MULTISPECIES DESIGN

by

Daniel J. Metcalfe

Thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy (PhD)

at the

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ABSTRACT

The devastating effects that unsustainable design practices have on the natural world and other species with whom we share this planet have gained widespread awareness and are the driving force behind attempts to develop more sustainable design approaches. These efforts tend to focus on minimising the negative effects that design has on the natural world by reduced material and energy usage. However, the possibility that design may have an *active* role in mitigating the erosion of biodiversity has only entered the discussion in recent years and remains a marginal activity for design.

Following an ongoing paradigm shift calling for the inclusion of a greater diversity of wild animals within human-dominated habitats (as a way of addressing both the erosion of biodiversity and humankind’s alienation from nature), this research proposes that there is a growing need for a design practice capable of responding to the needs of wild animals, while addressing questions of human-animal interaction.

In this thesis, *Multispecies Design* is proposed and developed as a theoretical framework for supporting the shift to more biodiverse human habitats. The research addresses both the physical and socio-cultural requirements of such a shift. Three distinct views define this emerging design approach: recognising *animals as clients of design*, recognising *human-animal interactions as designed experiences* and the view of *manmade systems as further extensions of ecological systems.*

The methodological implications of Multispecies Design have been explored in a case study design project concerned with the ecological enhancement of a coastal outfall pipe on a highly frequented beach in Cornwall, UK. The case study explored ways of designing to address the needs of both people and of wild animal species, as well as the interactions between the two groups. It focused on identifying and developing design approaches and tools for studying and representing wild animals in design projects to facilitate their integration into built environments. These tools were further refined in a series of workshops with design and art students carried out during the PhD research.

The insights from the practical work, together with the theoretical framework developed alongside them, have led to the development of ***Principles of Multispecies Design*** and practical and conceptual ***Tools for Multispecies Design***.

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This chapter introduces the general focus of the thesis, namely design instances that involve nonhuman species. The term Multispecies Design is introduced and defined, to frame the specific type of design involving nonhuman species explored in this work.

1.1. DESIGN FOR NONHUMANS

The effects of human activity on the natural world stretch out to all corners of the planet. Novel (modified by humans[1]) ecosystems are now more common than natural ecosystems (Green, 2013) and even the remaining natural ones exist within the same modified atmosphere and changing climate as the rest of the planet and are affected by these same anthropogenic forces (Hannah, 2015).

Nature conservation has traditionally focused on pristine wildernesses and their preservation and protection from human impact. However, natural systems also exist in proximity to, and overlap, human ones, and the ecological and social value of these systems is gaining increased attention from a wide range of disciplines. Some of these systems are remnants of old ecosystems that existed in the area long before humans arrived. Most are novel and emergent systems, containing hybrid assemblages of species from different origins, set in landscapes influenced by human activity. These systems are often ignored or brushed aside in the design and development of human habitats and are often repressed in the act of maintaining them. Phemister (2010) suggests they have been kept separate from human systems due to our valuing "predictability and simplicity" over "sustainable functionality and variability" in the planning of our cities and towns. Nature, it was assumed, would go on existing elsewhere while we design our human habitats to suit the needs of humans and a handful of other species. However, there is a price to pay for this separation of human systems from natural ones. A price paid in the constant act of fighting back nature, and in the perpetual war on species we consider to be weeds or pests. A price paid in the loss of ecosystem services that could be provided by these emergent ecosystems. A price paid in the alienation of people from the natural world. And a price paid in the loss of habitat for the many species that still subsist in the margins and shadows of our built environments, and many more which are absent now but could, given the right conditions, make their homes within these environments.

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[1] The term Novel Ecosystems is generally used to describe ecosystems modified by humans, which by some definitions include all the ecosystems on the planet (Marris, 2011, p. 114). The authors of *Novel Ecosystems: Intervening in the New Ecological World Order* define them as modified ecosystems which exist without historical precedents, are self-sustaining and are irreversible to their historical state (Hobbs et al., 2013). Even in this more narrow definition, Novel Ecosystems are more common than natural ones, taking up around 36% of the globe's ecosystems (Green, 2013).

If novel ecosystems are not without ecological value, as many scientists are now realising, then supporting them, allowing them to emerge and re-imagining their integration into human-dominated habitats, holds the key to a practice of design which can go beyond just minimising its negative effects on the natural world—to providing more, and more diverse habitats for other species in and amongst human activity.

Any act of design, intended in a broad sense[2], has an impact that goes beyond our own species. In procuring material resources for our designs, we mine the earth and sea thereby affecting the habitats of other species; we harvest natural materials derived from plant or animal species; we pollute the air, soil and water in our manufacturing processes; we use more resources and create more pollution in the use and maintenance of our designed artefacts; and we create additional waste and pollution when we discard them. The notion of an ecologically sustainable design practice is an elusive and often contested one, which tends to focus on minimising the negative effects that design has on natural systems by reducing, reusing and recycling resources in the design process.

