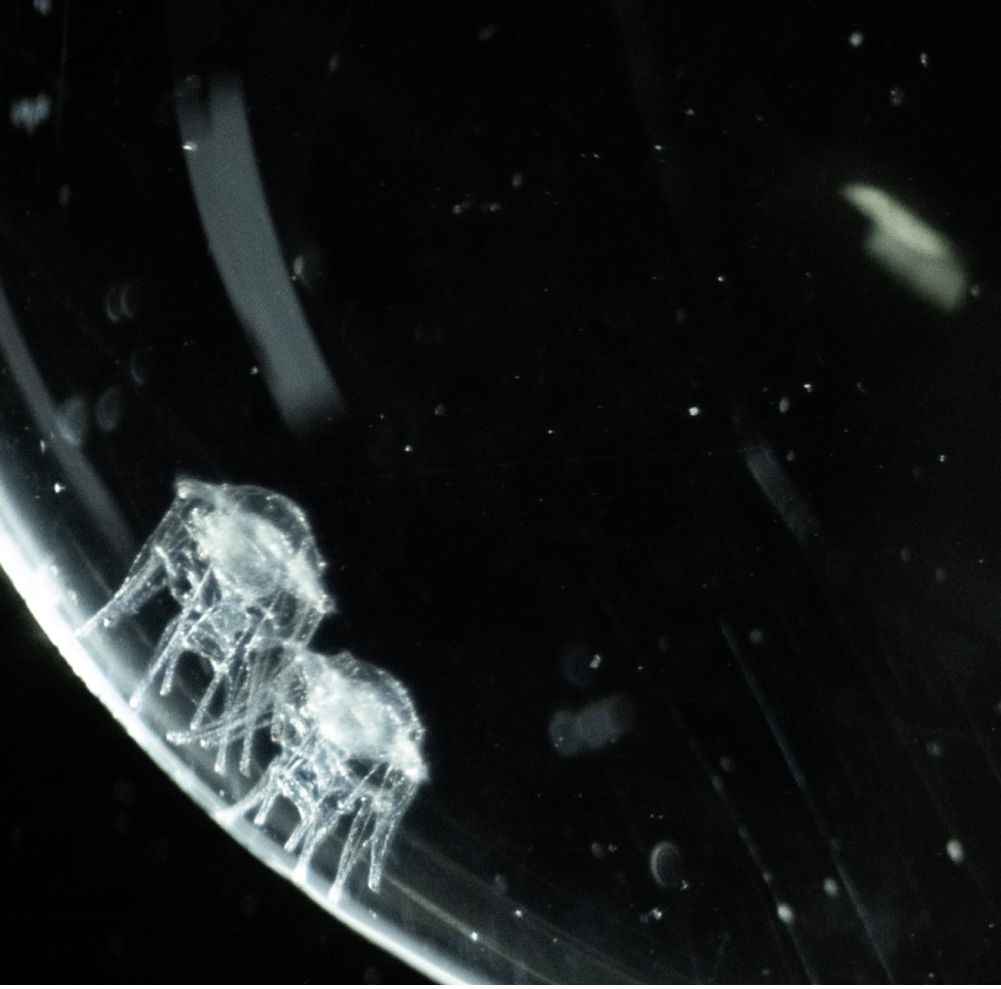


Figure 55. Two larvae at the edge of a waterdrop [Photograph], elaborated by the author



Figure 56. Larva with two weeks [Photograph], elaborated by the author

Note: Photograph as-is from the camera, adjusting the white balance and saturation to obtain a more artistic result

## Third and fourth weeks

In the third week, it was not possible to acquire images due to several constraints.

The period between the third and fourth weeks is a very delicate time for sea urchin larvae. Besides the physiological transformation they go through (see Figure 24 on page 69), they're moved from the tanks to the aquariums where are placed the substrates from different materials (produced by designers at LiDA) covered with a biofilm of algae. Lots of larvae die during this process.

On the 13th of May, the researcher responsible for the project at CETEMARES sent an e-mail titled "we have baby urchins" with two photos attached (Figure 57). The surfaces had finally yielded some success and scientists were able to grow microalgae and a form of macroalgae on the red clay and concrete substrates, and there were some urchins nested in them. Because of the problem with the photo acquisition software in the laboratory, they were only able to take photographs with a smartphone, through the electronic magnifying glass.

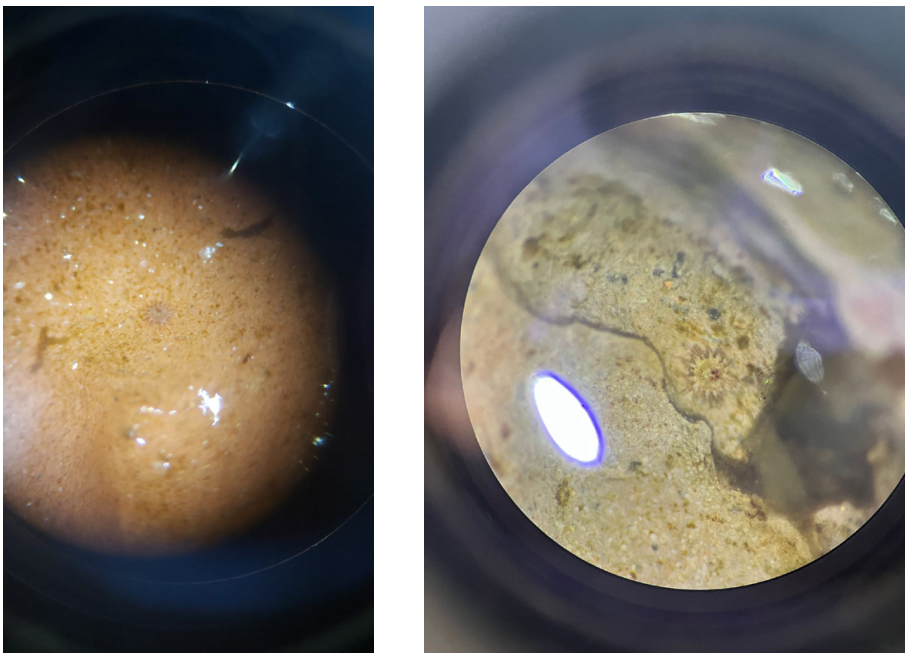


Figure 57. Photos of the "baby urchins" [Photograph], by Ana Gomes, 2024

In consequence of requesting to photograph the urchins, was given the information that there was a contamination of the substrates, and they didn't know for how long the urchins would survive. The biofilm that had successfully been growing microalgae (Figures 58-59) had become contaminated (it had been infiltrated by an external agent).



Figure 58. Cement and red clay substrates with biofilm [Photograph], elaborated by the author



Figure 59. Close up of cement substrate with biofilm [Photograph], elaborated by the author

Note: Substrates in cement and red clay are covered with biofilm. Sea urchin larvae had successfully settled in these prototypes.

Upon arrival at the laboratory two days later, no urchins were alive. Researchers and marine biology trainees were gathered around an electronic magnifying glass where was possible to observe the remains of a sea urchin (figure 60), also the last proof that this experiment was a success compared to the ones that preceded it.



Figure 60. One marine biologist points to the place where sea urchin was found [Photograph], elaborated by the author

In this session, it was only possible to take photos of the substrates covered with biofilm composed by the microalgae (Figures 58-60).

The newer camera had been sent to warranty, so there was no possibility of making a requisition of one with a better sensor, and the microscope and the electronic magnifying glass previously used were being used in another project, and the ones available needed a different size of adaptor.

The larval development experiment had come to an end, so for all researchers came the need to observe and analyse what had been made and prepare for the next experiment.

For designers at LiDA, this meant a new moment for material exploration

of the resources and processes that can be used in the next substrates.

This phase highlighted the importance of interdisciplinary collaboration and gave various cues on what can be improved in the next larval development trial, relating to image acquisition and material research.

During this week, even though the results had been very discouraging, were made efforts on choosing and improving photographs to participate in MARE's photo competition "Biodiversity". Accepting that it hadn't been possible to produce photographs with the expected quality, two photos were chosen and edited and one was sent to the competition (Figures 61-62).

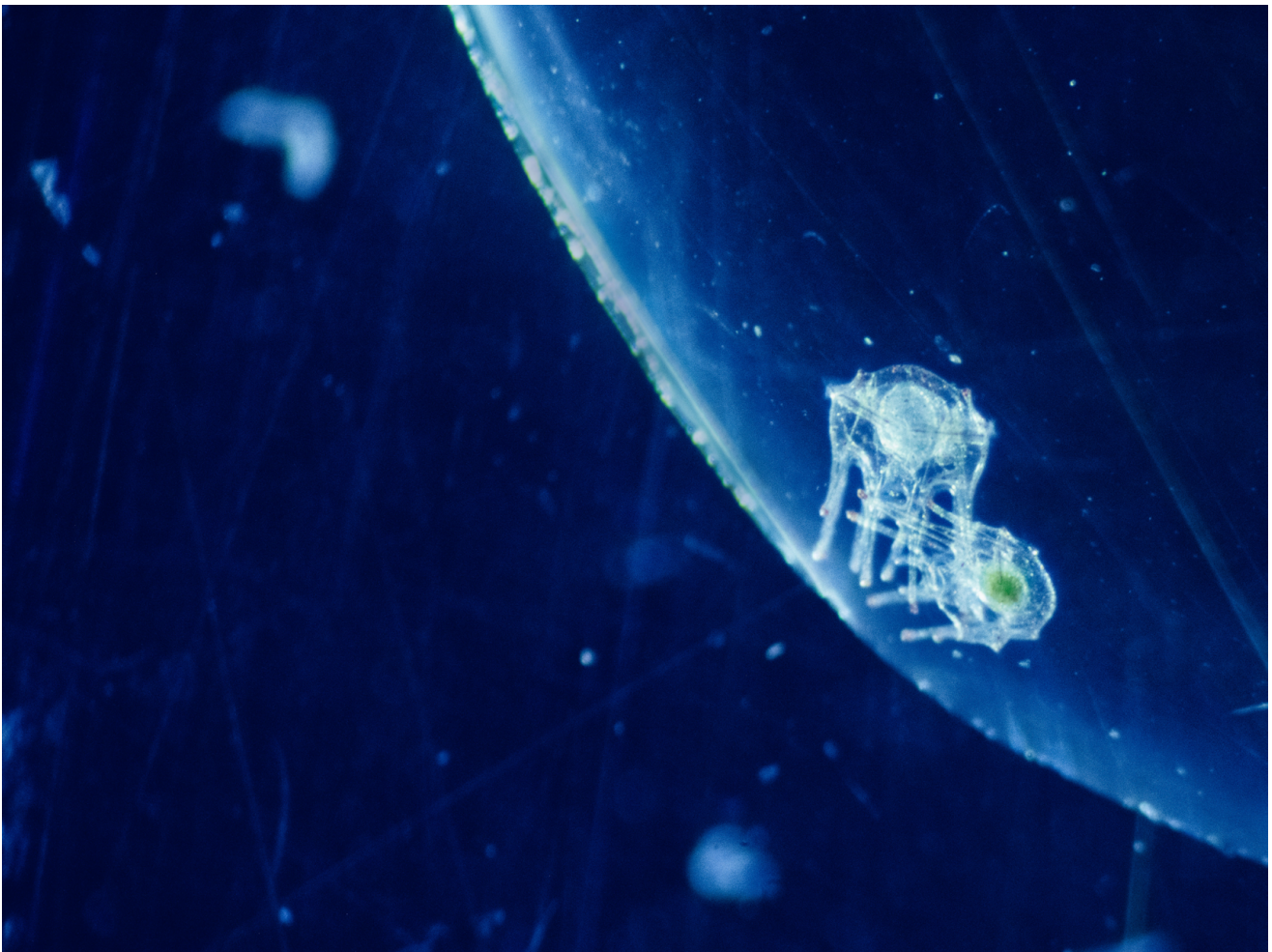


Figure 61. Who ate all the microalgae? [Photograph], elaborated by the author

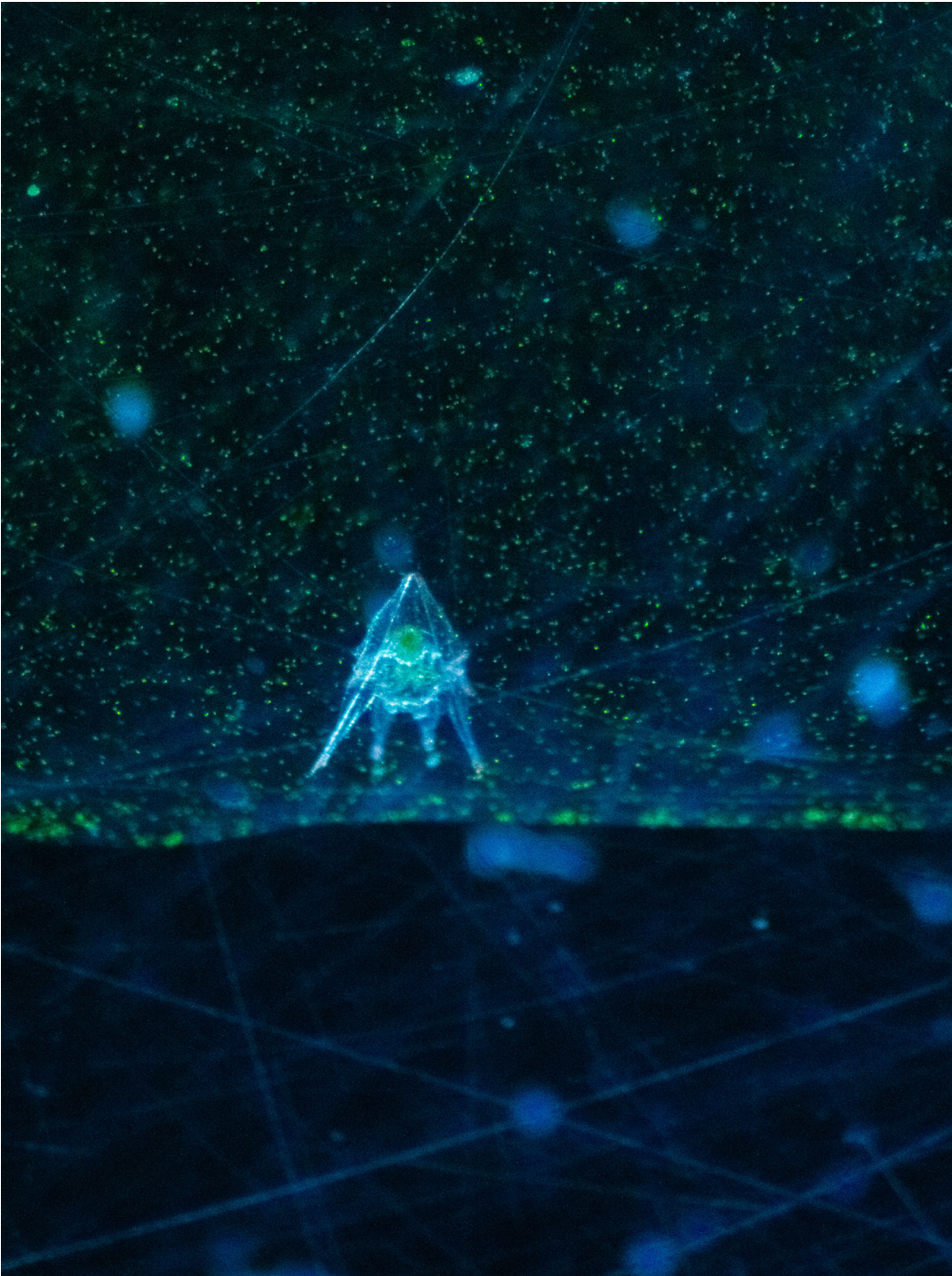


Figure 62. Cosmic lunch (a sea urchin larva surrounded by an unsurmountable amount of food) [Photograph], elaborated by the author

## 7.2 Experiences that weren't pursued

### Cyanotype on glass

One of the first ideas was to print photographs of the same subject at different focus on glass plates and make a photographic object, thus presenting the viewer with a sense of three-dimensionality (Figure 63).

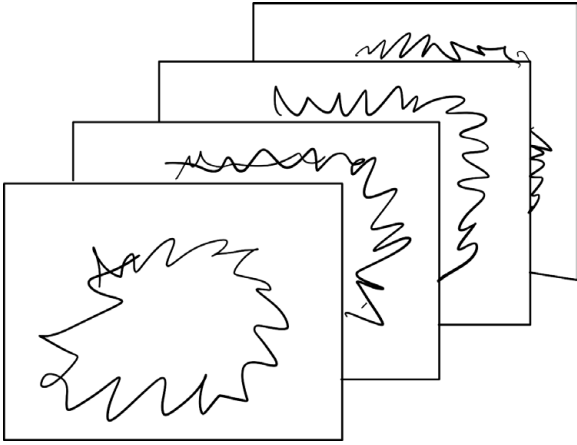


Figure 63. Sketch of a photographic object comprised of photographs with different focusing distances [Sketch], elaborated by the author

Upon experimentation with the technique (Figure 64), it was concluded that to obtain the intended result much experimentation would have to be conducted, the digital negatives would have to be very crisp and it would be necessary to devise a way to take photographs with different focus on a precise manner, that manual focus of the microscope doesn't allow.

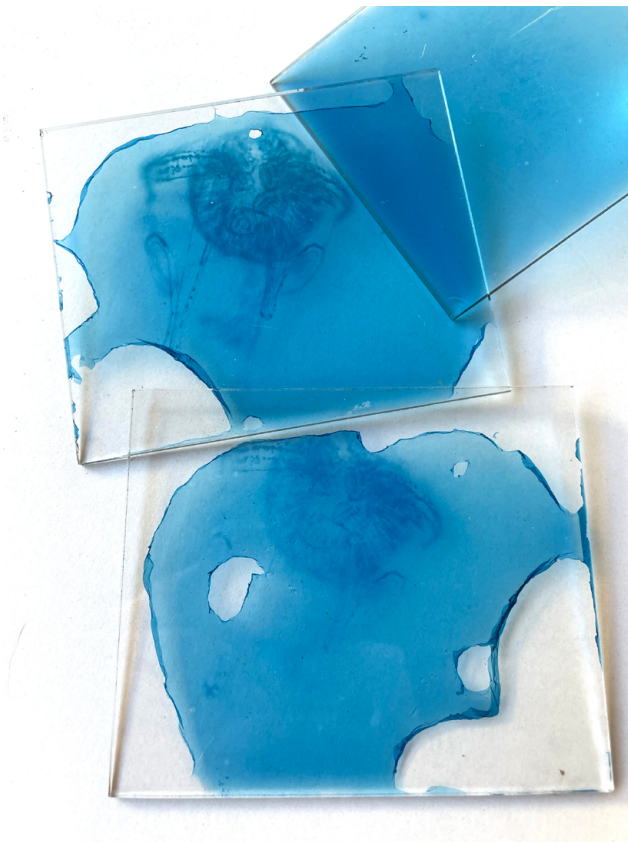


Figure 64. Tests for printing cyanotype on glass [Cyanotypes], elaborated by the author

The exploration of the present idea was postponed to a moment when several technical difficulties could be resolved.

## Albumin

After the end of the larval settlement experiment, it was conducted a workshop on albumin technique, at ESAD.CR, by the photographer António Rebolo.

The technique consists of applying egg whites to a paper (the name of the process derives from one constituent of the egg), then silver nitrate, and exposing the albuminized paper to sunlight with a digital negative on top.



Figure 65. Tests and proofs made during the workshop [Albumin prints], elaborated by the author

The results (Figure 65) showed some potentialities for the use of albuminized paper, because of its distinct silky-like texture, that appeals to the sense of touch. Given the colours produced with this technique, a range of browns, it was decided that it had no interest in a marine biology project, and no further tests were conducted. Nonetheless, the albuminized paper showed some promise if used in photographs that would be held or touched by the viewer.

## Optical toys

Upon researching the relationship between science and art, the idea of producing philosophical or optical toys came into existence (Figure 66). These optical instruments constituted “points of intersection where aesthetic, scientific and philosophical discourses overlap with mechanical techniques, institutional requirements and socio-economic forces.”(Crary, 2017, p.30).



Figure 66. Tests for a thaumatrope [Prototypes], elaborated by the author

The optical toys were artefacts that would show optical phenomena in an interactive and playful manner (Figure 67). From around 1920 there was vast scientific investigation around image persistence, and several artefacts and optical techniques were invented. Although these aesthetically pleasing objects were initially produced for scientific inquiry, soon they became also objects for entertainment (Crary, 2017, p.160).

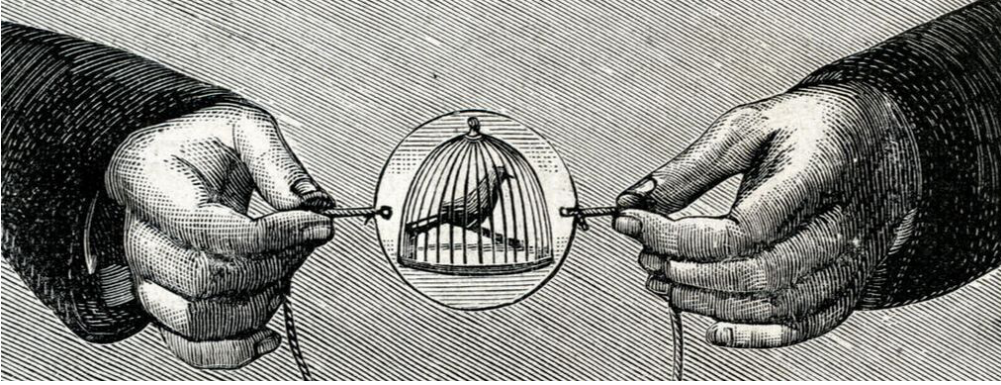


Figure 67. "Optic Wonder" - Thaumatrope [Illustration], by Anonymous, n.d. (<https://www.fortbendmuseum.org/blog/optic-wonder-make-your-own-thaumatrope>)

It was decided to explore the sense of touch these optical devices could also convey, to investigate the possibilities that could arise in a contemporary context. For this, was 3D printed a lithophane (a 3D-printed object that lets light shine throughv) (Figure 68).