Rather than focusing only on minimising the negative effects that design has on other species (and the planet in general), this thesis looks at the possibility of intentionally addressing, within a design context, the needs of nonhuman species by promoting and improving their integration into human-dominated habitats.

While nonhuman species are undoubtedly present in the world of design—in the form of material resources such as wood, wool, cotton, leather, and in the many forms of inspiration they provide for designers (e.g. biomimicry)—they are nevertheless, rarely considered as potential beneficiaries of the designed outcome[3]. This occurs despite the fact that nonhuman species make constant use of technical objects within human habitats, uses often unforeseen and unaccounted for by the designers of these objects. A myriad of species, from plants, invertebrates, bats and birds, to small and large mammals, make their homes in and amongst built environments; plants find their way into every niche and crack unless they are constantly removed, birds and bats nest in artificial

[2] Design is not an easily defined term and for a broad definition it is sometimes easier to see how it is defined in other fields. Wasson (2000), for example, adopts the definition of design as the act of envisioning and giving shape to new, or modified, products and services.

[3] There are exceptions to this that will be discussed in the following chapters.

constructions, animals share our streets and homes and feed on our refuse. For them, our constructed environments represent free ecological niches which can be exploited and made into a home (Luniak, 2004). Unlike green areas within human habitats that are designed and set aside for other species, this encroachment of nature into areas designed for human use is often met with dismay; it does not conform, and in some cases compromises their intended use, or our aesthetic perception, of the construction. However, what if the needs of nonhuman species were integrated into the designed artefact from the planning phase? Could we design our human habitats to support a wider diversity of species in a way that would benefit all?

Design has always played an important role in mediating human-animal relations; some of the earliest tools created by early humans were used for hunting and processing meat and animal skin, determining the relationship between the human (hunter) and the animal (hunted) (Fry, 2012). Design has been, and still is, used in asserting human dominance over other species and as a tool for domestication. As Dodington, (2014) points out, from its early days design and architecture "has been used to delimit animal spaces, control animal life and reinforce anthropocentric values from a dominant species onto the world at large". In mediating human animal interactions, design has worked mainly to the end of improving the human condition in the world. It has been used as a tool for delimiting and domesticating. Nevertheless, could it also be used as a tool for reconciliation? For creating interactions that promote respect and empathy between humans and wild animal species?

The shift in design practices to include more attention to the needs of wild animal species represents a way of both sustaining more biodiversity within human-dominated habitats, and creating more opportunity for humans to interact with other species in a meaningful and respectful way within human-dominated environments. When it comes to flora, it seems the shift is already on its way. The rise of the green cities movement, as well as the attention green infrastructure (GI) is receiving both in the scientific world and the design and planning world, is having an affect on cities around the world. New strategies are being developed and implemented for improving the ecological function, biodiversity and social value of land and water resources within built environments. These strategies, however, focus predominantly on plant life, while improved animal biodiversity is seldom mentioned in the literature and often only as a consequence of improved plant habitat (Naylor et al., 2014). However, intentional or not, as urban areas become greener they become more attractive for wild animal species which have been shown to migrate into urban areas around the world (Luniak, 2004). The population densities of some wild animals in cities exceed parallel populations in the wild and, in spite of efforts to minimize the phenomenon, wild animal populations in cities around the world is on the rise (ibid). Planning and facilitating the integration of these wild animals into urban areas can help reduce human-animal conflicts, improve urban biodiversity and provide richer opportunities for city dwellers to engage with the natural world.

The vision of wild animals roaming around cities may appear improbable or undesirable, but it often takes surprising and unexpected forms—as will be illustrated in the following chapters of this thesis. The idea is not to promote all wild species in built areas, but rather to introduce new sensitivities towards other species into the *planning* of human habitats to reduce human-animal conflicts, which often arise when animals proliferate in areas not intended or not suitable for them. This shift requires finding new socio-ecological balances; it strives towards human systems that look and behave more like ecosystems, and ecosystems that merge into human environments without being regarded as valueless. In the chapters of this thesis I will try to break this vision down into some of its various theoretical and practical components, with a focus on their design implications, i.e. how the design of built environments can support a transition to more bio-diverse and biophilic human habitats. This is by no means an exhaustive review of this emerging field but more of an exploration of its implications for designers. It is an attempt to learn about the process of designing for other species alongside humans. As such, the focus of this thesis is on the practice. It is through practice that the theoretical and methodological implications of Multispecies Design are considered. Specifically, through a case study design project taking into consideration the needs of both human and nonhuman species, as well as workshops with art and design students focusing on designing for nonhuman species. The insights, as well as the conceptual and practical tools emerging from these practices, are grouped together and presented as *Principles of Multispecies Design* at the end of this thesis.

1.2. Multispecies design

The involvement of design with nonhuman species can take on different forms. It may include for example, design for pets, for zoo or park animals, for farm animals, for lab animals, and into probes for conservation projects such as nets, fences, costumes, prosthetics. The focus in this thesis is on wild animals and their inclusion within human habitats. Specifically, I am interested in designs that perform both an ecological function, i.e. address the needs of one or more wild animal species, as well as a function for humans. I propose the term *Multispecies Design (MD)* to describe this specific type of design involving nonhumans. *Multispecies Design is the practice of designing systems and artefacts that address the needs of humans as well as wild animal species*. One of the consequences of MD is that it inevitably deals also with human-animal interaction; more specifically, it regards human-animal interaction as a designed experience, i.e. an experience that can be managed to reduce conflicts and promote a mutually beneficial interaction. Although power relations will always exist within these interactions, MD does not aim to assert dominance of one species over the other in these relationships, but rather use design as a tool for reconciliation, inclusion and promoting empathy.

Multispecies Design exists at the meeting point of sustainable design with two major contemporary paradigm shifts, one in the humanities and one in natural sciences (see Fig 1.1 below). The Animal Turn in the humanities (Ritvo, 2007), sees a growing focus on animals in fields previously concerned mainly with human activity. The Animal Turn gives rise to hybrid fields such as Animal Geography which studies the "where, when, why and how nonhuman animals intersect with human societies" (Urbanik, 2012), and Multispecies Ethnography, which centres on "how a multitude of organisms' livelihoods shape and are shaped by political, economic, and cultural forces" (Kirksey and Helmreich, 2010). These emerging fields are challenging the artificial separations between nature and culture and are stressing the interconnectedness and mutual dependencies between humans and other species on the planet (see for example Wolfe, 2010 p. xv or Kirksey 2014 p. 3). On the other hand, there has been a shift in the focus of conservation studies—which until recently left humans and their environments outside their scopes—from pristine, untouched wilderness (either through reservation or restoration), to *conservation everywhere*. Strategies are being developed to improve the ecological value of different habitats previously ignored by conservationists: from agricultural fields, through private land and abandoned and ex-industrial land, all the way to the most intensively built environments in terrestrial and marine landscapes. All these areas can be improved in ecological terms, and all of them can acquire a conservation value (Marris, 2011; Rosenzweig, 2003). Strategies for doing this can be grouped under the term

Reconciliation Ecology, which is defined as "the modification of anthropogenic systems to support biodiversity without compromising direct use" (Francis 2011).

At the meeting point of these two shifts is the question of human-animal interaction and the prospect of transforming anthropogenic systems—in terms of both physical infrastructure and shifting systems of culture and belief—to support a greater diversity of species. This transformation has many design implications. Endorsing it calls for an Animal Turn, of sorts, within the field of design. Multispecies Design is part of this transformation.