Figure 68. Litophane test [3D print], elaborated by the author

Note: Litophane printed on a Bambu Lab X1 Carbon 3D Printer

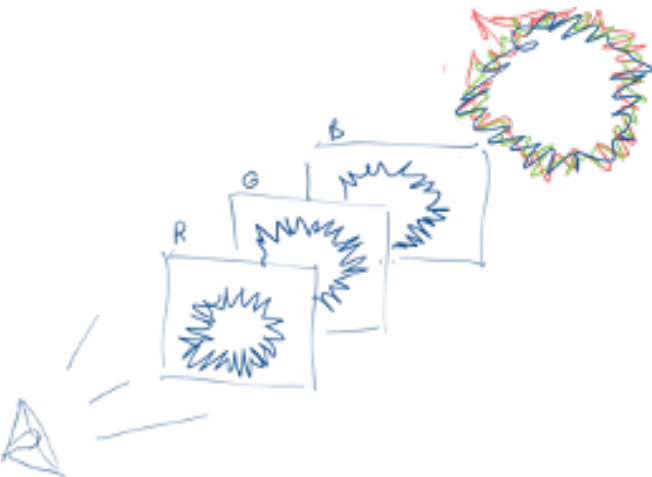


Figure 69. Sketch for 3D printed optical toy for projection [Sketch], elaborated by the author

Imagining a future exhibition, it was sketched a possible projection of light through lithophanes in primary RGB colours (Figure 69).

Even though this could become an interesting visual exploration, it was considered that it wouldn't be of much interest to proceed with it.

### Cyanotype on wood veneer

To test the possibility of making wooden objects that could be physically manipulated, the cyanotype technique was also tested on wood veneer (Figure 70).



Figure 70. Test showing difficulties that arise from wood porosity [Cyanotype on veneer], elaborated by the author

The best results achieved showed that a long practical study of the technique and porosity of wood surfaces will have to be developed if this path is to be pursued.

## 8. Phase III

### 8.1 Exploring possibilities for project dissemination

The present phase constitutes a synthesis of the reflective process achieved after the end of the larval developmental experiment and analysis of the collected data.

### 8.2 Photographic narrative “To plate or not too plate”

As mentioned earlier, one of the main threats to sea urchins is that they are consumed as a popular gastronomic delicacy in some regions of the world.

The visual exploration of the idea of sea urchins as food resulted in a photobook that contains a narrative about a group of sea urchins and their destruction for food purposes (Figure 71).

This photobook results from the efforts of trying to communicate aspects of marine biology, sustainability, culinary practices and socio-economic impacts while making a critique on their consumption.

On the first pages, the viewer is conducted through a series of colourful photographs of sea urchins, that sometimes look like they are a group of friends playing, and others look like sweet pastries, resembling macarons. A sudden stop of fallen spikes and an unsaturated photograph try to communicate a disquiet feeling, pushing the viewer into the narrative of the decimation of the colourful group of sea urchins.

The photobook can be found in Appendix 1.



Figure 71. Photobook “To plate or not too plate” [Photograph], by Pedro Cá, 2024

This photobook is aimed at fostering empathy towards the species and aiding behavioural change by changing perspectives about consumption.

### 8.3 Colourable Photobook

In respect of the photos obtained through the microscope, there had been since the beginning, the intention to produce them in a format that would request some sort of interaction from the viewer. From the exploration of this idea, was born the idea of making a prototype for a photobook that could be coloured in and drawn on.

For this, some photographs captured during phase II were selected and edited in Photoshop in a stylized way that is fit to be hand-coloured (Figure 72). The prototype was tested with watercolours and markers and digitally (Figure 73).

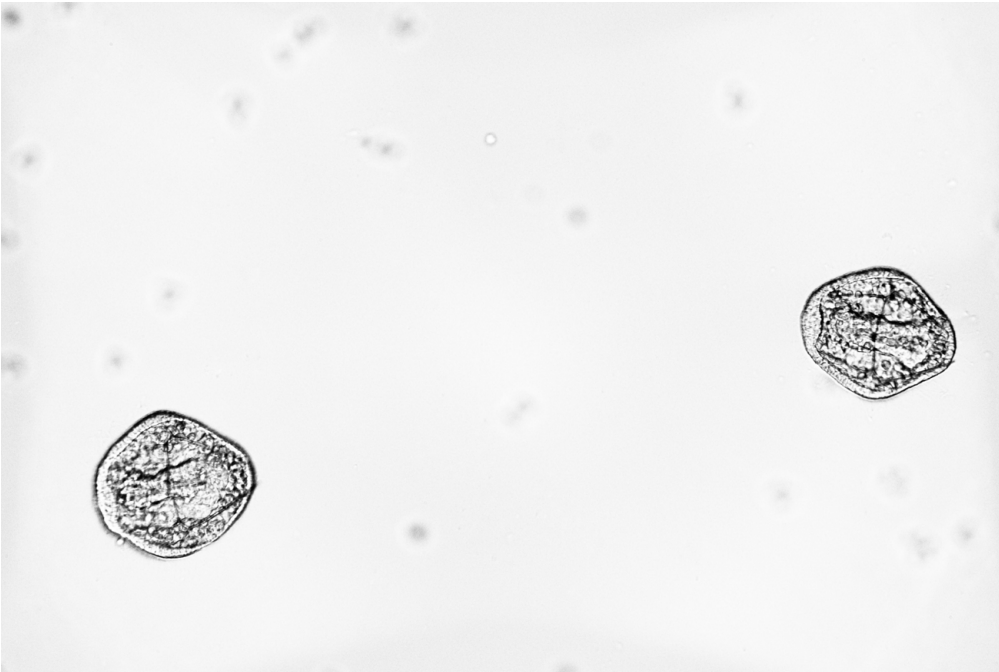


Figure 72. Test for a colourable image [Digital image], elaborated by the author

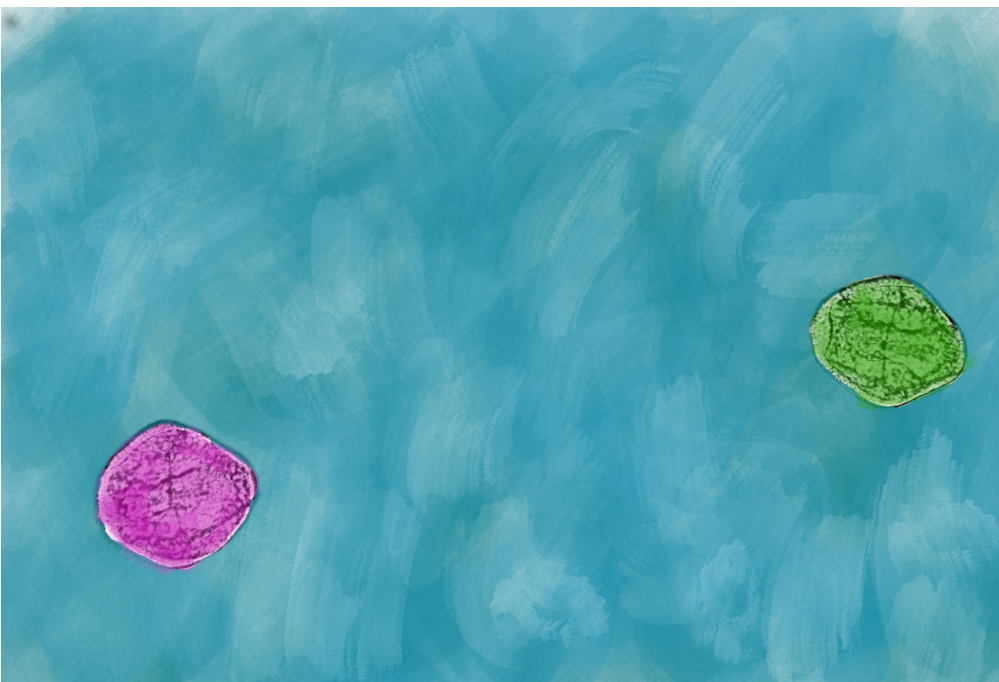


Figure 73. Experimenting with the test image by digitally colouring the image in Procreate [Digitally coloured image], elaborated by the author

The photobook presents an excerpt from a scientific article (Boudouresque & Verlaque, 2020) in its cover, with key aspects emphasised in bold, followed by images based on the photographs acquired during phase II (Figure 74). The physical version was printed on recycled paper Renova Print 180g, with pigmentation and yellow tint intended to promote interaction (Figure 75). The produced photobook is contained within Appendix 2.

*Paracentrotus lividus* gonads (roe) have been appreciated as a luxury seafood and it has been **intensively** harvested. *P. lividus* plays a **major role** in determining the organization of benthic communities. **Harvesting** of *P. lividus* is said to have resulted in a severe erosion of its populations, with **consequences for the health status of ecosystems**.

Boudouresque C., Verlaque M., 2020

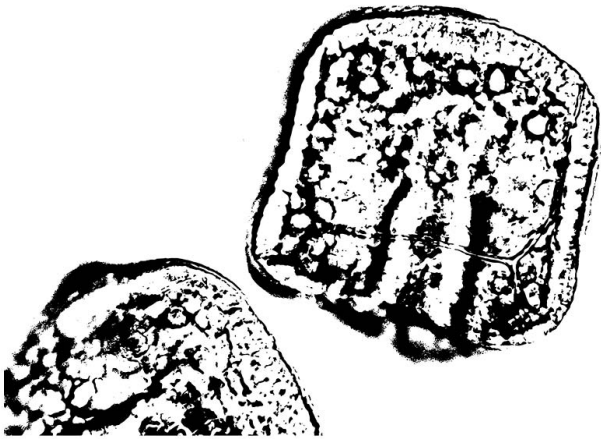


Figure 74. Colourable photobook [Digital image], elaborated by the author



Figure 75. Colourable photobook [Photograph], by Pedro Cá, 2024

There's an intention of exploring its use in a controlled environment where data from the ways people interact with it and their observations can be considered, and also observe the results of that interaction. The intention is to gather more photos of the metamorphosis in the next larval development experiment and have a colourable photobook subtitled with comments made by marine biologists about what can be seen in the photos, in an informal and relatable tone.

This photobook is aimed at fostering empathy towards the species by inciting connection through interaction with the images (Figure 76).



Figure 76. Sea urchin eating [Digitally coloured image], elaborated by the author

Note: Image from the colourable photobook, digitally coloured in Procreate.

## 8.4 Experiences with AI

### Adobe Firefly Image 3 Model

Efforts to enhance as much as possible the quality of the photographs took place. After extensive editing with Adobe Lightroom Classic and Adobe Photoshop, were used Photoshop's neural filters (Figure 77).

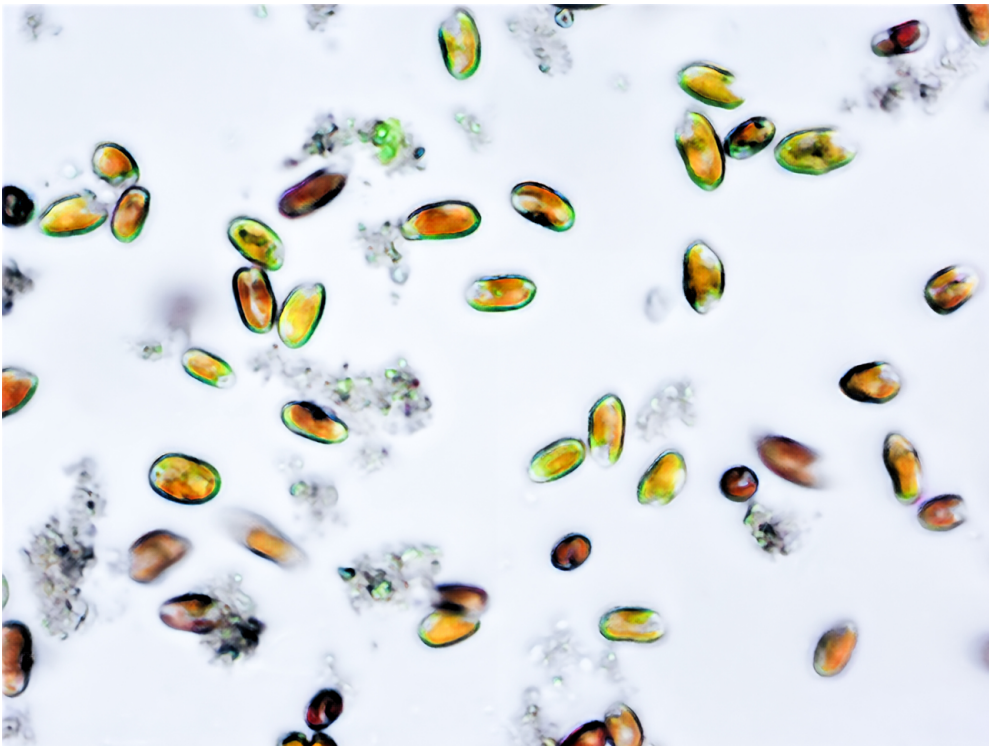


Figure 77. Rhodomonas [Photograph], elaborated by the author

Note: Figure 43 after manual editions on Lightroom, Photoshop and AI editions in Photoshop

Neural filters were used also in Figure 49 but didn't produce observable enhancement of the photo. During post-production of photographs obtained with the microscope, it became apparent that within such a context AI couldn't produce better results when compared with manual adjustments of various controls of colour and light in Lightroom and Photoshop (such as Levels, Black & White, Colour Grading, Curves, Colour Saturation, Detail and Vibrancy), possibly due to lack of reliable data.

Considering the lack of results could be derived from the lack of

references to enhance the photographs, some exploration of the generative AI within Photoshop took place. From an image were removed the elements, maintaining the ground and generative AI was used to fill the spaces, with no prompts (Figures 78-80).



Figure 78. Stages of destruction [Photograph], elaborated by the author

Note: Original photograph



Figure 79. First generated object [Digital image], generated by Adobe Firefly



Figure 80. Gaps filled  
[Digital image], generated  
by Adobe Firefly

While these iterations don't offer many possibilities, it was a way of having some insight into how the AI was interpreting the information he had, especially the way it interpreted shadows of the spikes as petals.



Figure 81. Crop of  
the first generated  
object [Digital image],  
generated by Adobe  
Firefly

As the first generated object was especially peculiar, it was isolated and the remaining image cropped (Figure 81), and then generative AI was used to expand the image with no prompt. Interestingly, the AI somehow made the connection with food, generating what can be a pattern with unreal and real elements (Figure 82).



Figure 82. Pattern generated [Digital image], generated by Adobe Firefly

## ChatGPT 4o mini + Dall-E

While the photographic narrative “To plate or not too plate” was being made, there was the intention of finishing it with a photograph where cutlery was placed on the sides of an open sea urchin. As the cutlery used wasn’t aesthetically adequate, the idea of using AI to substitute it took place (Figures 83-84). For that, was used ChatGPT 4o mini with integrated Dall-E. Interestingly, the integration of Dall-E had to take place on an entirely new conversation, as in an ongoing one the integration was said to not be possible. ChatGPT appears to integrate some functions (like Dall-E or the possibility of PDF upload) in some conversations while in others informs that it’s not possible to do so.



Figure 83. Test for photograph about consumption [Photograph], elaborated by the author

Figure 84. “Substitute the cutlery with one ‘not ugly’”, [Digital image], generated by Dall-E

Once the AI used the term beautiful to describe the cutlery set it created, a conversation around beauty took place, and then he was asked to create one with his own concept of beauty (Figure 85).

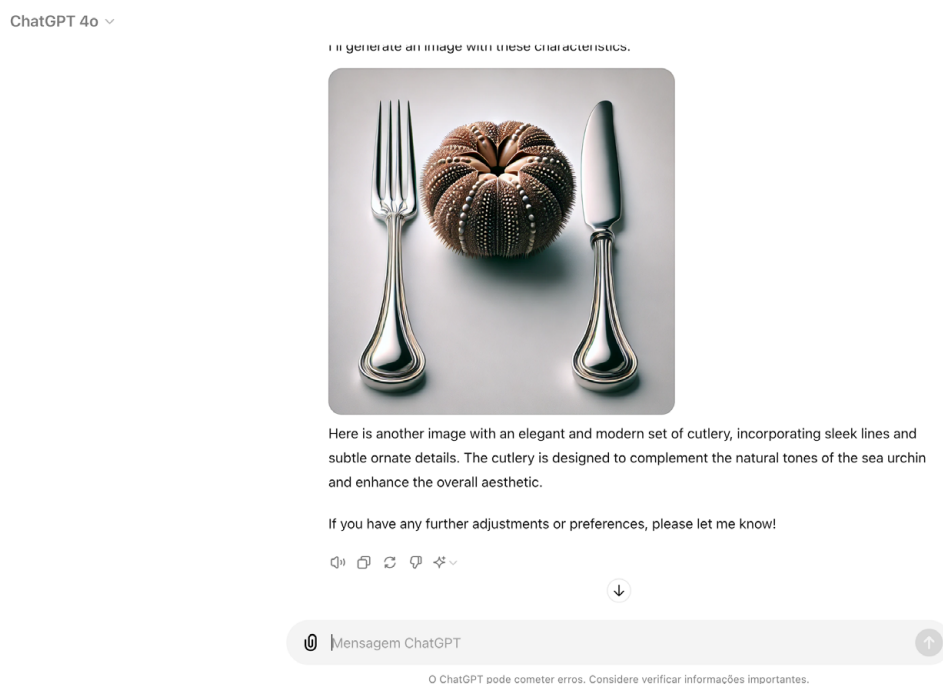


Figure 85. AI discussing beauty [Print screen], elaborated by the author

Some more iterations took place, with no interesting insights and some errors (Figures 86-87).



Figure 86. Error when iterating the initial image [Digital image], generated by Dall-E

Figure 87. Solarpunk cutlery [Digital image], generated by Dall-E

It was then decided to experiment with a few more iterations for illustrations of the sea urchin (*P. lividus* species) with natural elements, and then with elements of its habitat and showing all the colours the species can assume (Figure 88 and Appendix 3 – Explorations with AI).



Figure 88. *Paracentrotus lividus* depicted with species of its natural habitat [Digital image], generated by Dall-E

During the present work, Dall-E integrated in ChatGPT was used for the presented purpose and ChatGPT Scholar was used as an auxiliary tool mainly for two motives: article research and clarification of concepts from biology.

Pertaining to articles, Chat-GPT 4o mini, was able to find three more articles in Transition Design, that weren't found on internet research by the author, found articles on subjects of marine biology that were needed to better comprehend some concepts and terminology and also to test if the author had correctly comprehended the concepts in scientific literature. It was also used to find information within articles previously read, thus eliminating the necessity to use index cards (Eco, 2007, pp. 132-140), as can be seen in Appendix 4.

This small exploration of AI gave some insight into how AI can be used to assist research, especially when analysing information from other fields of knowledge.

## 8.5 Non-human personas as communicational tools

When analysing literature from the marine biology field, some documents were annotated. As a way of interpreting texts from another field were made annotations usually by handwriting on the margins of the texts, and sometimes sketches.

This activity was a way to translate abstract knowledge into more attainable information.

While reading a passage of text, about the sensibility of sea urchins to ammonia, emerged a draft of an identity card of a non-human persona, and the questioning of its validity as a design method or a communication tool for abstract knowledge dissemination (Figures 89-90).

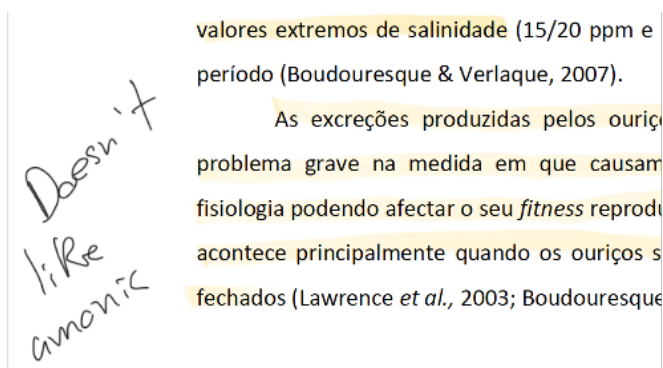


Figure 89. Annotation on a Dissertation of one of the marine biologists on the project [Print screen], elaborated by the author

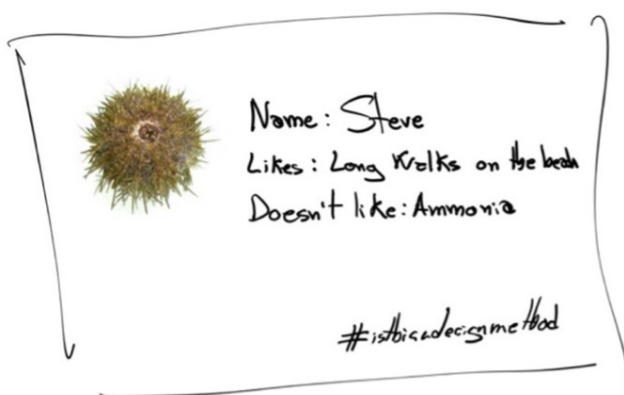


Figure 90. Sketch of a non-human persona to translate the apprehended concept [Sketch], elaborated by the author

As the insight revealed some interest, some more non-human personas were made while reading about sea urchins and later refined (Figures

91-94). Although the term persona is used, these characters don't constitute "personas" in the traditional sense the tool is used. The hashtags #isthisadesignmethod and #nonhumanpersona in Figures 99 and 100 constitute an expression of a reflection on Design tools, incited by the spontaneous act of sketching a card about a character and questioning if this act of translation of scientific knowledge could comprise a design method.

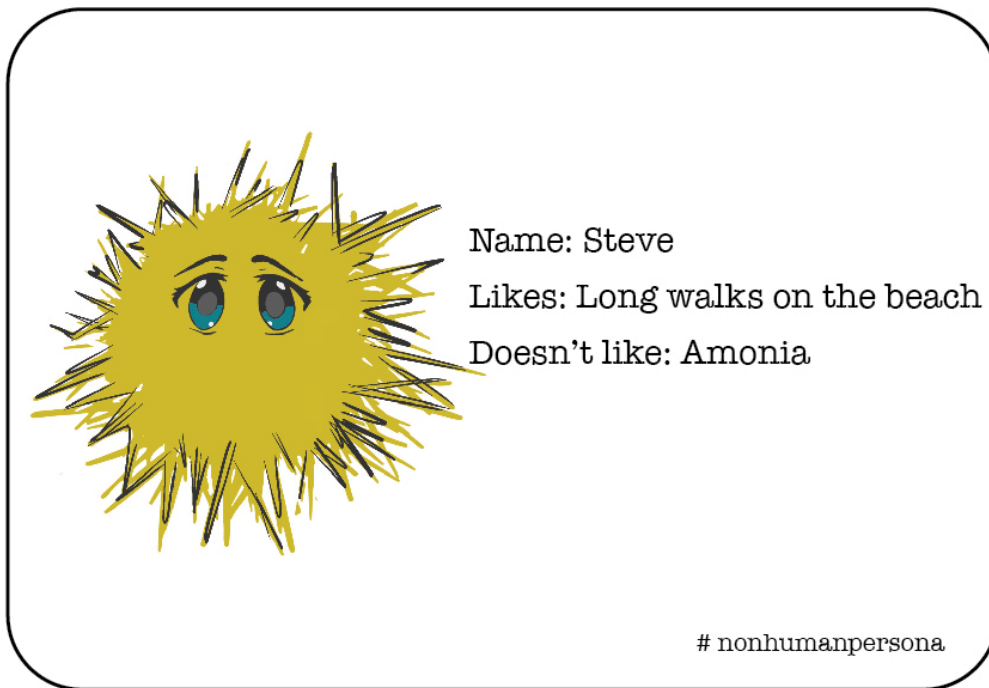


Figure 91. Steve [Illustration], elaborated by the author

Note: Refinement of the sketched character on image above

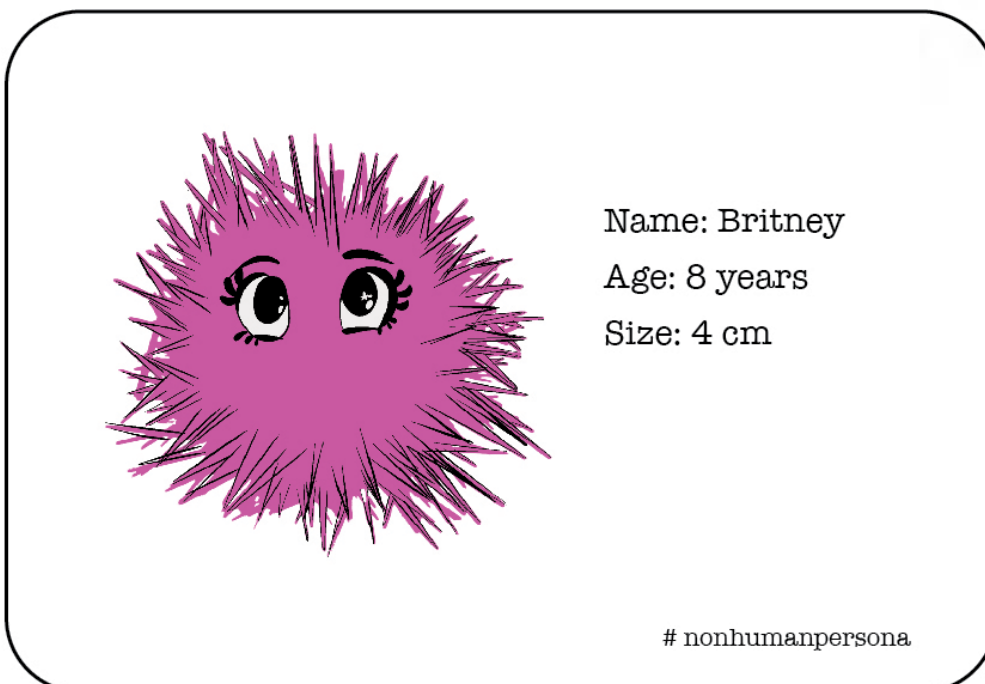


Figure 92. Britney [Illustration], elaborated by the author

Note: Card to be printed with urchin on real scale

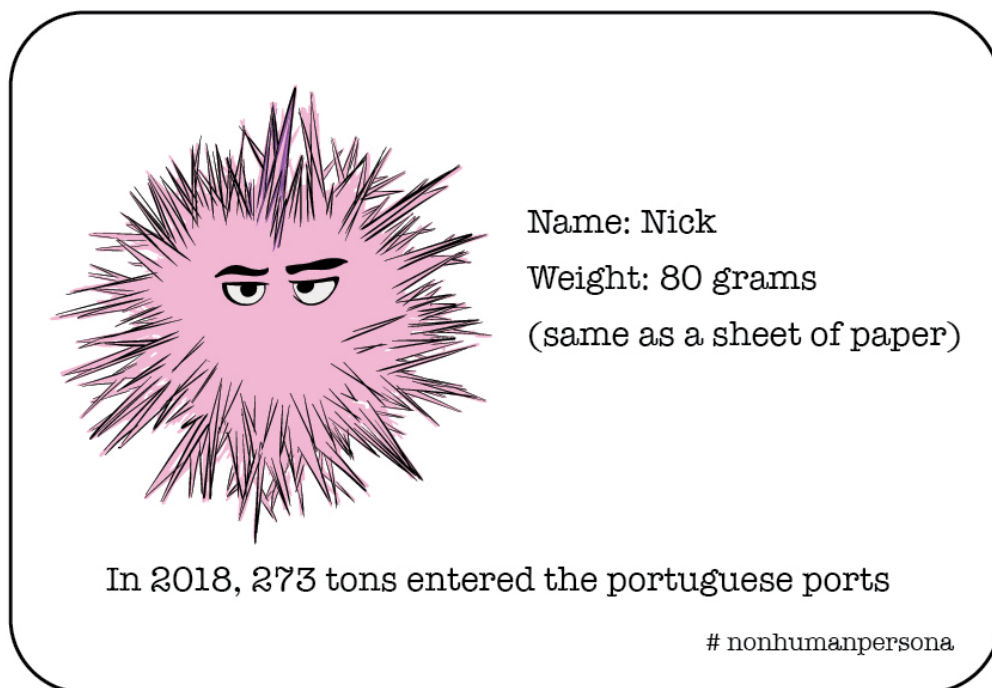


Figure 93. Nick [Illustration], elaborated by the author

Note: Card integrating facts about the species and their relation to harvesting

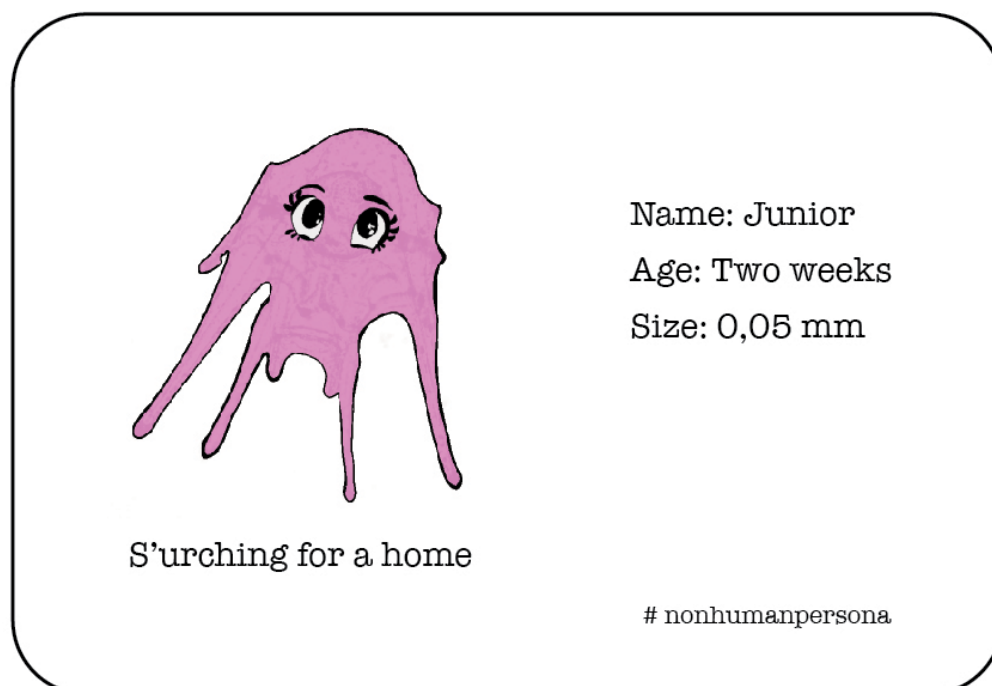


Figure 94. Junior – S'urching for a home [Illustration], elaborated by the author

Note: Card integrating facts about the species and a wordplay (urchin = orphan) relating to the work being conducted at LiDA, to create substrates for settlement of sea urchin larva

These ID cards with non-human personas will be tested and used in workshops. Their use is intended to foster empathy towards the species and provoke dialogue about consumption and human behaviour.

## 8.6 Illustrated book with stickers

As previously stated, during the development of the presented work, drawing played a role in visually translating concepts and ideas. Some initial drawings (and probably the reference of scientific sticker books that informed some decisions in the prototype for an instant book on phase I) gave rise to the idea of using stickers as an interactive mean to instil empathy towards sea urchins (Figure 95) and use them to connect with a junior public. Nonetheless, the idea wasn't pursued, and stickers remained a discarded possibility throughout most of the process.

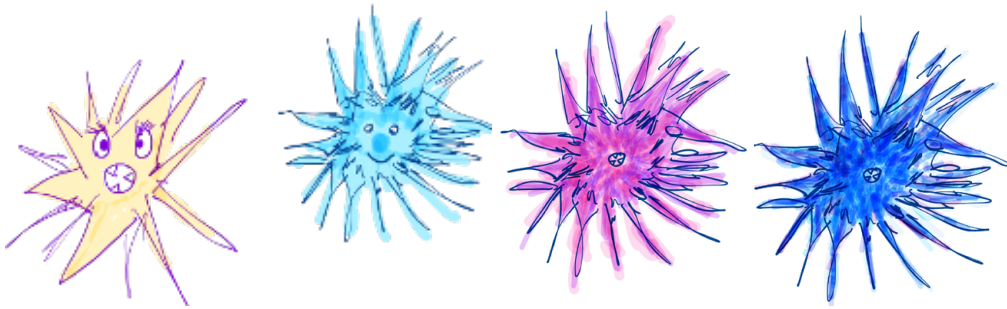


Figure 95. Relatable sea urchins [Sketches], elaborated by the author

While reviewing literature from the Marine Biology field, some drawings also took a more cartoonish dimension (Figures 96-98).

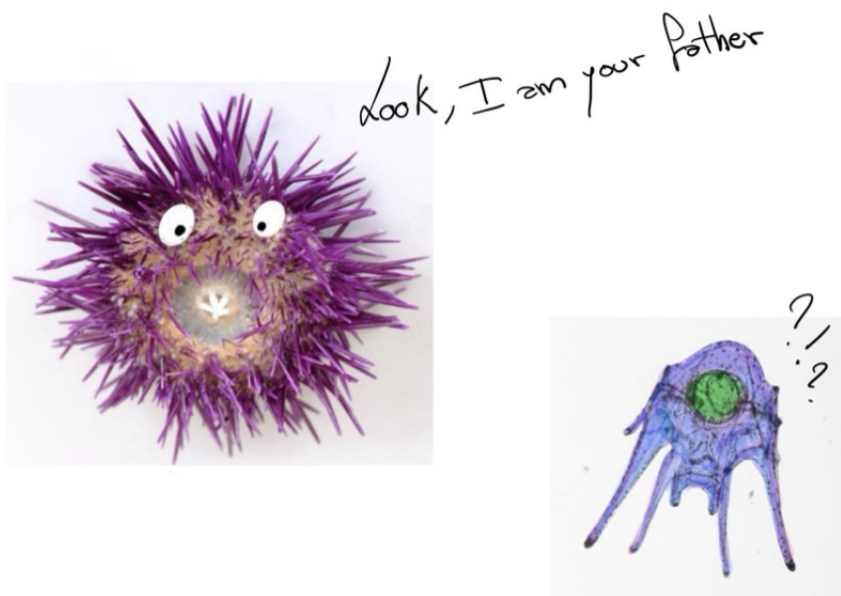


Figure 96. Reflecting on the metamorphosis of sea urchin larvae. [Sketch for digital collage], elaborated by the author

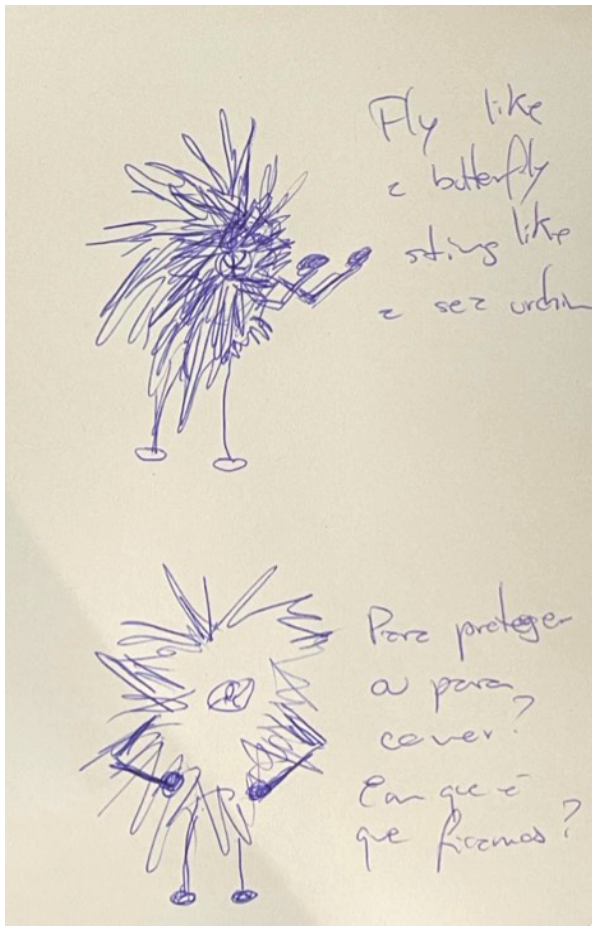
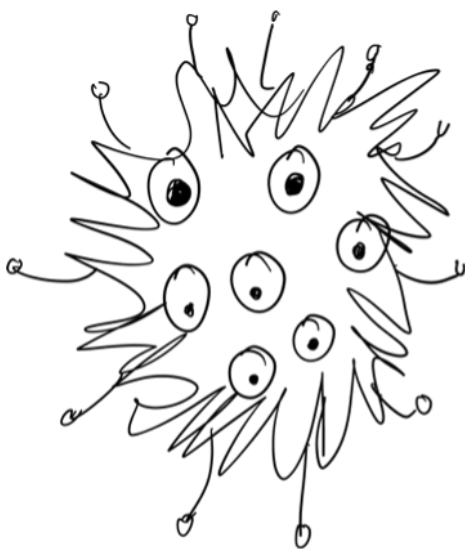


Figure 97. Exploring ideas for cartoons [Sketches], elaborated by the author



Os ouriços não possuem olhos, mas estão cobertos de células sensíveis à luz e movem-se com a ajuda de pés ambulacrários.

Figure 98. Anthropomorphised sea urchin [Illustration], elaborated by the author

Note: Translating the information “Sea urchins don’t have eyes, but are covered in photosensitive cells and move with the aid of ambulacral feet” on a relatable and visual way

Coincidentally, shortly after sketching Figure 98, a colleague in LiDA was placing some stickers with eyes and the author asked a pair to stick on a cyanotype test that was on her desk to anthropomorphise the subject (Figure 99).

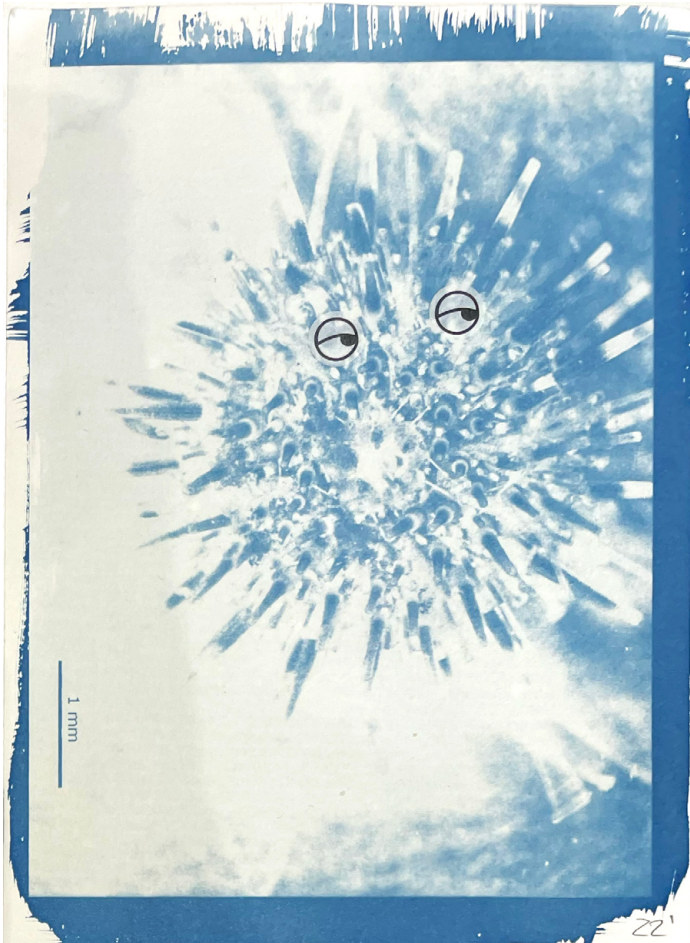


Figure 99. Whatever  
[Cyanotype with stickers],  
elaborated by the author

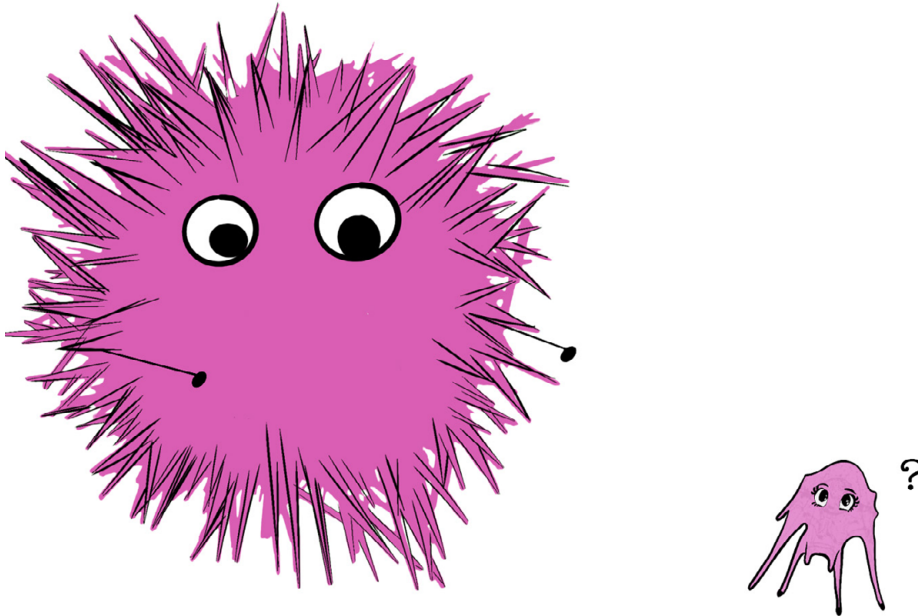
This humorous play with a discarded cyanotype triggered the idea of creating a small book that could be used in a future workshop with a junior public, where children could be invited to create their characters while gaining knowledge on sea urchins. The idea of creating design workshops has been manifesting itself throughout the present work, and it's expected to be developed in future studies (doctoral programme) as a way to connect and understand community relations with the sea urchin (*P. lividus* species).

For this small book, some sketches were refined, and the characters created as non-human personas appeared in some of the roles (Figure 100). The silhouettes and colours used were adapted from the photos of sea urchins captured while exploring the concept of sea urchins as food (Appendix 1) and from a photograph of a larva at two weeks of age (Figure 51).

Figure 100. Look, I am your father [Illustration], elaborated by the author

Note: Refinement of Figure 96 with silhouettes and colours from captured photographs

## Look, I am your father



Sea urchins are very different from their parents during their first month of age

The book is comprised of two parts. The first has some illustrations (example in Figure 100) and the second has silhouettes as an invitation to create characters. These parts of the book are separated by a sheet with stickers of eyes with different expressions and tube feet in different poses (Appendix 5). Inspired by the stickers used in Figure 99, these were drawn in a simple expressive visual language (Figure 101) to incite collaboration from the junior public in creating their own characters.