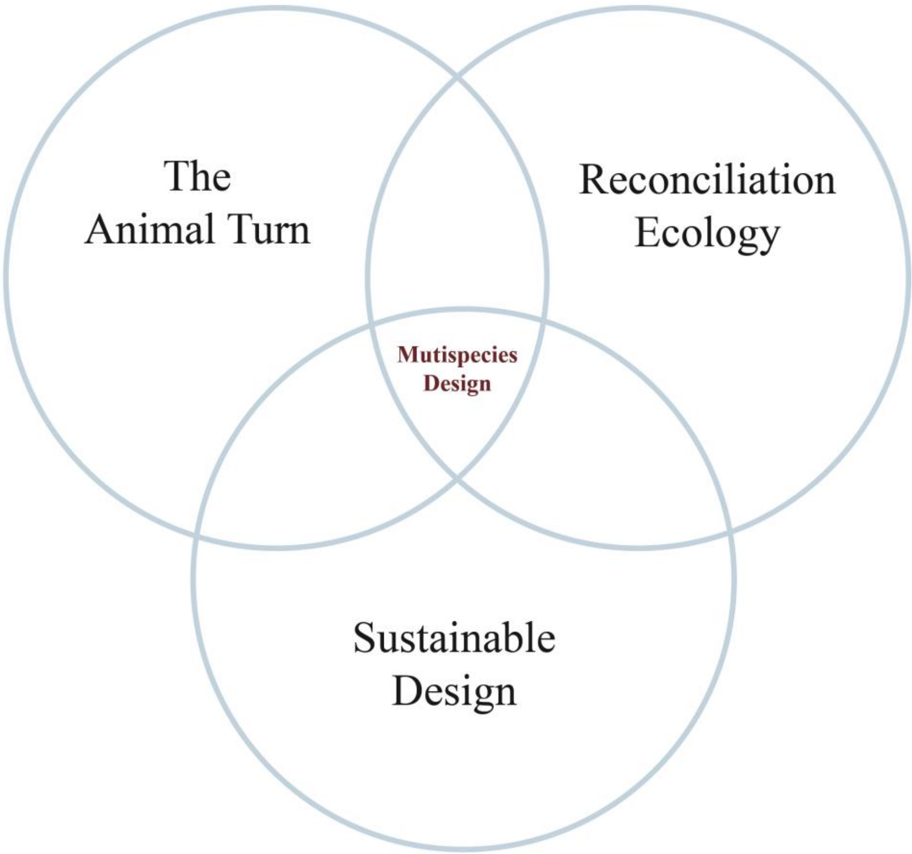

Fig 1.1 Placement of multispecies design at the meeting point of the animal turn, reconciliation ecology and sustainable design.

1.3. Research hypothesis and questions

Recent years have seen a paradigm shift calling for the inclusion of a greater diversity of wild animals within human-dominated habitats as a way of addressing both the loss of biodiversity and human alienation from nature. The hypothesis behind this research project is that the transition to more bio-diverse human habitats has significant implications for design as a discipline focused on shaping these habitats, and calls for the development of a design approach capable of supporting this transition. Moreover, it is suggested that while such a design approach may already be emerging, more work is needed to shape and structure it, as well as provide useful and appropriate tools for the design community to help them design with, and for, nonhuman species. As will be discussed, many pressing issues regarding human interaction with nonhuman species and natural systems require solutions that involve changes to the way anthropogenic systems are built and maintained, as well as influencing human and animal behavioural patterns. As a field that has always been concerned with modifying anthropogenic systems and, in recent years, is developing specific strategies for influencing human behaviour (see for example Lockton, 2013), design has the potential of contributing to these pressing issues. The examples presented hereafter demonstrate the potential of this contribution and the start of a shift in this direction. Nevertheless, on the whole, engaging with nonhuman species and their relationship to human habitats remains outside the scope of most designers and the theoretical and methodological connotations for this engagement have not been fully explored, developed or tested.

Based on this hypothesis, the research project sets out to explore specifically:

What role does the field of design have in facilitating the shift towards more bio-diverse human habitats? Furthermore, what conceptual and practical tools are needed to develop the field in this direction?

1.4. Aims and objectives

The aim of this thesis is to develop and describe a design approach capable of responding to the needs of wild animal species and their interactions with humans and human systems. It is a step away from a design tradition concerned exclusively with the human, and represents a view of human habitats as artificial extensions of natural ecosystems capable of supporting a wide diversity of life, rather than viewing the two in isolation. To better understand the conceptual and methodological implications of such a design approach, a general framework for addressing nonhuman species within design is proposed and named Multispecies Design.

This thesis looks at which existing design tools and approaches are suitable for situations involving nonhuman species, which existing tools require modifications and which new tools can be adopted from other fields. The tools and framework are shaped by, and put into practice through, a case study design project concerning the ecological enhancement of an artificial coastal structure. Here the role of design, and its points of contact and collaboration with other fields, are explored in a project which takes into consideration both human and nonhuman users of a concrete outfall pipe located on Hannafore beach in Cornwall, UK. In addition to the main case study for Hannafore beach, a follow-up design exploration was carried out during the PhD research to explore additional themes absent from the Hannafore project. This is described in detail in appendix 2 (page 176-183).

The objectives of the thesis are to:

- Describe the ecological, philosophical and societal motivations behind recent calls for the inclusion of a wider diversity of species within human habitats.
- Describe the potential role of design within this shift, highlight areas of the field where design can have an impact and by doing this, point in a possible direction for the emergence of a new design practice (i.e. Multispecies Design).
- Develop a case study design project for an intertidal context that explores and demonstrates the process of designing a structure with both a human and ecological function.
- Use the case study project to highlight various theoretical and methodological implications of Multispecies Design and reflect on the methodological differences between designing solely for human and designing multispecies products and environments.
- Propose a theoretical and methodological framework for the application of Multispecies Design based on insights from the case studies, as well as the engagement of other practitioners with wild animals.

- Undertake a series of workshops with design and art students focused on designing for wild animals, to further develop the theoretical and methodological aspects of Multispecies Design (the course and outcomes of these workshops are described in appendix 3, page 184-196).
- Propose an initial toolkit for Multispecies Design based on the methodological insights from the practice and workshops.