The physical version was printed on paper for sketching Fabriano Ecological Artist Paper 120g, that has a pleasing texture to draw on and proved to be adequate to support stickers and coarse manipulation, while transmitting a preoccupation with sustainable production practices.

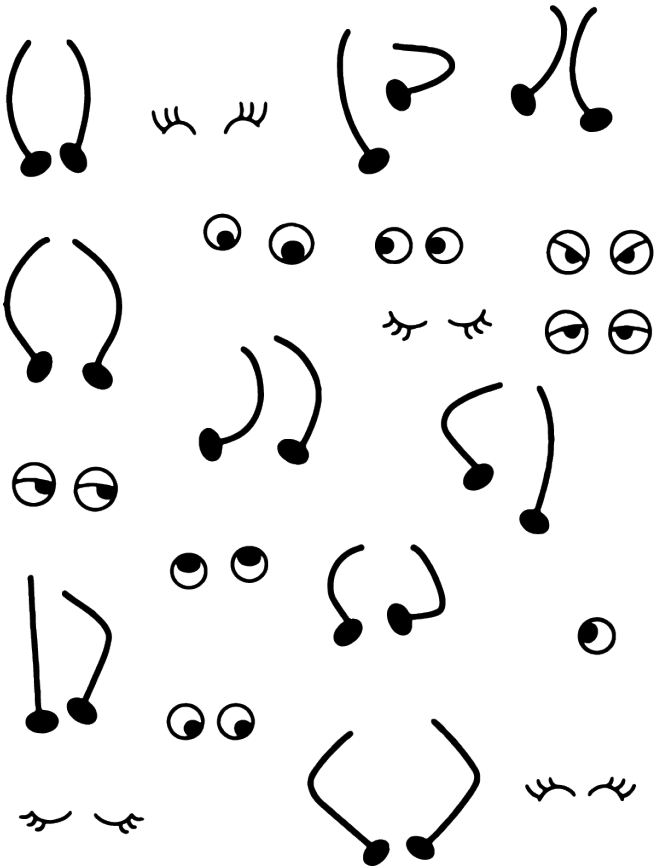


Figure 101. Eyes and tube feet [Illustration], elaborated by the author

This book is likely to be tested (after translation to Portuguese) with children from elementary school in a design workshop that's expected to be developed in the next stage. Its use is intended to foster empathy towards the species and provoke dialogue and knowledge about the species.



Figure 102. S'urchin for urchins [Book], elaborated by the author

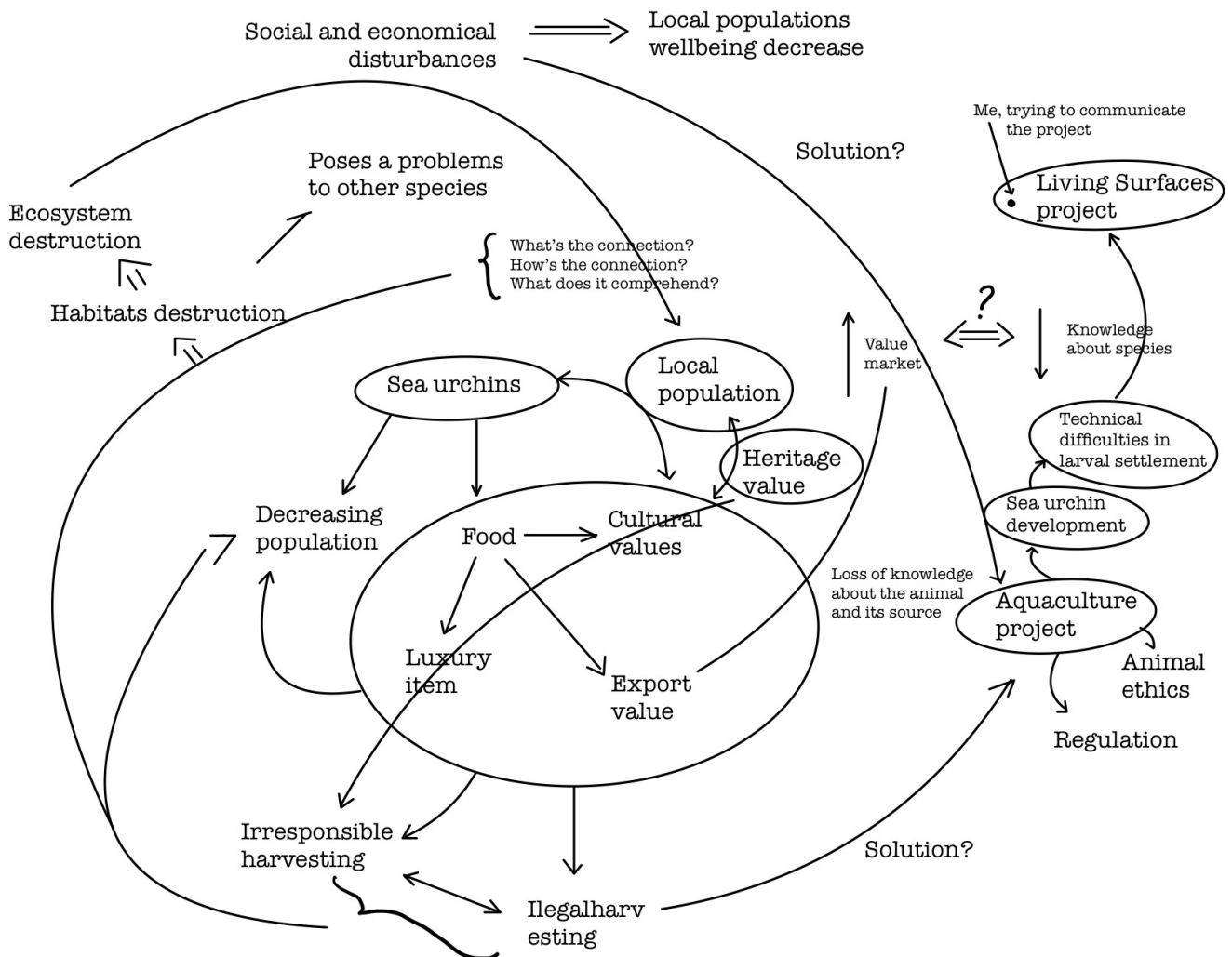
## 8.7 Mapping human-sea urchin system

The knowledge required to map the problem was acquired during phase II, especially through dialogue with scientists, and during Phase III mainly by review of the literature in the field of Marine Biology (Bao et al., 2006; Boudouresque & Verlaque, 2020; Caruso, 2020; Correia et al., 2023; Gomes, 2019; L. Costa et al., 2020; Plee & Suckling, 2024; Silva, 2012).

Various Design frameworks, such as User-centred Design, propose conducting the Design process centring on the subject of study (normally the user, the patient, or humans with specific problems or necessities). Using a Design method that places the object of study at the centre and expanding from there, it was decided to map the problems that surround the studied species of sea urchins (Figure 103).

Figure 103. Complex system centred at sea urchins [Map], elaborated by the author

Note: Mapping of the system where the studied species of sea urchins is embedded. The map showed an large number of associations and problems within the system pertaining to the relation between sea urchins and humans.



This problem mapping also made visible the complex system of “wicked problems” within which the project is embedded. It also indicated that lack of knowledge could be one of the most important factors contributing to the complexity of the problem (lack of knowledge about the species, its habitats’ preservation, ecosystem maintenance, legal harvesting framework, behavioural consequences, detachment from the source, and so on). Understanding this complex system will be an important aspect of future studies.

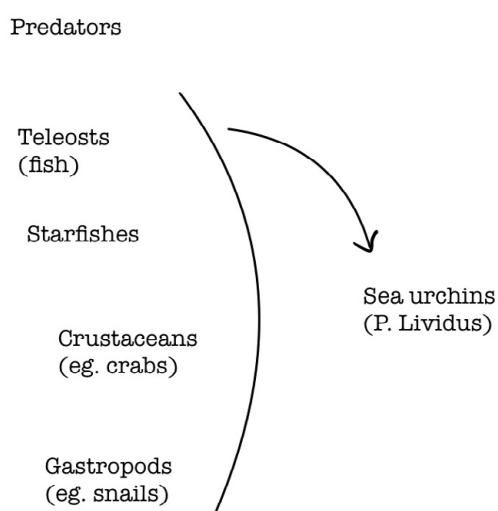


Figure 104. Natural predators [Map], elaborated by the author

Note: Sea urchins are also affected by their natural predators and available food resources, and indirectly by harvesting and fishing of their natural predators, which enhances the disruption of natural ecosystems. The relationship between humans and sea urchins was mapped discarding these relations to reduce complexity.

Sea urchins are embedded in a complex web (Figures 103-105) that summons the need to also think about issues like local cultural heritage, production processes, harvesting policies, and habitat destruction (and how other species - humans included - are affected).

It was found out that the human relation to sea urchins, besides being very complex and dichotomic, is also being nudged for behavioural change. Both academia and news media reveal active efforts to disseminate sea urchin gonads as a luxury product and also to promote its consumption in the Portuguese market; even though until recently it was only consumed scarcely in a few coastal regions, and consumption has been rooted in community traditions and not on satisfaction of hunger (some examples: Baião et al., 2021; Iken, 2019; Marques, 2017).

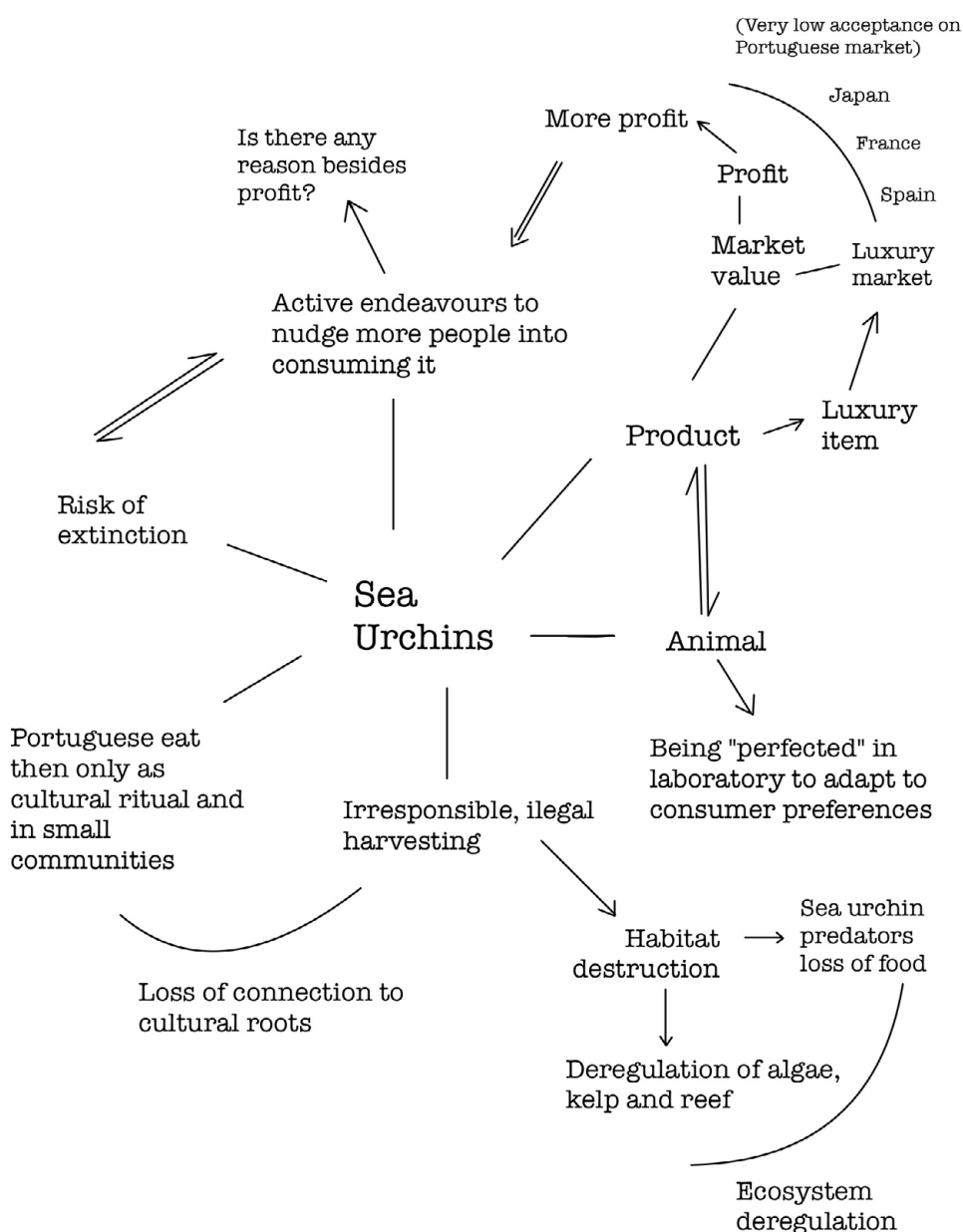
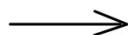


Figure 105. Mapping the complexity of the human-sea urchin (*P. lividus* species) relation in Portugal [Map], elaborated by the author

Having the previous map as a base, it was decided to explore the map with the United Nations Sustainable Development Goals for 2030. For that, were printed cards with 35x35mm and the goals were arranged in numerical sequence on a sheet of paper, in the format of questions to answer the question “Are sea urchins adequate ...?”. Upon reflection on the question the conclusions were annotated next to the card (Figures 106-107 and Appendix 6).

**Are sea urchins adequate to reduce hunger?**



No, their size is too diminute to satisfy hunger

Figure 106. Example of the use of SDGs as cards [Diagram], elaborated by the author



Figure 107. Using SDGs as cards [Method], elaborated by the author

The human relation to sea urchins is so complex that requests a study of its own, so it was decided to relegate it to future studies. Nonetheless, it was possible to gain insight into possible areas of intervention socially, at a local level, as well as in policy making. The problem that seems to point towards the main problem involving humans and sea urchins, appears to be in unsustainable consumption and production patterns. Future research will be focused on the local community and research into consumption and production patterns. Through the mapping of systems was possible to identify various perspectives from different societal groups and marine species (Appendix 6). This indicates that using SDGs as cards has the potential to produce valuable Design methods and tools.



# Results

## **Phase I: Visual Exploration**

During the first phase, from a range of alternative photographic processes were chosen cyanotype and gum bichromate to visually represent the first month of age of a *P. lividus* larva. These processes have proved to be suitable because of their potential to communicate the living environment of the larva and its delicate existence.

The deep blue produced by the cyanotype technique is particularly suitable to evoke a connection to the maritime habitat. The bichromate provided the flexibility to layer and play with colours that demand attention from the viewer. The movable photographs introduce an aspect of interaction to the small book, that may be adequate to promote empathy towards the species.

## **Phase II: Larval Development and Settlement Experiment**

The second phase focused on documenting the scientific experiment being conducted at CETEMARES for larval development and settlement. The process enabled the establishment of a deeper knowledge and connection to the species as well as a contextualization of the environment where the experience took place, and the activities that are conducted there.

Photomicroscopy was used to photograph stages of larval growth and document the results of the substrates that successfully were covered by biofilm

Due to technical constraints was not possible to produce photographs

with the desired quality, but the images were instrumental to translating knowledge into accessible visual forms.

The collaboration with marine biologists contributed to a deeper understanding of how Design research can be conducted in interdisciplinary contexts.

### **Phase III: Project Dissemination**

The third phase was of a reflective kind. All the work done previously and the collected data were carefully analysed and thought upon, to explore possibilities for the dissemination of the project into forms that could convey empathy towards the sea urchins.

A **photobook** that contains a photographic narrative and reflection about the consumption of the species, was produced and themed “To plate or not too plate”.

It was created a **colourable photobook** that is intended to be tested in design workshops and used as an interactive communicational tool.

The current capabilities of AI were tested to produce visual outputs of scientific knowledge but didn't yield satisfying results. It was concluded that **AI can be used to substitute index cards during research**, facilitating the retrieval of information previously read.

Four **cards portraying non-human personas** were created to act as communicational tools, providing facts about sea urchins playfully. These cards are expected to be used in the context of design workshops, to instil empathy towards the species.

It was made an **illustration book** that exhibits some facts about sea urchins playfully and invites the person using it to interact by drawing

on it and placing stickers. The act of creating a character is expected to foster a connection to the subject. This output is also intended to be used in design workshops.

It was made an initial approach to **map a complex system** portraying the relation between the human and *P. lividus* species and tested the use of **cards with the Sustainable Development Goals in an experimental Design Method** to rethink the connection. The use of SDGs as tools produced promising results and is being further tested and developed.

## Conclusions

This research set out to explore the role of Design in fostering empathy towards the common European sea urchin (*P. lividus*), opening a discourse on the role of biodiversity as a crucial factor in promoting Ecological Well-being. Due to a series of visual explorations, and collaborations with marine biologists, throughout the project, it is argued that Design has the potential to communicate complex scientific knowledge and evoke emotional responses that promote empathy and awareness.

The use of alternative photographic processes suggested that physical interaction with visual elements can be effective in creating a connection with a subject of a scale not visible to the human eye. The interactive and tactile nature of the visual outputs further explores this connection, making the species more relatable to a broader audience. The collaboration with marine biologists also highlighted the possibilities of interdisciplinary research, showing that Design can thrive in scientific contexts and contribute to knowledge dissemination in meaningful ways.

The dissemination mediums — such as the creation of interactive photobooks, illustrated materials, and non-human persona cards — offer promising results in promoting empathy towards *P. lividus* and engaging the public in environmental issues. Even though no human-centered design methodologies were used, the process gradually steers towards humans. This research constitutes an exploratory study and precedes a participatory design approach on the next phase. The creation of forms of communication destined to a junior public happened naturally and gradually as they constitute a determinant public when behavioural

change is intended to promote desirable futures. They also can play an important role when addressing adults, and for that reason research is now being directed to communication with families.

Although some challenges were encountered, with AI-based methods and above all with photographic equipment issues, the overall project demonstrated the versatility of Design as a tool for ecological communication and potentially for changing behaviour. Moreover, the Design process, as described in Part II, was time and constraint-bound to a scientific experiment with living beings that partially dictated the evolution of the design process. There was a realization, at the end of the larvae settlement experience, that in this kind of collaborative environment, the design process is in some ways limited and time-bound. During the process of accompanying the scientific experiment, there were contingencies, especially in technical aspects of photography, and so the photographic aspect didn't yield the expected results. In the face of the impossibility of repeating steps of the process during this master's research, it was crucial to understand what could be produced in this stage of the project and pave the way to an ulterior phase of the project, that will take place on the next larval settlement trial. The realization of a need to adapt the design process to external constraints (as is the development of a life form) despite technical challenges, and the need to make decisions within this context, constituted one of the most important insights of the present work.

This study contributes to the growing discourse on Design's role in addressing ecological challenges, specifically through emergent approaches and concepts such as Transition Design and Ecological Well-being. By focusing on the interplay between Design and Science, this research opens new paths for interdisciplinary collaboration and positions Design as an important tool in pursuing desirable futures.

Limitations such as technical constraints, system complexity and the need for public behavioural change set the tone for further research.

On the sequence of presenting the results of this work, the “Living Surfaces” team is devising strategies to create interdisciplinary workshops aimed at families that will occur at the beach and will blend science and art.

It is so concluded that this research highlights the potential of Design to tackle contemporary challenges, in this case, biodiversity loss. By fostering empathy and promoting sustainable behaviours, as well as acting in interdisciplinary contexts, Design can contribute to the preservation of vulnerable species and play a critical role in the transition to desirable futures.

## Future Possibilities

The outputs of this investigation can already be used in different contexts, but the investigation is far from concluded.

Building on the findings of this research, several possibilities for future studies emerge. Further exploration into the concept of Ecological Well-being is a crucial step. Transition Design constitutes a promising approach that is intended to be further explored, as it's especially vocated for systems-level change and for designing for desirable futures.

Future research can further investigate how design strategies used in this study for *P. lividus* can be adapted for other endangered species and ecosystems. This can offer valuable insights into how Design can contribute to ecological preservation.

Testing and refining the Design methods and results applied and obtained in this research also presents an opportunity for further study.

The challenges faced in achieving the desired photographic quality demand improved technological approaches in following scientific experiments. Additionally, while the current AI-based methods did not yield satisfying results, there is potential for these tools to be explored. Exploration of this topic may also be able to promote public engagement with scientific knowledge.

The strategies developed for *P. lividus* could be tested in other communities, ecosystems, and species. Understanding how these approaches translate to different social and environmental settings will offer valuable lessons in designing for Ecological Well-being.

Interdisciplinary collaboration was a crucial aspect of this research, and future studies should seek to deepen knowledge about interdisciplinary projects and collaborations. Collaborations between designers, scientists, and experts from fields such as behavioural science and policy-making constitute a path that will be further explored, for its great potential in promoting biodiversity and sustainable behaviours in an integrated way.

Further research will be needed to evaluate the long-term effects of design interventions on public behaviour and empathy-building. Future studies can also focus on how design-driven educational programs and workshops can foster engagement with environmental issues, contributing to the broader goal of Ecological Well-being.

## Bibliography

- Acaroglu, L. (2017). Champions of Sustainable Design. Medium. <https://medium.com/disruptive-design/champions-of-sustainable-design-302f005400ed>
- Anderson, C. Z. (2019). *Cyanotype : the blueprint in contemporary practice*. Routledge.
- Angelique, H. (2014). Fostering Pro-environmental Behavior. *Encyclopedia of Quality of Life and Well-Being Research*, 2343–2348. [https://doi.org/10.1007/978-94-007-0753-5\\_4141](https://doi.org/10.1007/978-94-007-0753-5_4141)
- Archer, B. (1995). The Nature of Research. *Co-Design, Interdisciplinary Journal of Design*, 6–13.
- Atkins, A. (1843). Photographs of British algae: cyanotype impressions. <https://digitalcollections.nypl.org/collections/photographs-of-british-algae-cyanotype-impressions#/?tab=navigation>
- Baião, L. F., Rocha, C., Lima, R. C., Marques, A., Valente, L. M. P., & Cunha, L. M. (2021). Sensory profiling, liking and acceptance of sea urchin gonads from the North Atlantic coast of Portugal, aiming future aquaculture applications. *Food Research International*, 140, 109873. <https://doi.org/10.1016/J.FOODRES.2020.109873>
- Bao, W.-Y., Satuito, C. G., Yang, J.-L., & Kitamura, H. (2006). Larval settlement and metamorphosis of the mussel *Mytilus galloprovincialis* in response to biofilms. *Marine Biology*, 150(4), 565–574. <https://doi.org/10.1007/s00227-006-0383-4>
- Barbosa, J., & Cardoso, C. (2023). Riscos Climáticos e a Saúde dos Portugueses: Futuro(s) por imaginar e construir.
- Bergland, R. (2024). *Natural Magic: Emily Dickinson, Charles Darwin and the Dawn of Modern Science (EPub Edition)*. Princeton University Press.
- Biosafety Unit. (2024). Biodiversity and Health. <https://www.cbd.int/health>
- Bispo, R. (2019). Design as Translation: what does it mean to have an healthy life? Conference in Dialogue between Post-Disciplinary Fields. <https://iconline.ipleiria.pt/handle/10400.8/9446>
- Boeke, K. (1957). *Cosmic View - The Universe in 40 Jumps*. <https://archive.org/details/CosmicView-TheUniverseIn40Jumps/page/n29/mode/2up>
- Boling, E. (2010). The Need for Design Cases: Disseminating Design Knowledge. *International Journal of Designs for Learning*, 1(1), 1–1. <https://doi.org/10.14434/IJDL.V1I1.919>
- Boudouresque, C. F., & Verlaque, M. (2020). *Paracentrotus lividus*. In *Developments in Aquaculture and Fisheries Science (Vol. 43, pp. 447–485)*. Elsevier. <https://doi.org/10.1016/B978-0-12-819570-3.00026-3>

Caruso, G. (2020). Microbial Colonization in Marine Environments: Overview of Current Knowledge and Emerging Research Topics. *Journal of Marine Science and Engineering*, 8(2), 78. <https://doi.org/10.3390/jmse8020078>

Chaigneau, T., Coulthard, S., Daw, T. M., Szaboova, L., Camfield, L., Chapin, F. S., Gasper, D., Gurney, G. G., Hicks, C. C., Ibrahim, M., James, T., Jones, L., Matthews, N., McQuistan, C., Reyers, B., & Brown, K. (2021). Reconciling well-being and resilience for sustainable development. *Nature Sustainability*, 5(4), 287–293. <https://doi.org/10.1038/s41893-021-00790-8>

Coops, F., Hummels, C., Dorst, K., Goldstein, B. E., Loorbach, D., & Gaziulusoy, İ. (2022). Designing for transitions and transformations. *DRS Biennial Conference Series*. <https://doi.org/10.21606/DRS.2022.897>

Corner, J. (1999). *The Agency of Mapping: Speculation, Critique and Invention*. In D. Cosgrove (Ed.), *Mappings*. Reaktion Books.

Correia, M. J., Mega Lopes, P., Santos, P. M., Jacinto, D., Mateus, D., Maresca, F., Quintella, B. R., Cruz, T., Lourenço, S., Pombo, A., & Costa, J. L. (2023). Pilot studies for stock enhancement of purple sea urchins (*Paracentrotus lividus*, Lamarck, 1816): usefulness of refuges and calcein marking for the monitoring of juveniles released into the natural environment. *Aquatic Living Resources*, 36, 12. <https://doi.org/10.1051/ALR/2023009>

Crary, J. (2017). *Técnicas do Observador (1a)*. Orfeu Negro.

Cross, N. (2001). Designerly Ways of Knowing: Design Discipline versus Design Science. In *Design Issues* (Vol. 17, Issue 3).

Cunsolo, A., Derr, V., Professor, A., Kotcher, J., Silka, L., Fellow, S., George, S. J., Tabola, J., Director, S., & Morganstein, J. (2017). *Mental Health and Our Changing Climate: Impacts, Implications, and Guidance*.

Curry, M. (2024). Anand Varma: Hidden Wonders (Master's of Photography - S1.E2) [Broadcast]. National Geographic. <https://www.imdb.com/title/tt29544792/>

Dunne, A., & Raby, F. (2013). *Speculative Everything: Design, Fiction and Social Dreaming* (EPub Edition). MIT Press.

Eames, C., & Eames, R. (1977). *Powers of Ten (1977)* [Video recording]. <https://vimeo.com/466954086>

Eco, H. (2007). *Como se Faz uma Tese em Ciências Humanas (13.a edição)*. Editorial Presença.

Fiolhais, C. (2002). O livro das “Potências de dez.” *Gazeta de Física*, 25(1), 68–69. <https://>

estudogeral.uc.pt/handle/10316/42052?mode=full

Fothergill, A., Hughes, J., & Scholey, K. (2020). David Attenborough: A Life on Our Planet [Video recording]. Netflix. <https://www.imdb.com/title/tt11989890/>

Gomes, A. S. (2019). Effect of different microalgae diets on larval development of sea urchin *Paracentrotus lividus* (Lamarck, 1816): impacts in growth, survival and settlement [Master's Dissertation]. Instituto Politécnico de Leiria.

Gomes, A. S., Lourenço, S., Santos, P. M., Neves, M., Adão, P., Tecelão, C., & Pombo, A. (2022). High dietary protein, n – 3/n – 6 ratio and  $\beta$ -carotene enhances *Paracentrotus lividus* (Lamarck, 1816) larval development. *Aquaculture Research*, 53(15), 5398–5412. <https://doi.org/10.1111/ARE.16023>

Grouzet, F. M. E., & Lee, E. S. (2014). Ecological Well-Being. In *Encyclopedia of Quality of Life and Well-Being Research* (pp. 1784–1787). Springer Netherlands. [https://doi.org/10.1007/978-94-007-0753-5\\_3966](https://doi.org/10.1007/978-94-007-0753-5_3966)

Helne, T. (2021). Well-being for a better world: the contribution of a radically relational and nature-inclusive conception of well-being to the sustainability transformation. *Sustainability: Science, Practice, and Policy*, 17(1), 221–231. <https://doi.org/10.1080/15487733.2021.1930716>

Hemkendreis, A. (2021). Icy Hieroglyphics: Wilson Bentley's Snow Crystals. *W/k - Between Science and Art*. <https://doi.org/10.55597/E7077>

Humble, J. (n.d.). The Design of Really Big Things: Planet-Centric Design. The Fountain Institute. Retrieved June 14, 2024, from <https://www.thefountaininstitute.com/blog/design-of-really-big-things>

Hustwit, G. (2009). Objectified [Video recording]. [https://www.youtube.com/watch?v=yPyAg3Zbs\\_8](https://www.youtube.com/watch?v=yPyAg3Zbs_8)

Hutchison, N. (2023). Anand Varma's innovative photography reveals nature's stunning and secret world, hidden in plain sight. *National Geographic*. <https://www.nationalgeographic.com/impact/article/anand-varma-explorer-story>

Iken, F. (2019). Ouriços - Mar em estado puro. *Revista de Vinhos: A Essência Do Vinho*. <https://www.revistadevinhos.pt/comer/ouricos-mar-em-estado-puro-2>

Interaction Design Foundation - IxDF. (n.d.). What is Human-Centered Design (HCD)? Retrieved June 29, 2024, from <https://www.interaction-design.org/literature/topics/human-centered-design>

Irwin, T. (2015). *Transition Design: A Proposal for a New Area of Design Practice, Study, and*

Research. *Design and Culture*, 7(2), 229–246. <https://doi.org/10.1080/17547075.2015.1051829>

Irwin, T., Tonkinwise, C., Kossoff, G., Irwin, T., Tonkinwise, C., & Kossoff, G. (2022). Transition Design: The Importance of Everyday Life and Lifestyles as a Leverage Point for Sustainability Transitions. *Cuadernos Del Centro de Estudios En Diseño y Comunicación. Ensayos*, 105, 73–106. <https://doi.org/10.18682/CDC.VI105.4189>

Ito, J. (2016). Design and Science. *Journal of Design and Science*. <https://doi.org/10.21428/F4C68887>

James, C. (2016). *The Book of Alternative Photographic Processes (Third Edition)*. Cengage Learning.

Jurjonas, M., May, C. A., Cardinale, B., Kyriakakis, S., Pearsall, D. R., & Doran, P. J. (2024). The perceived ecological and human well-being benefits of ecosystem restoration. *People and Nature*, 6(1), 4–19. <https://doi.org/10.1002/pan3.10558>

Kornbluth, J. (Ed. ). (1968). *Notes from the new underground: an anthology (1st ed.)*. The Viking Press. <https://archive.org/details/notesfromnewunde0000korn>

Kossoff, G., Irwin, T., & Willis, A.-M. (2015). Transition Design. *Design Philosophy Papers*, 13(1), 1–2. <https://doi.org/10.1080/14487136.2015.1085681>

L. Costa, R., Mata, B., Conceição, P., & Silva, F. (2020). Literacia do Oceano: Dos Princípios à Década da Ciência do Oceano. <https://doi.org/10.23906/WP62/2020>

Latour, B. (2008). *A Cautious Prometheus? A Few Steps Toward a Philosophy of Design (with Special Attention to Peter Sloterdijk)*.

Latour, B. (2020). What protective measures can you think of so we don't go back to the pre-crisis production model? <http://www.bruno-latour.fr/node/853.html>

Lawson, B. (2005). *How Designers Think: The Design Process Demystified (4th edition)*. Elsevier.

Living Surfaces. (2024). <https://lida.pt/research/living-surfaces/>

Mari, E. (2019). *Autoprogettazione?* Edizioni Corraini.

Marques, M. (2017). E se os ouriços-do-mar fossem o “caviar” português? *Biologia | Público*. <https://www.publico.pt/2017/09/02/ciencia/noticia/e-se-os-ouricosdomar-fossem-o-caviar-portugues-1784071>

Method Definition & Meaning - Merriam-Webster. (n.d.). Retrieved July 26, 2024, from <https://www.merriam-webster.com/dictionary/method>

Methodology Definition & Meaning - Merriam-Webster. (n.d.). Retrieved July 26, 2024, from <https://www.merriam-webster.com/dictionary/methodology>

Moore, S. L., Howard, C. D., Boling, E., Leary, H., & Hodges, C. B. (2023). Research methods for design knowledge: clarifying definitions, characteristics, and areas of confusion. *Educational Technology Research and Development*, 1–25. <https://doi.org/10.1007/S11423-023-10271-8/TABLES/1>

Morrison, P., Morrison, P., Eames, R., & Eames, C. (1982). *Potências de Dez* (Porto Editora, 2002). Porto Editora.

Müller, F. (2021). Introduction: Design as a Discipline of Alternation. In *Design Ethnography Epistemology and Methodology* (pp. 1–6). Springer International Publishing. <https://doi.org/10.1007/978-3-030-60396-0>

Munari, B. (1978). *A Arte Como Ofício*. Editorial Presença.

Munari, B. (1997). *Fantasia* (2024th ed.). Edições 70.

Muratovski, G. (2016). *Research for Designers: A Guide to Methods and Practice*. SAGE Publications.

Nat Geo Live. (2015). *Zombie Parasites* [Video recording]. Nat Geo Live. <https://www.youtube.com/watch?v=3n4kt-hOpzc>

Norman, D. (2023). *Design for a better world: meaningful, sustainable, humanity centered*. MIT Press.

One Health – Geneva Environment Network. (n.d.). Retrieved July 10, 2024, from <https://www.genevaenvironmentnetwork.org/resources/updates/one-health/>

Papanek, V. (1992). *Design for the Real World: Human Ecology and Social Change*.

Pillsbury, A. C. (1937). *Picturing miracles of plant and animal life*. J. B. LIPPINCOTT COMPANY. <https://archive.org/details/picturingmiracle00pillrich>

Pillsbury-Foster, M. (n.d.). Arthur C. Pillsbury Foundation. Retrieved June 26, 2024, from <http://www.acpillsburyfoundation.org/ACP-Biography.html>

Plee, T., & Suckling, C. C. (2024). Improving green sea urchin (*Strongylocentrotus droebachiensis*) hatchery production by determining effective settlement cues and post-settlement conditions. *Aquaculture*, 581, 740386. <https://doi.org/10.1016/J.AQUACULTURE.2023.740386>

Quadrupartite Memorandum of Understanding (MoU) signed for a new era of One Health collaboration. (2022). <https://www.who.int/news/>

item/29-04-2022-quadripartite-memorandum-of-understanding-(mou)-signed-for-a-new-era-of-one-health-collaboration

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169. <https://doi.org/10.1007/BF01405730/METRICS>

Silva, P. (2012). Crescimento do ouriço-do-mar *Paracentrotus lividus* em viveiro na zona costeira da Ericeira, Portugal [Master's Dissertation]. Faculdade de Ciências da Universidade de Lisboa.

Simon, N. (2016). *The Art of Relevance*. Museum 2.0 Santa Cruz.

Smith, E. K. (2007). *How to Make Books - Fold, cut & Stich Your Way to a One-of-a-kind Book*.

Spoelstra, J. (2023). What is Life-Centered Design? Life-Centered Design School. <https://lifecentereddesign.school/blog/what-is-life-centered-design>

Strona, G., & Bradshaw, C. J. A. (2022). Coextinctions dominate future vertebrate losses from climate and land use change. *Science Advances*, 8(50), eabn4345. [https://doi.org/10.1126/SCIADV.ABN4345/SUPPL\\_FILE/SCIADV.ABN4345\\_SM.PDF](https://doi.org/10.1126/SCIADV.ABN4345/SUPPL_FILE/SCIADV.ABN4345_SM.PDF)

The Transition Design Framework – Transition Design Seminar CMU. (n.d.). Retrieved June 19, 2024, from <https://transitiondesignseminarcmu.net/the-transition-design-framework/>

Transforming our world: the 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs. (n.d.). Retrieved July 10, 2024, from <https://sdgs.un.org/2030agenda>

Varma, A. (2023). *Invisible Wonders: Photographs of the Hidden World*. National Geographic.

Williamson, C. (2022). The Garden in the Laboratory: Arthur C. Pillsbury's Time-Lapse Films and the American Conservation Movement. *Philosophies*, 7(5), 118. <https://doi.org/10.3390/philosophies7050118>

Wizinsky, M. (2022). *Design after capitalism: transforming design today for an equitable tomorrow*. The MIT Press.

Yin, R. K. (2018). Getting Started: How to Know Whether and When to Use the Case Study as a Research Method. In *Case study research and applications : design and methods* (pp. 30–36). SAGE Publications.

Zingale, S. (2016, June 25). Design as translation activity: a semiotic overview. <https://doi.org/10.21606/drs.2016.401>

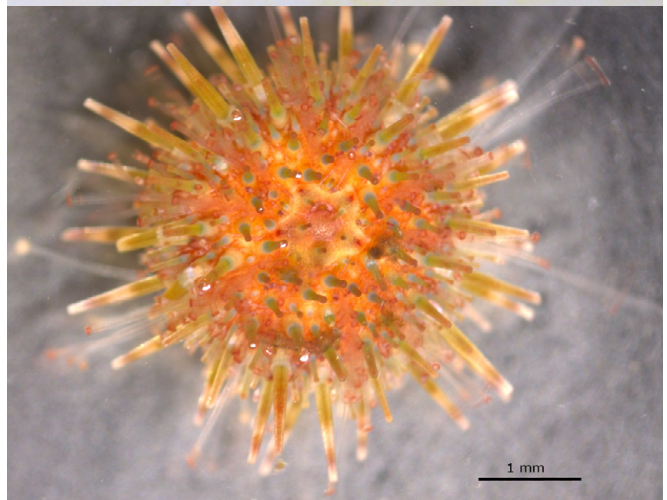
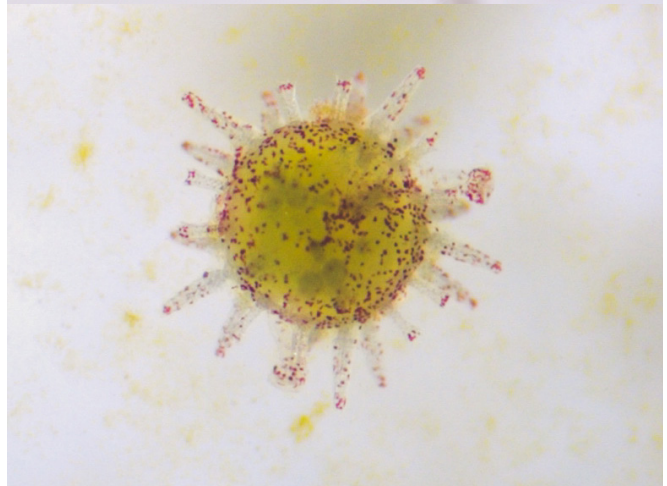
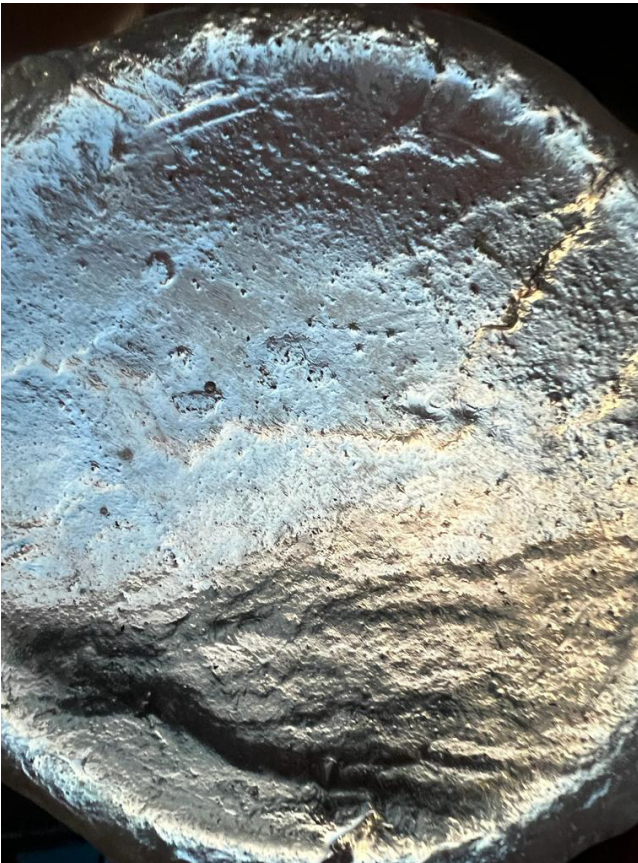
Zizek, S. (2010). Ecology as religion [Video recording]. <https://www.youtube.com/watch?v=IQblqNd5D90>



# Annexes and Appendices

# Annex 1

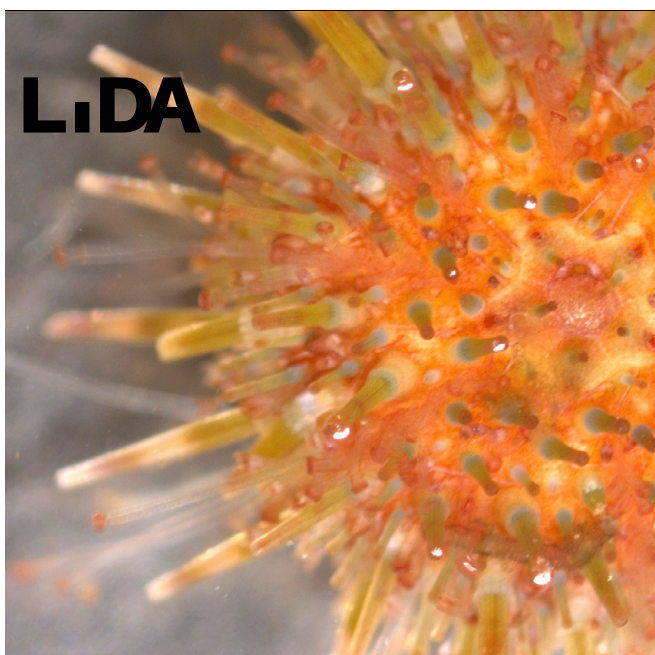
## Photographs delivered for communication of the “Living Surfaces” project on LiDA’s website



## Annex 2

# “Living Surfaces” project on LiDA’s website

RESEARCH ABOUT CALLS PEOPLE SEARCH #  
PROJECTS EVENTS EDITIONS



## LIVING SURFACES

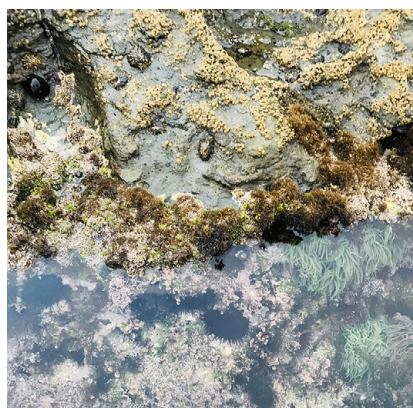
Design of physical structures for sea urchins regeneration in portuguese coast

#DESIGN | #EDUCATION | #ECOLOGY

MAIN RESEARCHER  
Renato Bispo  
renato.bispo@ipleiria.pt

DURATION  
01.09.22 – present

The Living Surfaces project aims to develop physical structures – substrates – that will house sea urchins after settlement, the stage in their life cycle when they metamorphose and adopt a life-style on the seabed. These substrates will be placed at sea in shallow areas, as part of programmes to regenerate populations of these animals, offering protection and maximising their survival during the first weeks of their insertion into their natural habitat.