1.5. Position

My intention in this work is to propose a framework and methodology of designing for animals and their interaction with human systems. The work sits within the emerging landscape of expanding design principles from ID (Interaction Design), UCD (User Centred Design) or PD (Participatory Design) to include nonhuman species (see Frawley and Dyson, 2014; Jönsson, 2014, p. 8; and Resner, 2001, p. 17 for example) as well as more generally placing animals at the centre of the design process (see Mancini, 2013). Unlike other attempts to systematically consider animals within the design process, my focus is strictly on *wild animals* and their interactions with humans and human systems. This is due in part to the recognition that design has a strong domesticating power that should be taken into account in designing for wild animals if it is wished to respect and protect their wild nature; and in part to the fact that the motivation and theoretical grounding for this work comes mainly from conservation science rather than post-humanistic theory which is often referenced as the theoretical background in other instances of designing with, and for, animals (see for example Barnett, 2013; Dodington, 2014; Frawley and Dyson, 2014; Jönsson, 2014; Mancini, 2013). While influences from the humanities are undoubtedly present in this work there is a leaning towards conservation biology both in the aims and motivation for the work (supporting biodiversity within human habitats) and in the way some inherent conflicts between the values of nature conservation and humanistic values (Tsovel, 2015) are navigated and addressed (although resolving these conflicts is by no means within the scope of this work).

ACI (Animal Computer Interaction) appears to be the most comprehensive attempt to develop a systematic method for designing for animals to date. Developed by Mancini (2011) as an expansion of HCI (Human Computer Interaction) it is defined as “the explicit and systematic application of design principles that place the animal at the center of an iterative development process as a legitimate user and design contributor”. Despite this broad definition, ACI's focus is on direct interaction between animals and technology (Frawley and Dyson, 2014) and tends to concern itself mainly with pets and farm animals (ibid). In line with a humanistic tradition, ACI tends to focus more on the welfare of individual animals (reducing the suffering of farm animals for example), rather than on conservation goals (providing habitat for wild species in areas where it is missing for example). Although the focus of ACI is on domesticated animals, it should be noted that Mancini (2011) does make reference to wild animals in the aims of ACI: "ACI aims to inform the development of interactive technology… (that) produces only negligible side effects on the animals involved in conservation studies" (Mancini, 2011), as well as speculative considerations on the use of ACI to "support the very biodiversity that sustains us, by exploring the design of computer interactions that can support wildlife" (Mancini, 2013).

Unlike ACI, the focus of MD is exclusively on wild animals and their interaction with human systems. The motivation and goals of the work come mainly from conservation sciences with the aim of sustaining more biodiversity within human-dominated habitats. My intention in this work is to delve deeper into the specifics of designing for wild animals and to highlight the specific traits of such an activity that make it different from designing for animals which have been domesticated for human consumption or pleasure.

One other design practice that does focus on wild animals, and that also takes its goals from conservation science, is Conservation Design. Described by Root-Bernstein and Ladle (2010) as the design of objects "used to interact with or control animals or to influence the interaction of animals with their environments". Conservation Design focuses on designing products for use within specific conservation projects such as for example helping wild animals breed or rear young in captivity, or preparing them for release back into the wild by simulating predators (ibid). In contrast, my focus with Multispecies Design is on how elements of the built environment, intended originally for human use, could be re-conceived with an ecological function in mind, addressing the needs of wild animals already living within human-dominated habitats and inviting new ones in. Unlike Conservation Design, it is not intended for use in isolation from human activity (in nature reserves for example) but focuses on weaving together animal and human activities.

2. METHODOLOGICAL FRAMING

This chapter discusses the methodologies and epistemological stances adopted in this research for addressing the research questions. A constructionist methodology, rooted in a tradition of research through design is considered the most appropriate. The structure of the thesis as well as the research strategy and specific methods are outlined.

2.1. BACKGROUND

This PhD research project was born as an ESF (European social fund) funded project bringing together three academic institutions: Falmouth University, Exeter University and Plymouth University; and three corresponding academic disciplines: design, geomorphology and marine ecology. The aim of the project was to explore design applications that make use of scientific knowledge regarding the colonisation of hard coastal structures by marine animals and plants. Design was thought to be useful in this context as a way of addressing the aesthetics and appeal of bio-colonised surfaces as well as exploring innovative surface designs intended for biocolonisation using digital manufacturing technologies. To support this process, the supervisory team was comprised of experts on the biocolonisation of coastal structures, both from an ecological perspective and a geomorphological one, as well as experts in design and digital manufacturing technologies[4].

At the time of the application, I had just started a personal research journey investigating notions of designing with, and for, wild animal species. What drew me to apply for this research opportunity was that it presented itself as a vital opportunity to further explore instances of designing for wild animals in a case study project that involved a comprehensive body of scientific knowledge as well as the support of experts from corresponding scientific fields.

2.2. EPISTEMOLOGICAL STANCE

The epistemological, and consequently also methodological, aspects of this work stem from its relationship with the other disciplines it is in dialogue with, as well as its relationship to *design as practice*. At the starting point of the project is a body of scientific knowledge and the wish to engage with this knowledge in new ways (i.e. through the lens of design thinking). Thus, rather than mimicking a scientific approach in searching for new

[4] The project was also conceived with a local business partner, expert in the field of marine concrete, capable of advising and supporting the manufacture of test samples. However, halfway through the course of the project the company shut down their Cornish plant and contact was lost.

knowledge, the research positions itself at an epistemological distance from a traditional scientific approach, with the intention of complementing rather than opposing it. Empirical observation and objective reasoning take a secondary place and give way to a non-linear, reflective approach to knowledge generation, sitting within a tradition of design research as a *reflective practice* (Schön, 1983). Feast and Melles (2010) associate this tradition within a constructivist epistemological position, distinguishable from an Objectivist tradition of design research concerned with design as rational problem solving; and a Subjectivist tradition concerned mainly with the act of making, without subsequent reflection.

It is important to acknowledge, as Feast and Melles (2010) do, that most design research would incorporate elements of all three epistemological positions. This is true for this work as well, though the aim of generating a contribution to knowledge by means of *reflecting upon the design process* as well as the recognition of the role of the *researcher as a subjective entity influencing the research*, positions the work mainly within a constructivist epistemological framework.

Cross (2007) describes the emergence of this "epistemology of practice" as the birth point of design as an academic discipline in its own right, separate and complementary to the scientific one, a culture suited for dealing with a different set of problems: Problems where not all the parameters are available, and thus, cannot be addressed in a linear way. Problems located in areas of "uncertainty, instability, uniqueness, and value conflict" (Cross, 2007). Irwin et al. (2015) also talk about the ability of design to address complex problems that are often beyond the domain of one discipline, problems that are "multi-faceted/multi-scalar, are comprised of many stakeholders with conflicting agendas and because their 'parts' are interconnected and inter-dependent, there is no single solution". As Buchanan (2009) noted before them, they refer to these problems in the context of design as *wicked problems*.

This distinct epistemological positioning allows opening up the scientific knowledge base explored in the case study design project to new questions and modes of enquiry. To re-frame the problems, it addresses them in new ways rather than trying to solve known problems. Perhaps most importantly, this process of research through practice allows a reflection on new possibilities for design to develop as a discipline, possibilities that go beyond human-centred design and seek to include other species in the scopes of design.

2.3. METHODOLOGY

The notion that there is knowledge that can only be obtained through practice, and that the way of cultivating this knowledge is through reflection on practice, is central to different practice-based design methodologies. Although these have been given different names over the years (see for example Wang and Hannafin, 2005; Zimmerman and Forlizzi, 2008) there are many overlaps in the scopes and methods they describe. An attempt to group these approaches under one methodological umbrella has led to the introduction of the term Constructive Design Research which appeared in a book by Koskinen in 2011. The book provides a wide overview of different design research projects from both academic and other sources, all of which have construction at their core. Construction in this context refers to prototypes, scenarios or concepts where production is not necessarily the final goal but rather the notion of *learning by doing,* to reveal things of interest which may otherwise go unnoticed (Koskinen, 2011, p. 43). The author describes three typologies of constructive design research, referred to in the book as *programs*, these are *Lab, Field* and *Showroom*.

Lab refers to projects carried out in a controlled environment where the aim is to isolate and study one phenomenon at a time. Empirical proof is the main aim of this kind of design research which borrows many of its methods from scientific experimental research (Koskinen, 2011, p. 51).

Field refers to projects that aim to contextualize rather than isolate the design from its sociocultural context. This program borrows its methods from interpretive social science and aims to understand human systems of meaning rather than trying to find general laws for explaining human behaviour (Koskinen, 2011, p. 69).

Showroom refers to research projects rooted in a tradition of critical design where the aim is to challenge people's view and experience of the material world and promote change through debate and discussion (Koskinen, 2011, p. 94). This program is linked in its aims to critical theory, as it views theory as a means of changing phenomena rather than just describing them (for the use of critical theory in the context of design research see Ceschin, 2012, p. 55).