Sea urchins are key species of our coastal ecosystems and can be considered bio-engineers of intertidal and shallow habitats. They are voracious grazers responsible for transforming leafy kelp forests in rocky bottoms populated by (“only”) coralline algae and for excavating the characteristic alveoli of our coastline that are home to great biodiversity of other animals and algae. Sea urchins are also marine resources of high commercial value. Their roe is a gastronomic delicacy appreciated in many regions of the world. The common European sea urchin *Paracentrotus lividus* is the species with the highest commercial value and for this reason the most susceptible to overfishing, with several populations already practically decimated along the Mediterranean.



In this context, aquaculture appears as an option both to produce roe with high commercial value and juvenile sea urchins, which can be used to repopulate wild populations under intense coastal exploitation and other anthropogenic risks. One of the biggest challenges in producing juveniles for repopulation is finding a substrate that offers both shelter and food in the first weeks of life after the small and fragile sea urchins metamorphose.



The Seed Reef project seeks to develop such substrates, which mimic the rocky forms colonized by sea urchins in their natural habitat, providing food and shelter at a stage when survival rates are often low. At this stage of their life cycle, sea urchins measure around 1 mm in length and feed on microalgae and newly germinated macroalgae. The substrates to be developed must allow these algae to grow in order to provide food for the small urchins.



01



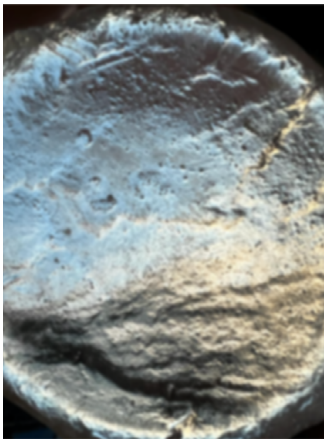
02



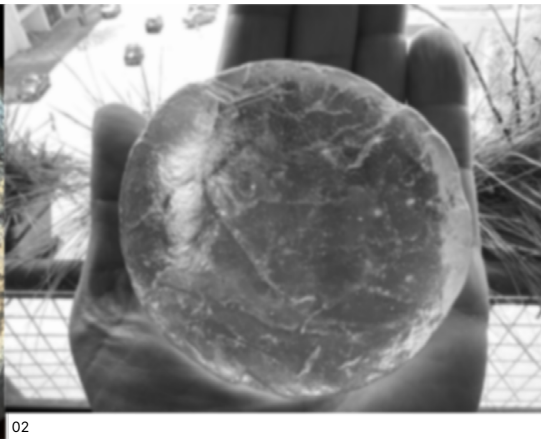
03

To be installed in the natural habitat of the intertidal zones of the Portuguese coast these substrates must resist the force of the sea for at least the necessary time for the small urchins to transit to the surrounding natural structures and must not leave any contaminating residues in the habitat where they are inserted.

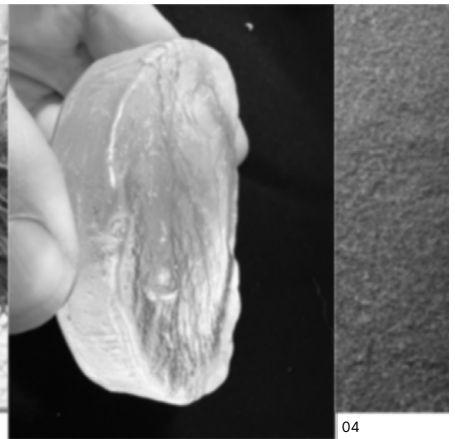
These artificial structures, by having a presence in the intertidal habitat, cohabit also with people and for that reason present a great potential to be used in educational and environmental awareness programs, promoting not only the observation of the various stages of growth of these life forms but also contributing to an awareness of the importance of preserving the marine ecosystem in which they live.



01



02



03

04

External team members:

MARE Politécnico de Leiria: Sílvia Lourenço, Ana Sofia Gomes, Ana Pombo

## Annex 3 Ten Rules, by Corita Kent

### IMMACULATE HEART COLLEGE ART DEPARTMENT RULES

Rule 1

FIND A PLACE YOU TRUST AND THEN TRY TRUSTING IT FOR A WHILE.

Rule 2

GENERAL DUTIES OF A STUDENT:  
PULL EVERYTHING OUT OF YOUR TEACHER.  
PULL EVERYTHING OUT OF YOUR FELLOW STUDENTS.

Rule 3

GENERAL DUTIES OF A TEACHER:  
PULL EVERYTHING OUT OF YOUR STUDENTS.

Rule 4

CONSIDER EVERYTHING AN EXPERIMENT.

Rule 5

BE SELF DISCIPLINED. THIS MEANS FINDING SOMEONE WISE OR SMART AND CHOOSING TO FOLLOW THEM.

TO BE DISCIPLINED IS TO FOLLOW IN A GOOD WAY.  
TO BE SELF DISCIPLINED IS TO FOLLOW IN A BETTER WAY.

Rule 6

NOTHING IS A MISTAKE. THERE'S NO WIN AND NO FAIL. THERE'S ONLY MAKE.

Rule 7 The only rule is work.

IF YOU WORK IT WILL LEAD TO SOMETHING.  
IT'S THE PEOPLE WHO DO ALL OF THE WORK ALL THE TIME WHO EVENTUALLY CATCH ON TO THINGS.

Rule 8

DON'T TRY TO CREATE AND ANALYSE AT THE SAME TIME. THEY'RE DIFFERENT PROCESSES.

Rule 9

BE HAPPY WHENEVER YOU CAN MANAGE IT. ENJOY YOURSELF. IT'S LIGHTER THAN YOU THINK.

Rule 10

"WE'RE BREAKING ALL OF THE RULES, EVEN OUR OWN RULES. AND HOW DO WE DO THAT? BY LEAVING PLENTY OF ROOM FOR X QUANTITIES." JOHN CAGE

HELPFUL HINTS: ALWAYS BE AROUND. COME OR GO TO EVERYTHING. ALWAYS GO TO CLASSES. READ ANYTHING YOU CAN GET YOUR HANDS ON. LOOK AT MOVIES CAREFULLY, OFTEN. SAVE EVERYTHING-IT MIGHT COME IN HANDY LATER.

THERE SHOULD BE NEW RULES NEXT WEEK.

# Appendix 1

## Photobook “To Plate or Not to Plate”







[Photographs] by Pedro Cá, 2024

or not  
too  
plate

A story about

To

plate

consumption

“ In spite of its popular name (purple sea urchin), the color is highly variable: black-purple, purple, red-brown, dark brown, yellow-brown, light brown, or olive green. ”

Boudouresque C., Verlaque M.



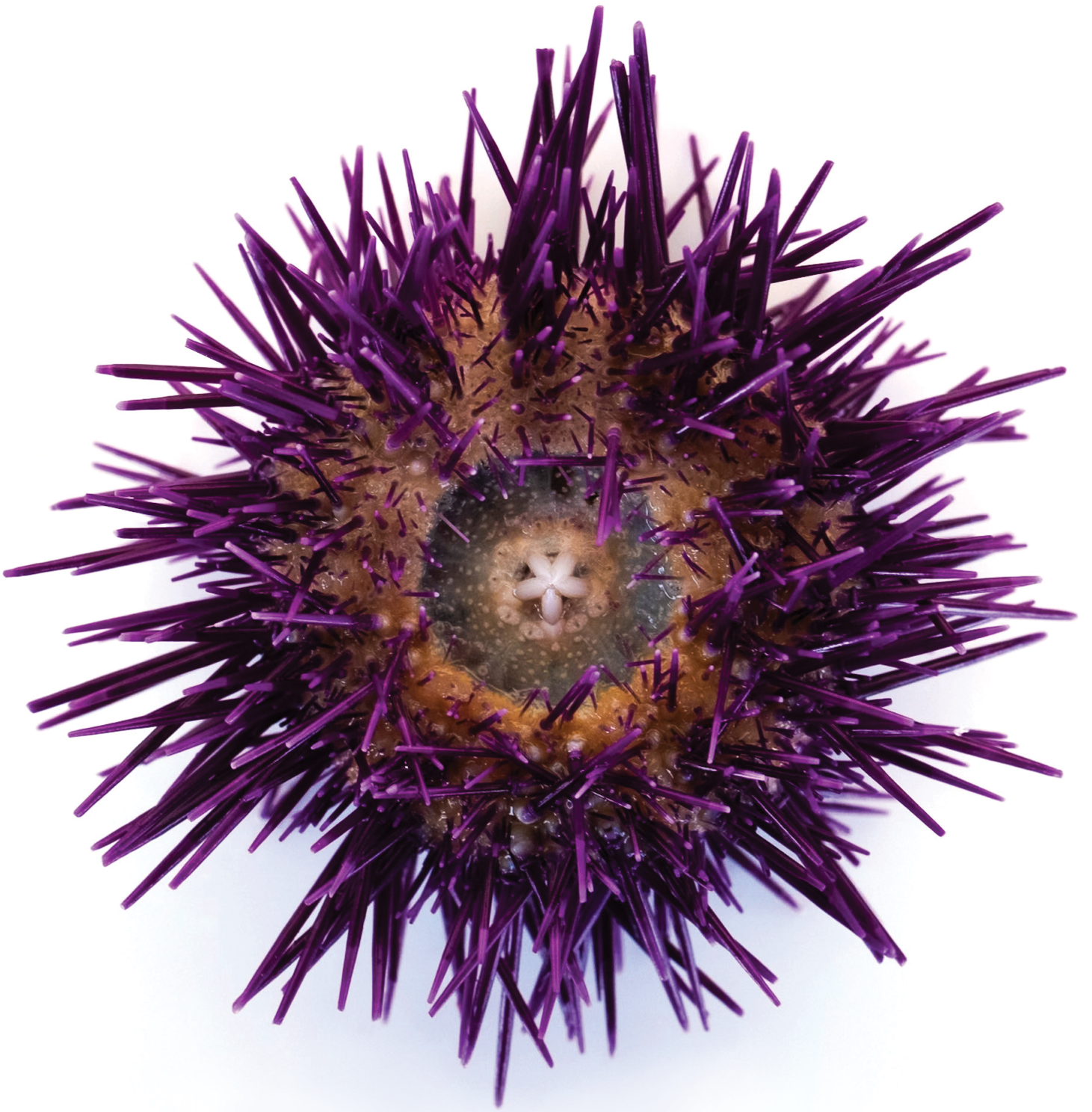








































“ *Paracentrotus lividus* gonads (roe) have been appreciated as a luxury seafood and it has been intensively harvested. *P. lividus* plays a major role in determining the organization of benthic communities. Harvesting of *P. lividus* is said to have resulted in a severe erosion of its populations, with consequences for the health status of ecosystems. ”

Boudouresque, C. F., & Verlaque, M. (2020)

*Paracentrotus lividus*. In *Developments in Aquaculture and Fisheries Science* (Vol. 43, pp. 447–485). Elsevier.  
<https://doi.org/10.1016/B978-0-12-819570-3.00026-3>

This work is financed by national funds through FCT - Fundação para a Ciência e a Tecnologia, I.P., under the Base Funding with the reference UIDP/05468/2020 and the identifier doi.org/10.54499/UIDP/05468/2020.

by Ana Cação, 2024

## Appendix 2

# Colourable photobook





[Photographs] by Pedro Cá, 2024



[Photograph] elaborated by the author

Paracentrotus lividus gonads (roe) have been appreciated as a **luxury** seafood and it has been **intensively** harvested. P. lividus plays a **major role** in determining the organization of benthic communities. **Harvesting** of P. lividus is said to have resulted in a severe erosion of its populations, with **consequences for the health status of ecosystems**.

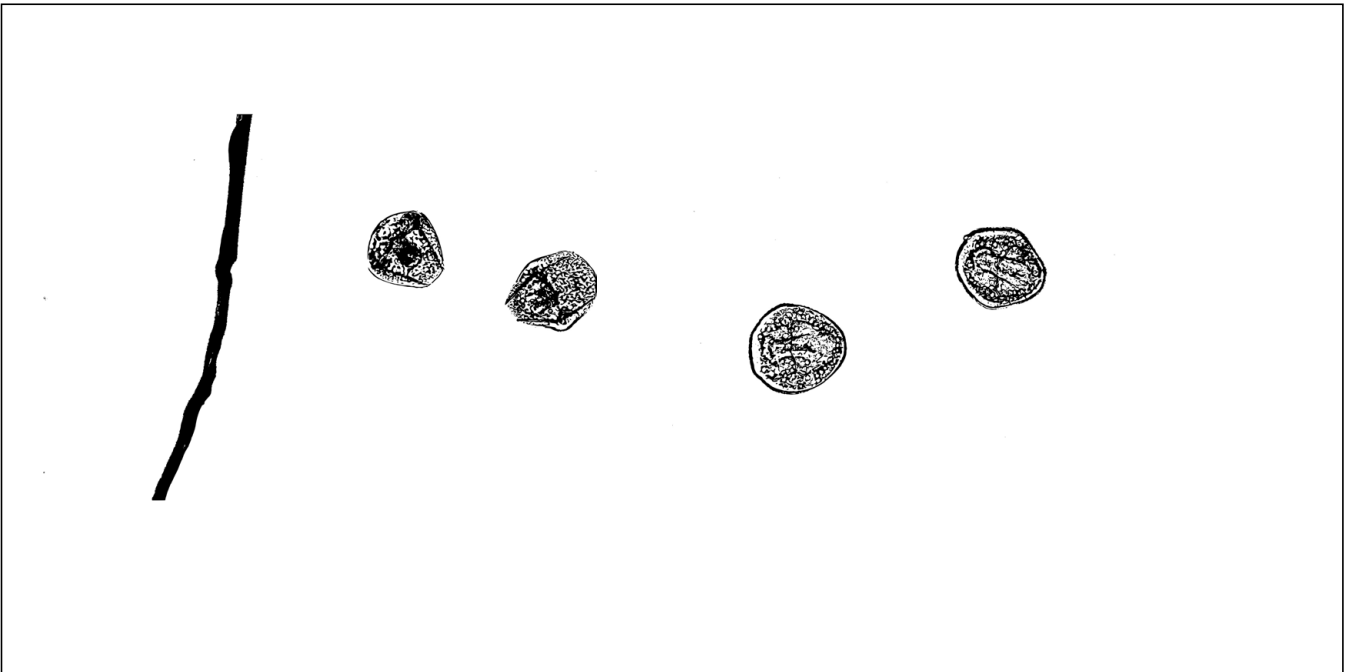
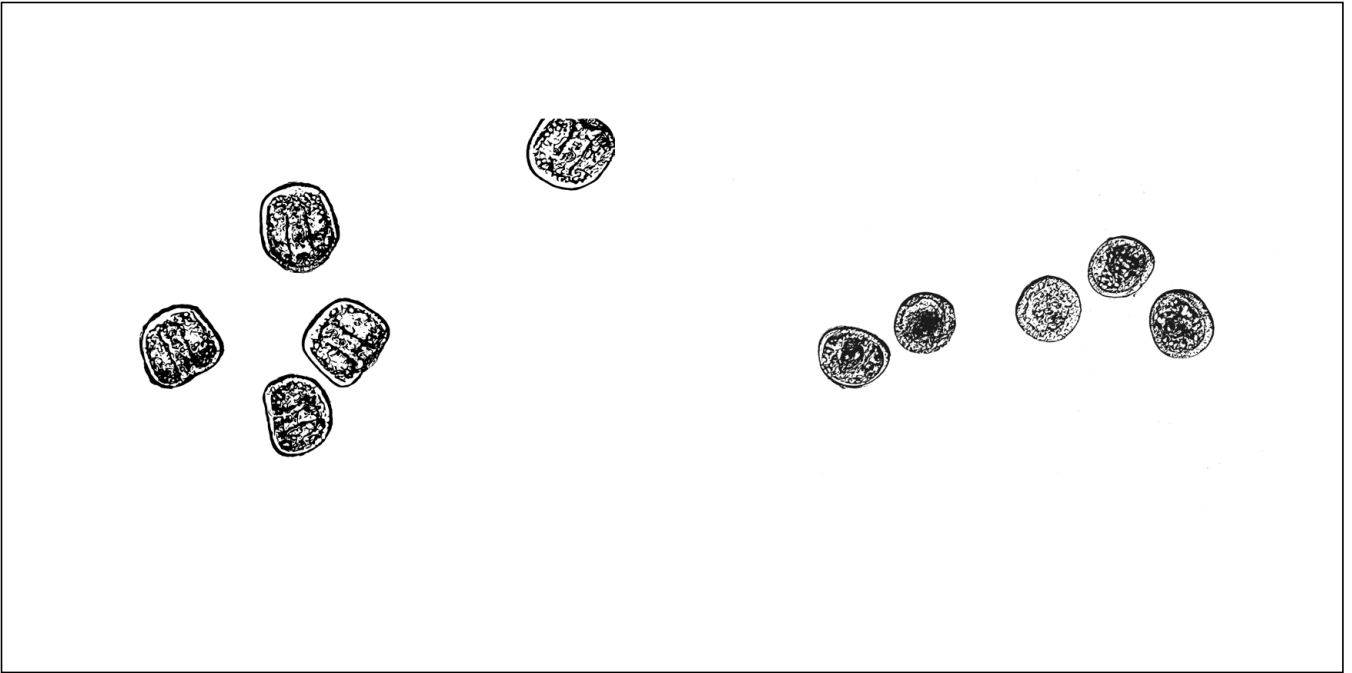
Boudouresque C., Verlaque M., 2020

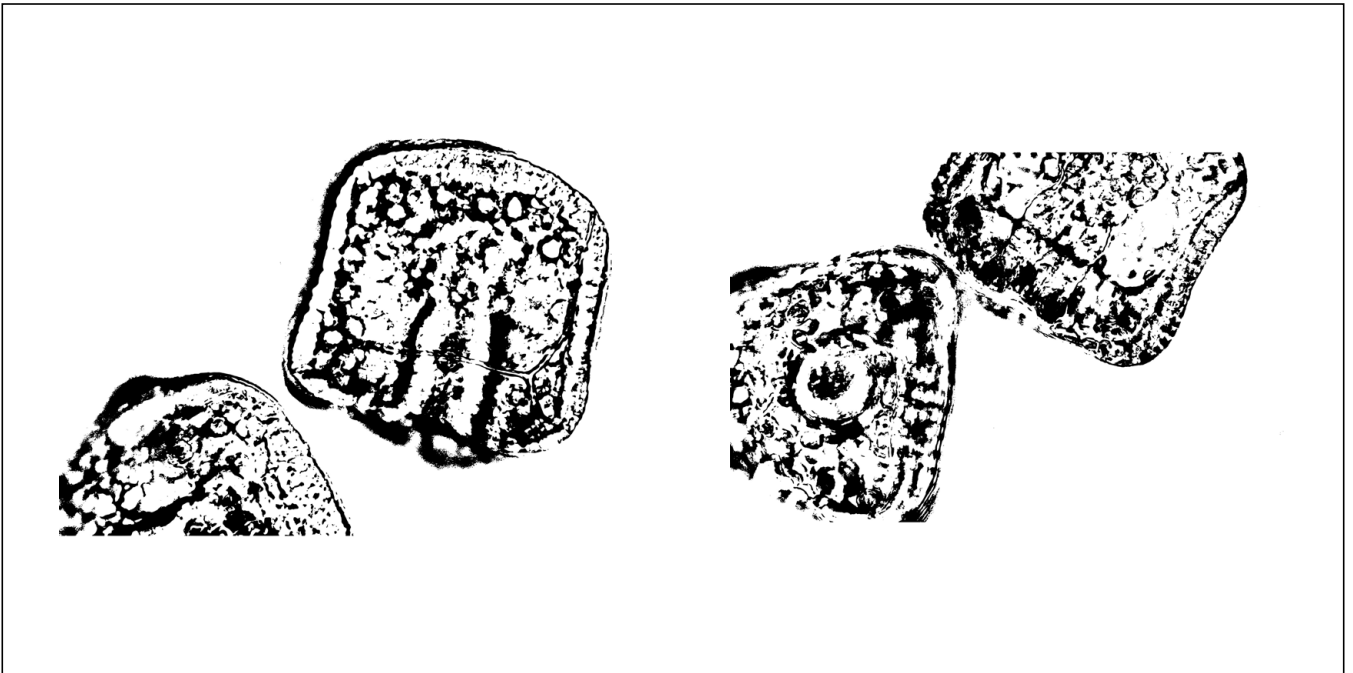
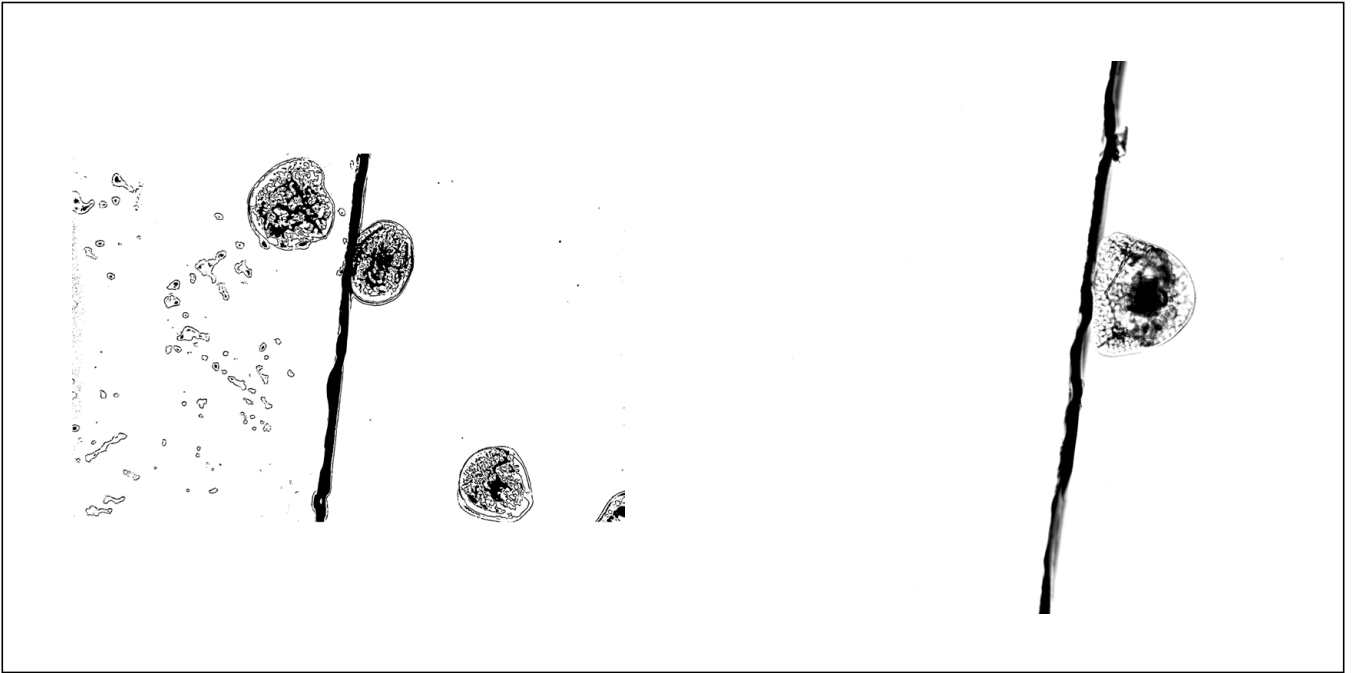
This is a colourable photobook, feel

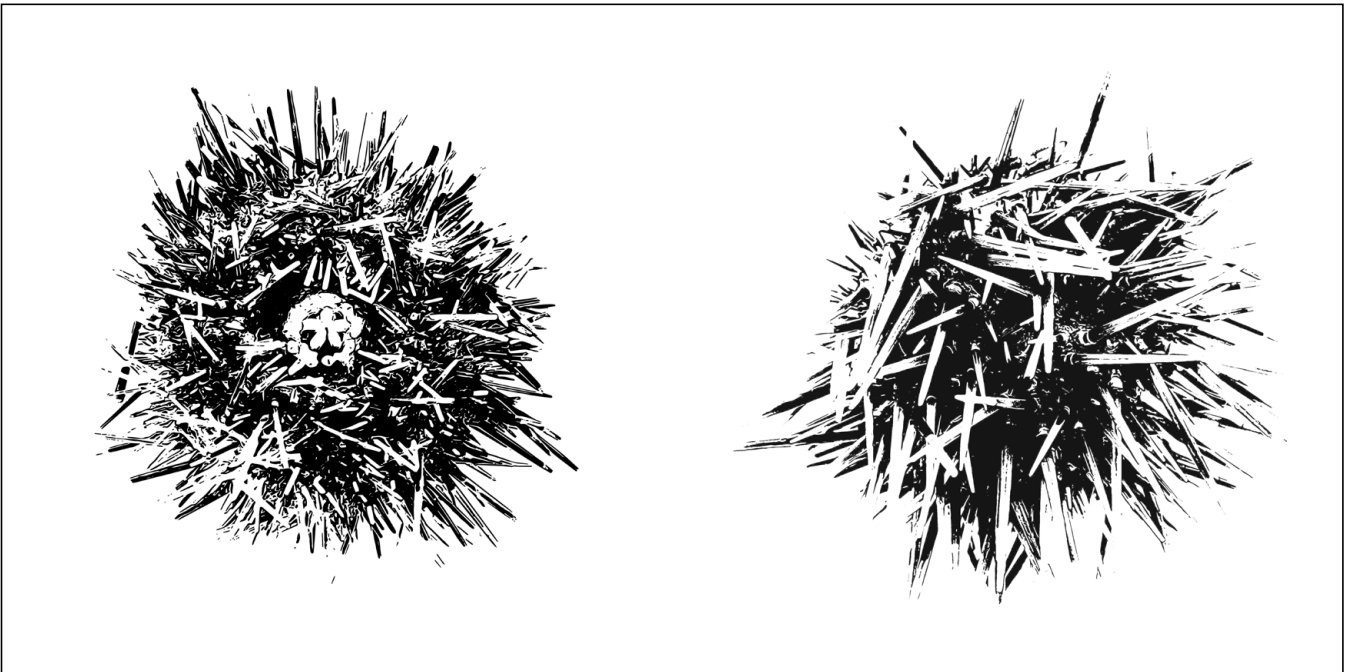
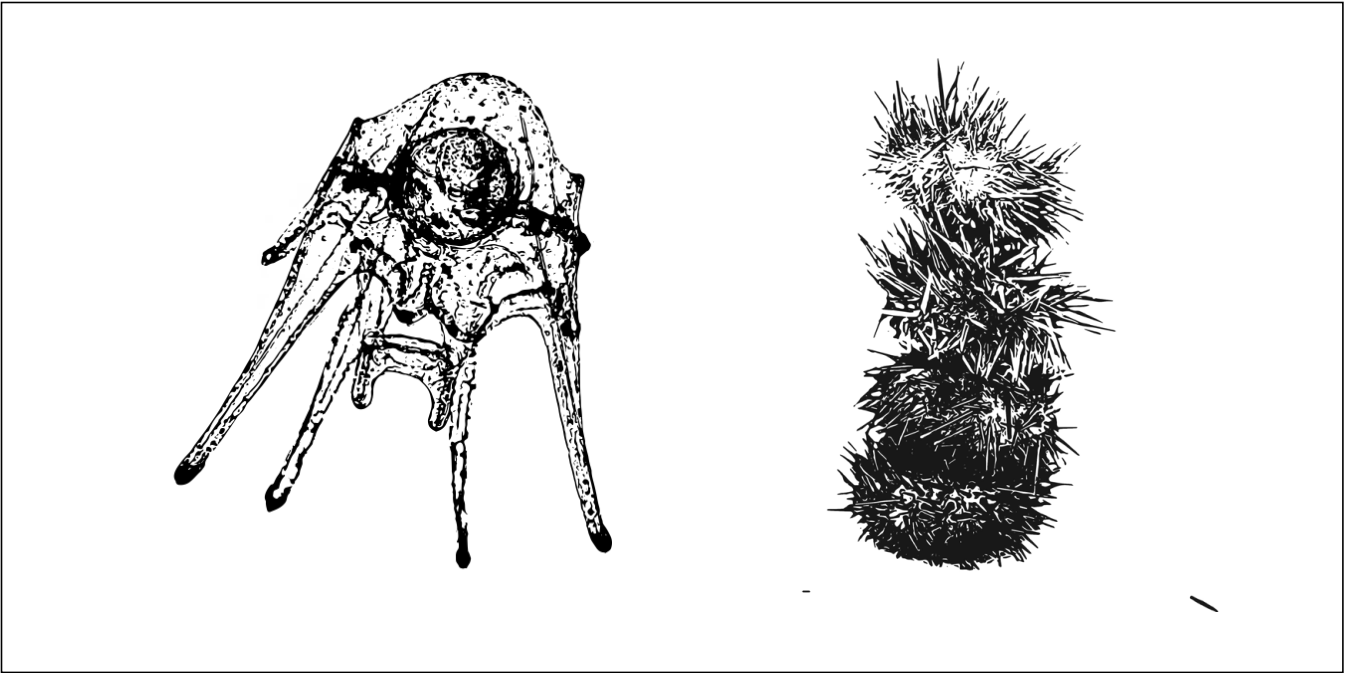
free to paint and draw on it.

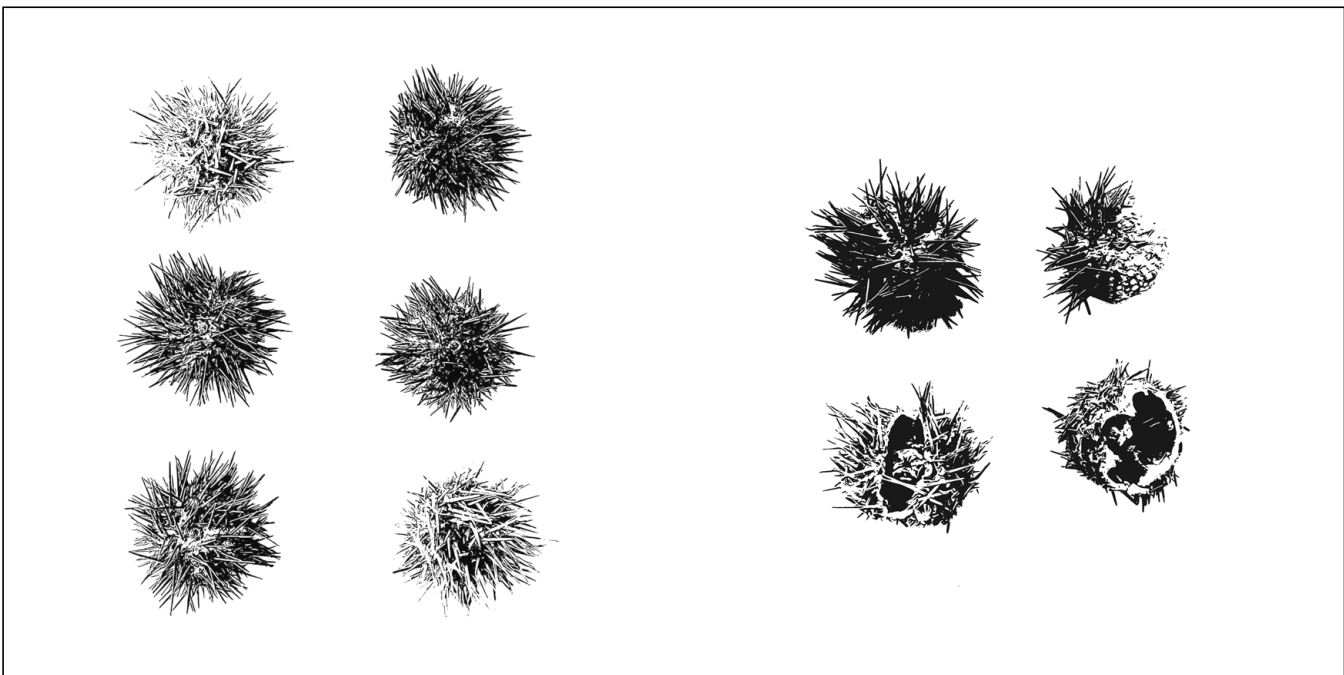
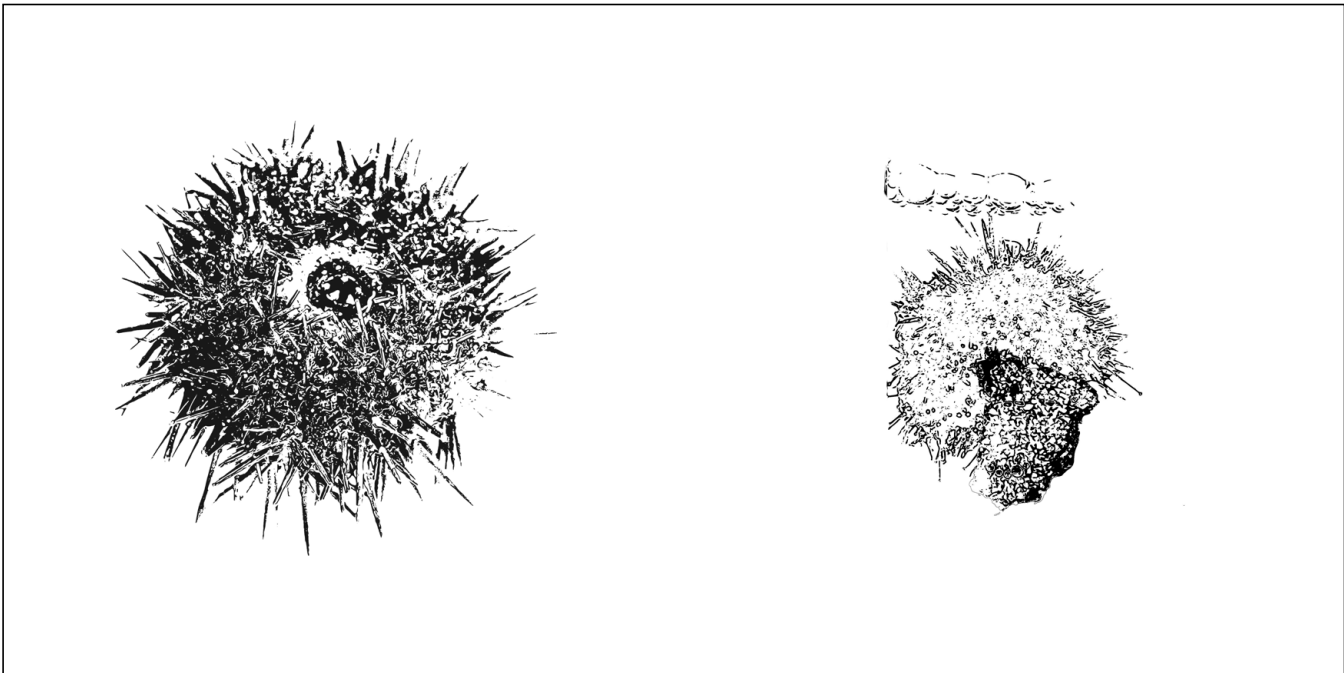
Share your imagination

#livingsurfaces









by Ana Cação, 2024

Share your imagination

#livingsurfaces

This work is financed by national funds through FCT - Fundação para a Ciência e a Tecnologia, I.P., under the Base Funding with the reference UIDB/05468/2020 and the identifier doi.org/10.34469/UIDB/05468/2020.



# Appendix 3

## Explorations with AI





# Appendix 4

## ChatGPT as a tool in research

ChatGPT 4o mini ▾

↑ AN

there's a book from humberto eco on how to make a thesis

Yes, Umberto Eco wrote a book titled "How to Write a Thesis," originally published in 1977 in Italian as "Come si fa una tesi di laurea." It was later translated into several languages, including English. The book offers practical advice on the research and writing process for crafting a thesis, particularly aimed at students completing their undergraduate or graduate degrees.

### Key Features of Eco's "How to Write a Thesis":

- Research Methods:** Eco provides detailed guidance on how to conduct scholarly research, including how to find relevant sources, organize notes, and make use of libraries and archives effectively.
- Writing Tips:** The book covers aspects of writing a thesis, from structuring an argument to the stylistic and technical aspects of writing scholarly text.
- Practical Approach:** Eco's advice is grounded in practical strategies rather than theoretical aspects, making it accessible for students who are in the process of writing their theses.
- Time Management:** He also discusses how to plan one's work schedule, emphasizing the importance of starting early and setting realistic goals.
- Intellectual Rigor:** While the book is practical, Eco does not shy away from insisting on intellectual rigor and critical thinking in the thesis-writing process.

This book remains a valuable resource for students and is often recommended in academic writing courses for its thorough and insightful approach to the complexities of thesis writing. It blends practical advice with Eco's characteristic wit and depth of knowledge, making it not only useful

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This book remains a valuable resource for students and is often recommended in academic writing courses for its thorough and insightful approach to the complexities of thesis writing. It blends practical advice with Eco's characteristic wit and depth of knowledge, making it not only useful but also engaging to read.

there's one chapter where he explains how to make reading cards from books read during research

Indeed, in Umberto Eco's "How to Write a Thesis," one of the key methods he discusses is the creation and use of reading cards or index cards. This method helps students organize their research and thoughts efficiently. Here's a brief overview of how Eco suggests using these cards:

### Eco's Method for Making Reading Cards:

- Organization:** Eco advocates for a systematic approach where each book or article gets its own series of cards. Each card should contain specific and concise information drawn from the reading.
- Categories:** He suggests categorizing the cards into various types, such as bibliographical cards, which record full citation information, and content cards, which contain summaries or quotes along with page numbers.
- Content Detail:** On each content card, students should write down significant quotes, summaries of important sections, or their own thoughts about the content. It's crucial to include page numbers to easily locate the original text for review or citation.
- Cross-referencing:** Eco encourages the use of a cross-referencing system. This means

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4. **Cross-referencing:** Eco encourages the use of a cross-referencing system. This means linking cards by a common theme, argument, or author, which facilitates an integrated understanding of the topics and supports the development of the thesis argument.
5. **Physical Handling:** The physical nature of the cards allows for easy rearrangement, which can be particularly useful during the structuring phase of the thesis writing, where ideas and sections need to be ordered cohesively.
6. **Ongoing Process:** The creation of reading cards is an ongoing process that should accompany the reading phase of research. It ensures that all important information and citations are accurately recorded and readily available for writing and revising the thesis.

This method, while somewhat traditional in the digital age, is still valuable for its discipline and tactility. It forces the researcher to summarize and reflect on information continually, which aids in deeper understanding and retention of the material. For those who prefer digital tools, similar methods can be applied using software and apps designed for research organization and note-taking.

is the correct term reading cards or reading index?

In the context of Umberto Eco's method for organizing research, the term commonly used is "index cards" rather than "reading cards." Eco's technique involves using these index cards to jot down notes, summaries, and key pieces of information from the literature reviewed during research for a thesis or any scholarly work.

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The use of index cards allows for easy organization and reorganization of thoughts and sources, facilitating a structured approach to assembling and synthesizing information. Each card typically contains a single piece of information or a summary along with references, making it straightforward to arrange and rearrange as the structure of the thesis evolves. This method can be adapted to digital formats using software that mimics the function of physical index cards for those who prefer a more modern approach.

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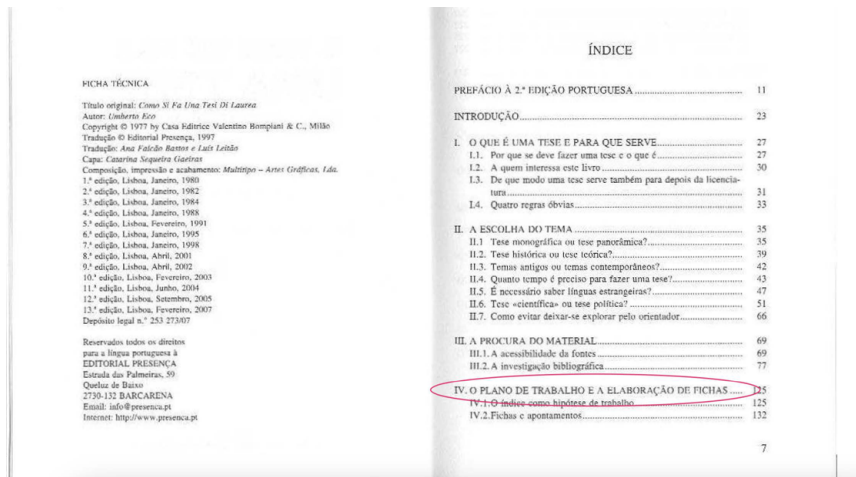
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which chapter is that?

In Umberto Eco's book "How to Write a Thesis," the detailed discussion on how to use index cards for organizing notes and citations from research materials is primarily found in Chapter 3, titled "The Work Plan and the Index Cards." This chapter provides comprehensive guidance on creating a systematic approach to collecting and organizing research data effectively using index cards. Eco outlines various techniques for categorizing, referencing, and using these cards to support the writing process of a thesis. This method is aimed at helping students manage large amounts of information efficiently, fostering a structured development of their argument or thesis.