The work in this thesis sits mainly within the *field* program, though it also relates to *showroom* in some of its aims and objectives. It adopts methods of fieldwork and design ethnography and aims to contextualize the case study design project by situating it in a localized, eco-socio-cultural context. In addition, the design process focuses on the inclusion of different stakeholders, from scientists, local residents and commercial companies to the local ecology on site. At the same time, the case study project is also critical; it does not aim to study a localised phenomenon and design *for it*, but rather to propose design interventions that challenge the existing relationships between human and wild animals in the specific context—linking it to the critical scopes of showroom programs.

The field case study is used as a way of critically reflecting on human-animal relationships and more specifically, on the role design plays in influencing these relationships. The work can be read as a critical overview of the human-centeredness of current design activities and aims to offer ways of changing this by promoting the inclusion of multi-species perspectives into design practises. Knowledge is constructed with the intention of influencing methodological processes within the discipline of design; as such it can also be placed within the framework of Metadesign.

2.4. METADESIGN

Dealing with the challenges of biodiversity impoverishment and mankind's alienation from nature requires a paradigm change in the way we as a society regard the natural world and our relationship with it. For designers, this involves a shift from a human-centred design approach to a design approach that regards nonhuman species as potential clients and participants in the design process. Such a shift suggests a *redesigning of design* theory and practice.

The term Metadesign has been used to describe this process of redesigning design. Manzini (2007) gives the definition of Metadesign as "the design of a set tools, methodologies and ways of doing capable to support designers in a variety of design processes". This definition sees the use of the prefix '*meta'* as a source of transformation, which is slightly different from its original Greek meaning as *behind* or *after* (Giacardi 2003: 72). A slightly different take on Metadesign has been developed by John Wood, together with others, at metadesigners.org (2011). They have been developing Metadesign as a methodological framework for initiating and promoting paradigm change (in society as a whole) as well as dealing with complex design problems (Wood 2011). So, while the prefix 'meta' (understood as transformation) in Manzini's definition refers to the process of design, in Wood's definition it refers to society at large. Metadesign can be understood in this case as design for the transformation of society. This is similar in many ways to the objectives of critical design but while critical design tends to focus on highlighting the problems of the phenomenon it critiques to raise discussion, Metadesign focuses on proposing alternative visions of reality. Both interpretations of the term are relevant to this research as it seeks to offer transformations to the process of design (by means of new conceptual and practical tools emerging from the design process) to enable it to support transformations within society (by means of supporting a paradigm shift in our relations with wild animals).

Although the term has been around since the 1980s (Giaccardi, 2003, p. 69), Metadesign is not an established design practice (Giaccardi, 2003, p. 2) and could not be used as a single methodological framework for this research. Many of the tools found on metadesigners.org (2011), for example, are still works in progress. Instead, this work, while remaining within the framework of Constructive Design Research, adopts Metadesign as a general approach for transformation as well as adopting Metadesign tools within the practice phase.

The main transformation this work aims to introduce to design practices is in regarding non-human species as equal stakeholders in a design process. Metadesign offers a useful framework for doing this by revisiting existing design methods from a perspective of flattened species-hierarchies: essentially, treating wild animals as clients of design alongside humans. This approach sees, for example, the application of ethnographic design methods to non-human species as well as a search for new methods when the existing ones cannot be applied. To support this process, the work draws on theoretical frameworks deriving from other fields.

2.5. RELATIONSHIP WITH THEORY

One of the reasons for proposing *Constructive Design Research* as a new umbrella term for describing design research through practice, has been, according to Koskinen, the lack of recognition in previous frameworks of the importance of theory in shaping design research (Koskinen, 2011, p. 5). While a design project does not necessarily have to start from theory, every design activity has a theoretical background. Products and services reflect integrated patterns of thought of the society they reside in and occasionally also try to challenge these notions.

A workshop highlighting how theory influences design was carried out by Philip Ross at the Eindhoven University of Technology (2008). In the workshops, participants first learnt about four different ethical systems[5] and were then split into three groups. Each group was asked to design two functionally similar products based on two different ethical perspectives (Ross, 2008, pp. 12–17). In addition to showing how products with similar functions can deliver distinctly different experiences when based on different ethical systems, the workshop also highlighted how many of the products and services we interact with today reflect Kant's rationalistic ethics based on universal reasoning and the notion of duty (Koskinen, 2011, p. 127).

Similarly, this thesis would argue that many of the systems that humans design, and through them the way the anthroposphere is shaped, are rooted in notions of human-exceptionalism (Haraway, 2007, p. 244). Although these systems constantly interact with nonhuman species and have implications that go beyond our own species at all stages of their life-cycle, nonhuman perspectives are rarely taken into consideration in the process of design.