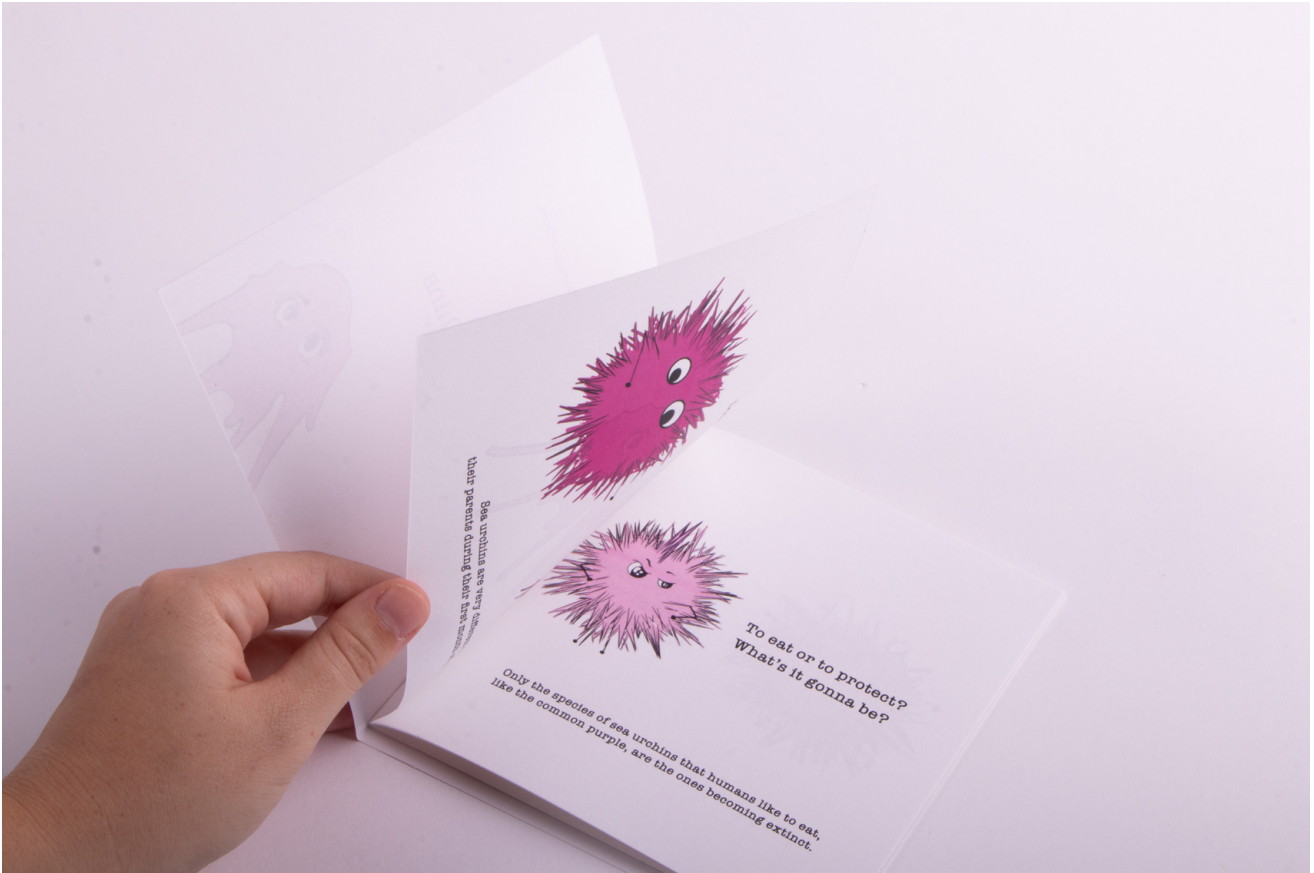
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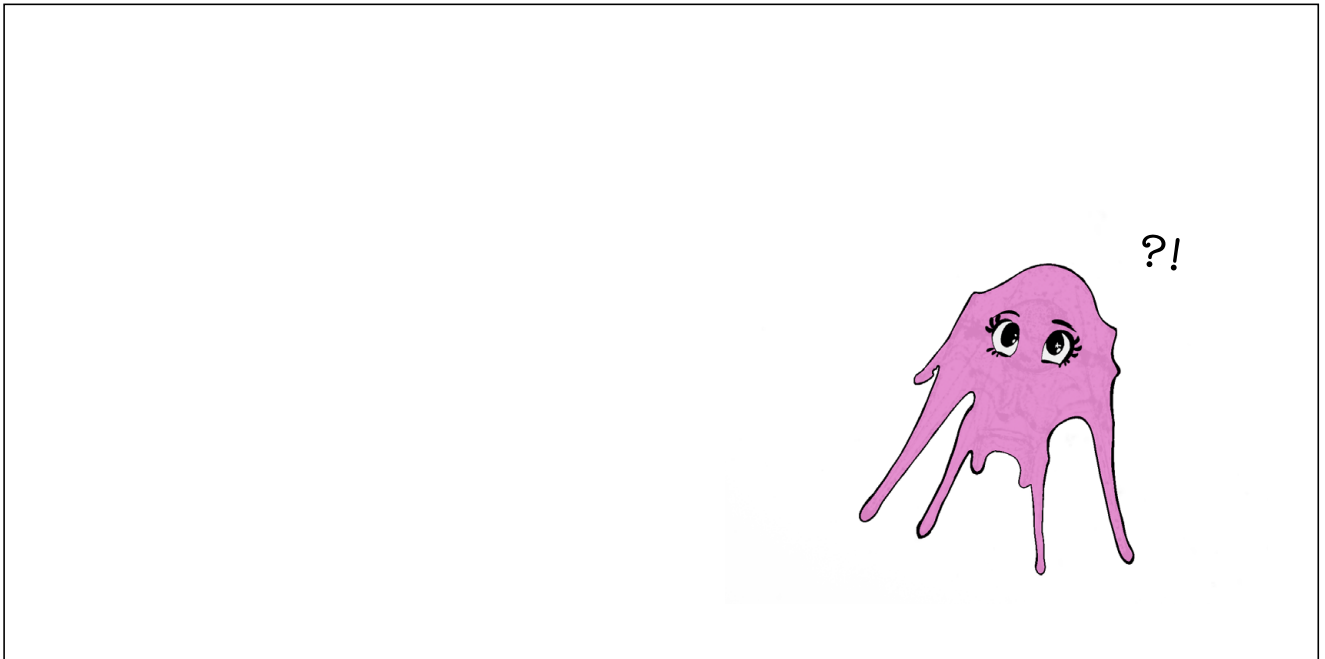
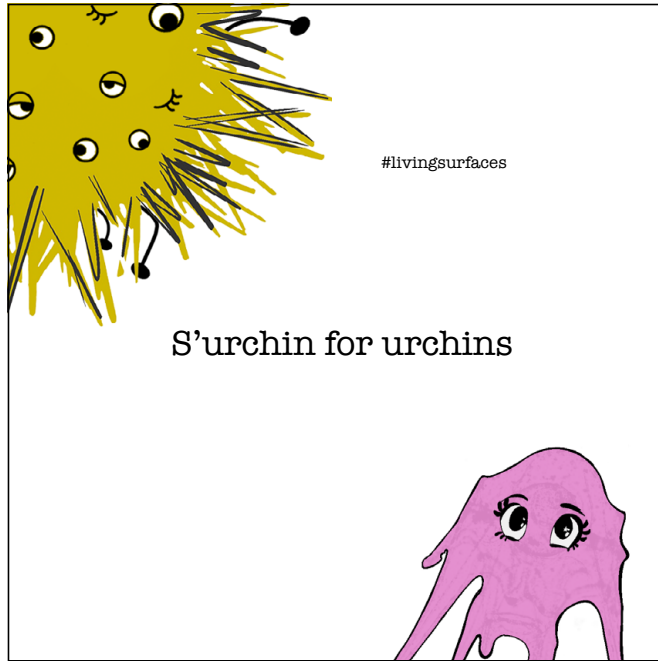
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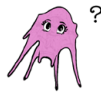
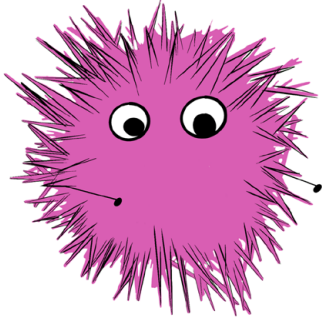
# Appendix 5

## Illustration book

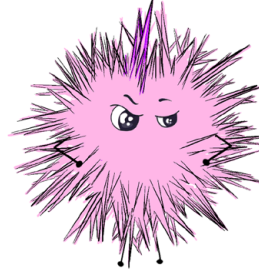




Look, I am your father

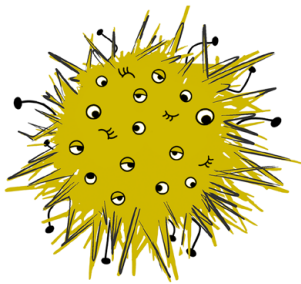


Sea urchins are very different from their parents during their first month of age



To eat or to protect?  
What's it gonna be?

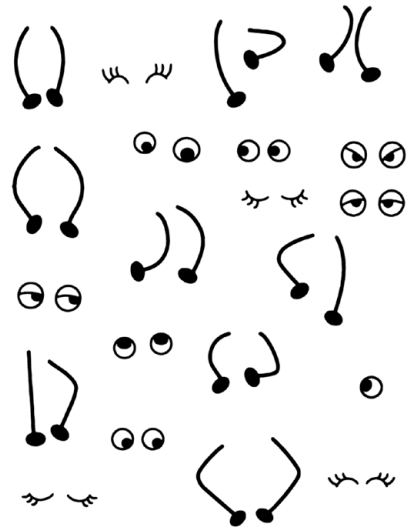
Only the species of sea urchins that humans like to eat, like the common purple, are the ones becoming extinct.

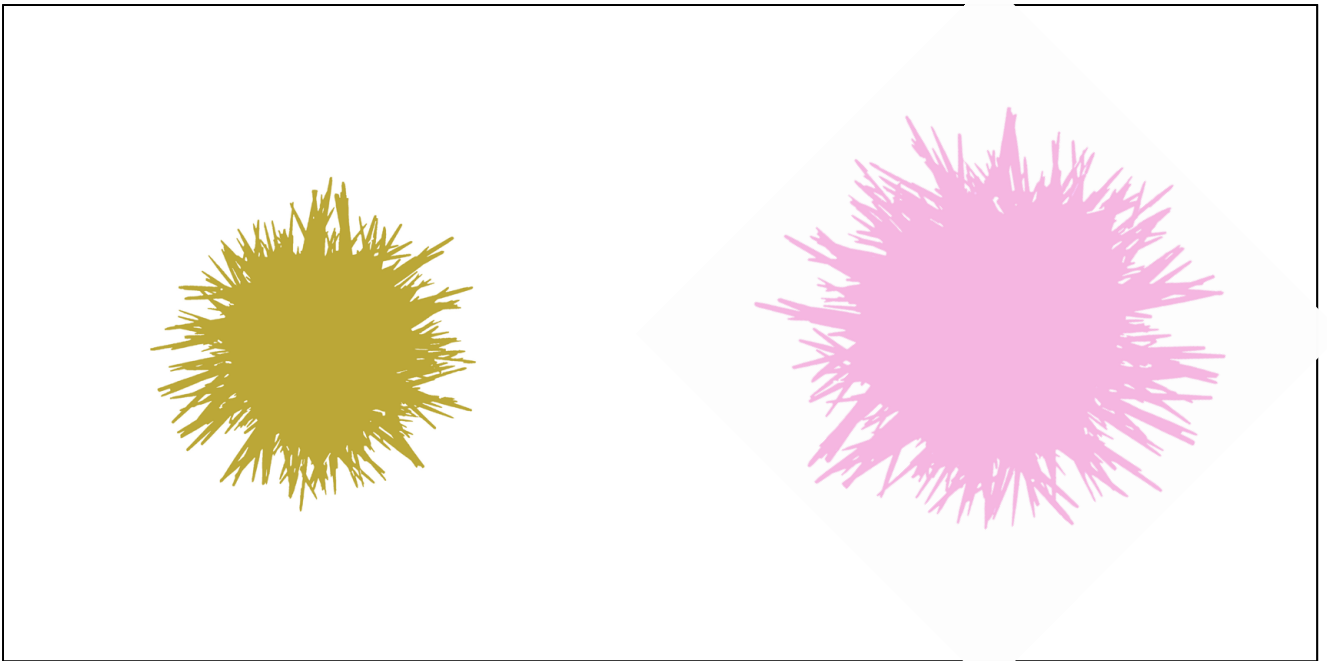
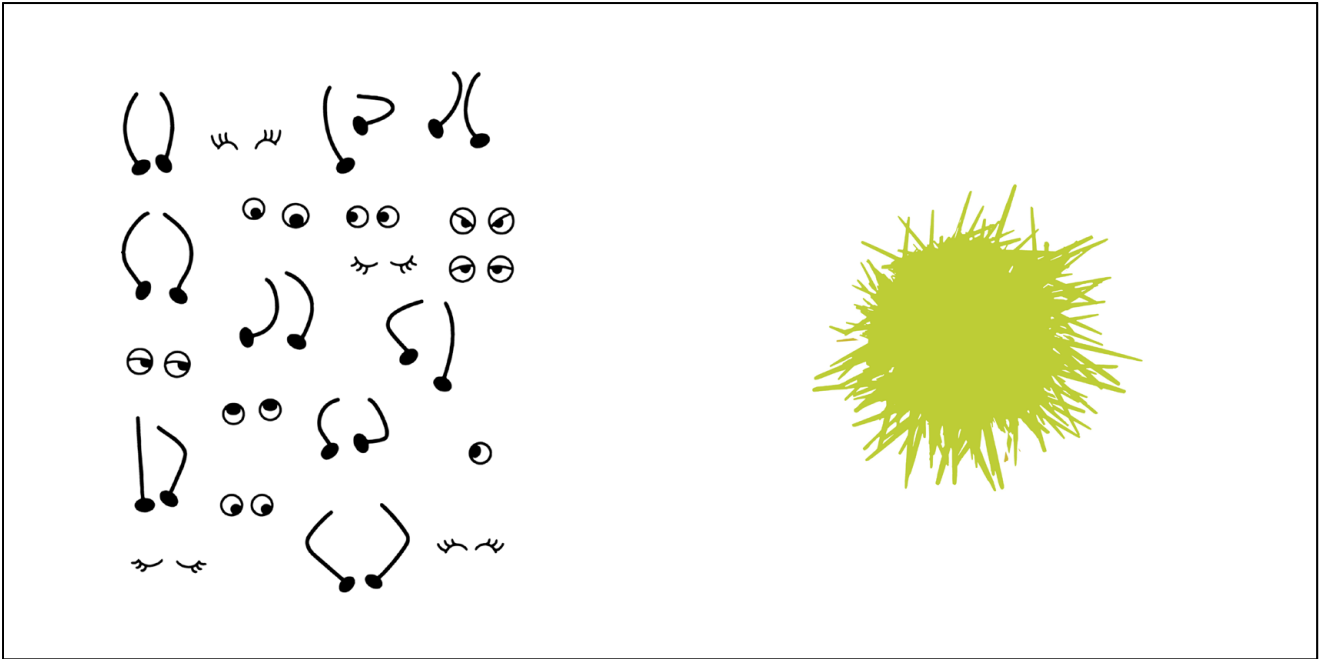


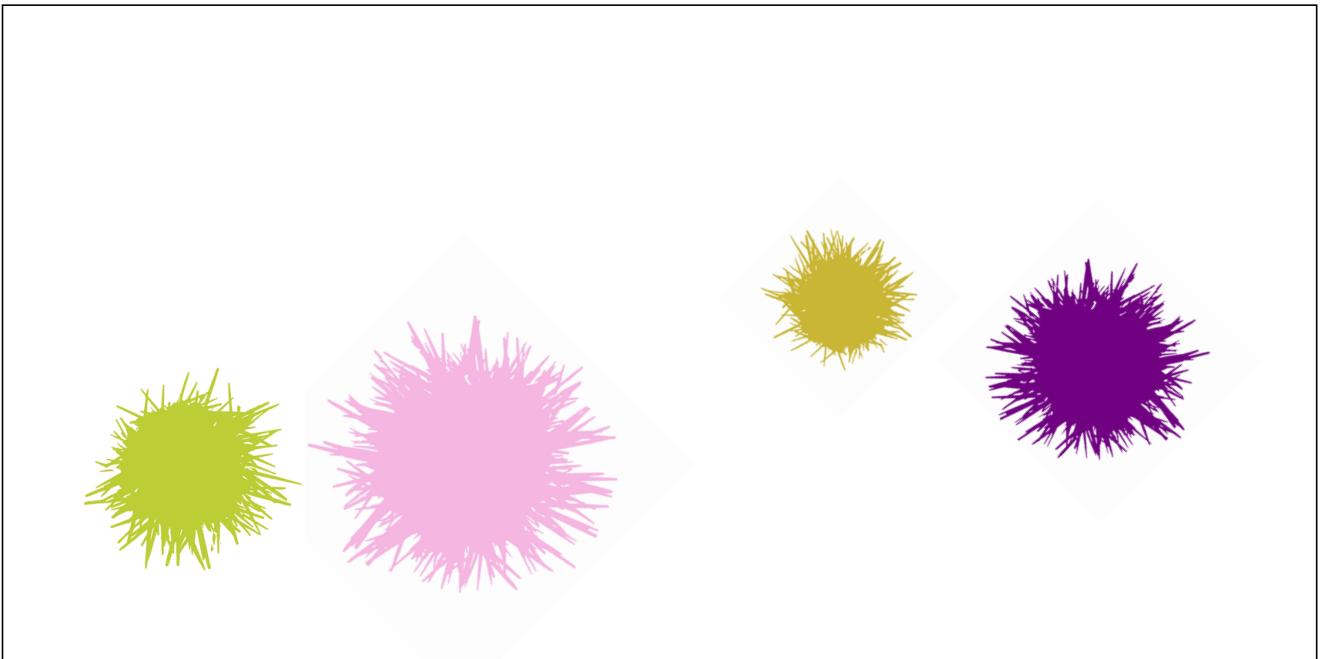
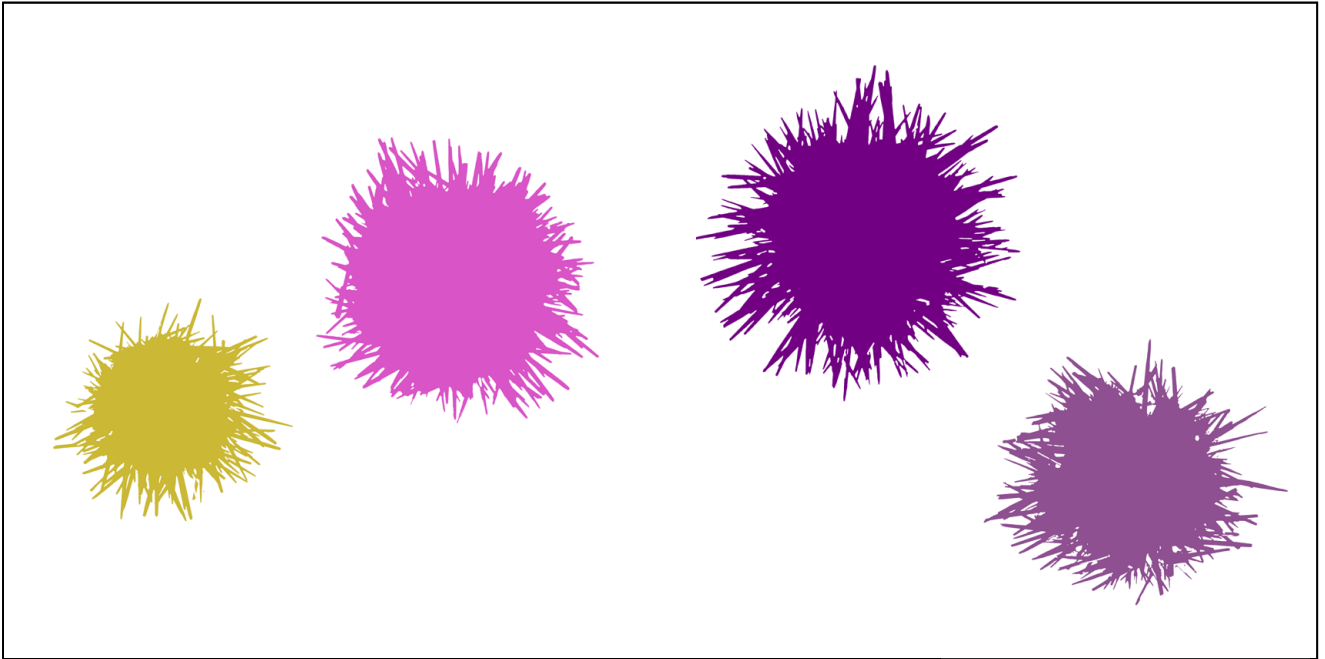
Sea urchins have cells sensitive to light and tube feet all over their body

Place stickers and draw on the next pages to create your own characters

Share them!  
#livingsurfaces







by Ana Cação, 2024

Share your imagination

#livingsurfaces

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# Appendix 6 SDGs as Design tools

**1 NO POVERTY** Are sea urchins adequate to stop poverty?  
→ with Aquaculture local families can become more resilient

**2 ZERO HUNGER** to end hunger?  
→ no (proportionality issues) achieve food security → only to very small local communities  
improve nutrition? → maybe, probably not  
promote sustainable agriculture? → No

**3 GOOD HEALTH AND WELL-BEING** ensure healthy lives?  
→ no  
promote well-being?  
→ maybe  
→ biodiversity  
→ empathic relation to nature

**4 QUALITY EDUCATION** (faster) Inclusive and equitable? (quality education)  
Lifelong learning opportunities?  
→ yes

**5 GENDER EQUALITY** Achieve gender equality?  
→ No  
Empower all women and girls?  
→ only through education

**6 CLEAN WATER AND SANITATION** Ensure availability and sustainable management of water?  
→ No  
(of water)  
→ Yes (they detect chemicals and proteins) and sanitation for all? → maybe

**7 AFFORDABLE AND CLEAN ENERGY** Energy for all?  
→ No

**8 DECENT WORK AND ECONOMIC GROWTH** Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work?  
→ maybe, might on a small community

**9 INDUSTRY, INNOVATION AND INFRASTRUCTURE** Build resilient infrastructure?  
→ No  
Promote inclusive and sustainable industrialization?  
→ on a very small scale  
Foster innovation → maybe

**10 REDUCED INEQUALITIES** Reduce inequality within countries?  
→ disability  
→ smaller scale  
Between countries?  
→ disability

**11 SUSTAINABLE CITIES AND COMMUNITIES** Make cities and human settlements inclusive?  
→ safe → no  
→ resilient → maybe  
→ sustainable → yes

**12 RESPONSIBLE CONSUMPTION AND PRODUCTION** Ensure sustainable consumption and production patterns  
→ Wicked-problem

**13 CLIMATE ACTION** Urgent action to combat climate change and its impacts.  
→ maybe?  
→ maybe  
→ Biodiversity

**14 LIFE BELOW WATER** Conserve and sustainably use the oceans, seas and marine resources for sustainable development?  
→ Yes  
→ Yes (need to control populations to ensure maintenance of some species of algae)

**15 LIFE ON LAND** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably use their services and resources?  
→ Needs?  
→ Good regulation on harvesting and aquaculture  
→ Make small communities more resilient

**16 PEACE, JUSTICE AND STRONG INSTITUTIONS**

**17 PARTNERSHIPS FOR THE GOALS** → map connections

Ana Cação

2024