The main theoretical background for this work comes from new approaches and theories in natural sciences and specifically from shifts within nature conservation. New approaches to nature conservation [e.g. Reconciliation Ecology (Rosenzweig, 2003)], focusing on human-dominated habitats as prime sites for biodiversity protection, have brought the field closer to the domain of design. They offer new challenges and opportunities for designers, and the work here is an attempt to understand some of these challenges and opportunities, respond to them in the case study project, and develop conceptual and practical tools for facilitating the shift in design practices to include a multispecies perspective.

[5] Namely: Confucianism, Nietzschian Ethics, Kantian Rationalism and Romanticism. See Ross (2008, pp. 13–14) for a description of each ethical framework.

2.6. THESIS STRUCTURE

This section describes the different elements making up this thesis and the relationships between them (see Fig 2.1 below).

As with any project, there are different possible starting points for describing this thesis and the elements of which it is constructed. The chapters of the thesis move from the personal and specific (my own practice) to the more general and generalizable (the contextual review and general principles of Multispecies Design). This structure was chosen in part because the practice did in fact start very early on in the course of my PhD and influenced many of the choices I made in conducting the contextual review, and in part, because it allowed me to reflect on the practice while developing the general theoretical framework. The purpose of the diagram below is to show the elements of the thesis in a non-linear way, to highlight the relationship between them and offer a conceptual summary of the different ideas, inputs and outputs of this work.

At the core of this work is the process of *research through design*, i.e. cycles of practice and reflection aiding the development of *theory* to address the *research questions* that in turn derive from the *challenge and opportunity* identified. Feeding into this process of research through design are elements of the *contextual review* including the *scientific knowledge base*, a *critical review of design* and the *eco-socio-cultural context* for the work. Deriving from the process are the different *outcomes* of the thesis including the *design outcomes* of the case study and the *tools for Multispecies Design*. Therefore, within the diagram, the relationship between the elements below is illustrated:

CHALLENGE

The broad challenges addressed by the work are those of the erosion of biodiversity and mankind's alienation from nature, and specifically their interconnectedness.

OPPORTUNITY

The opportunity comes from identifying a gap in knowledge/practice within design, i.e. a lack of design tools and approaches for supporting the shift towards more bio-diverse human habitats.

Research questions

What role does the field of design have in facilitating the shift towards more bio-diverse human habitats? Furthermore, what conceptual and practical tools are needed to develop the field in this direction?

Methodology

The methodology describes the way this thesis sets out to engage with the research questions. A constructionist approach is adopted, based on the notion that there is knowledge that can only be obtained through practice and that reflection upon practice can advance theory.

Eco-socio-cultural context

The contextual framework for the work is an emerging paradigm shift calling for a better inclusion of wild animals within human-dominated habitats. In short:

1. Biodiversity can and should be sustained in proximity and overlap with human activity.
2. There is inherent social and ecological value in novel ecosystems.
3. Sustaining more biodiversity within human habitats can have positive impacts on human physical and mental health as well as providing crucial ecosystem services.
4. There is a need to re-imagine human habitats as part of the wider earth's ecosystem.

Critical review of design

Current design practice is inherently human-centric. There is a need for the development of new sensitivities towards nonhuman species within the field, as well as conceptual and practical tools for engaging with wild animals.

Scientific knowledge base

Consists of a body of scientific research into the relationship between intertidal species and coastal structures. In short:

1. It is possible to enhance the habitat value of hard coastal structures by increasing their surface 3D complexity and water-capturing features.
2. It is possible to target specific species with specific features.
3. Colonising species may have a positive impact on the structures they inhabit.

PRINCIPALS OF MULTISPECIES DESIGN

This is an evolving theoretical and methodological design framework for addressing the paradigm shift. It focuses on the changes design practice should undergo to realise the opportunity identified by the thesis. The framework both sets the theoretical reference for the practice, and is advanced by cycles of practice and reflection.

CASE STUDY DESIGN PROJECT

This is a case study design project exploring the notion of designing with, and for, wild animals, making use of the scientific knowledge base.

ADDITIONAL PRACTICE

This section (described in appendix 2) describes additional practice conducted during this PhD work, highlighting some aspects of working with wild animals that were not fully explored in the case study.

WORKSHOPS

Workshops with design and art students (described in appendix 3) were used to explore the principles of Multispecies Design in a wider context and without reference to a specific scientific knowledge base.

REFLECTION

This is a phase of reflection upon practice (taking place throughout the practice stages) in order to advance the theoretical framework for Multispecies Design.

DESIGN OUTCOMES

These are the products of the case study project and the additional practice.

TOOLS FOR MULTISPECIES DESIGN

This is a summary of the methodological aspects of the *Principles of Multispecies Design* in the form of practical tools that can be used for designing with, and for, wild animals.

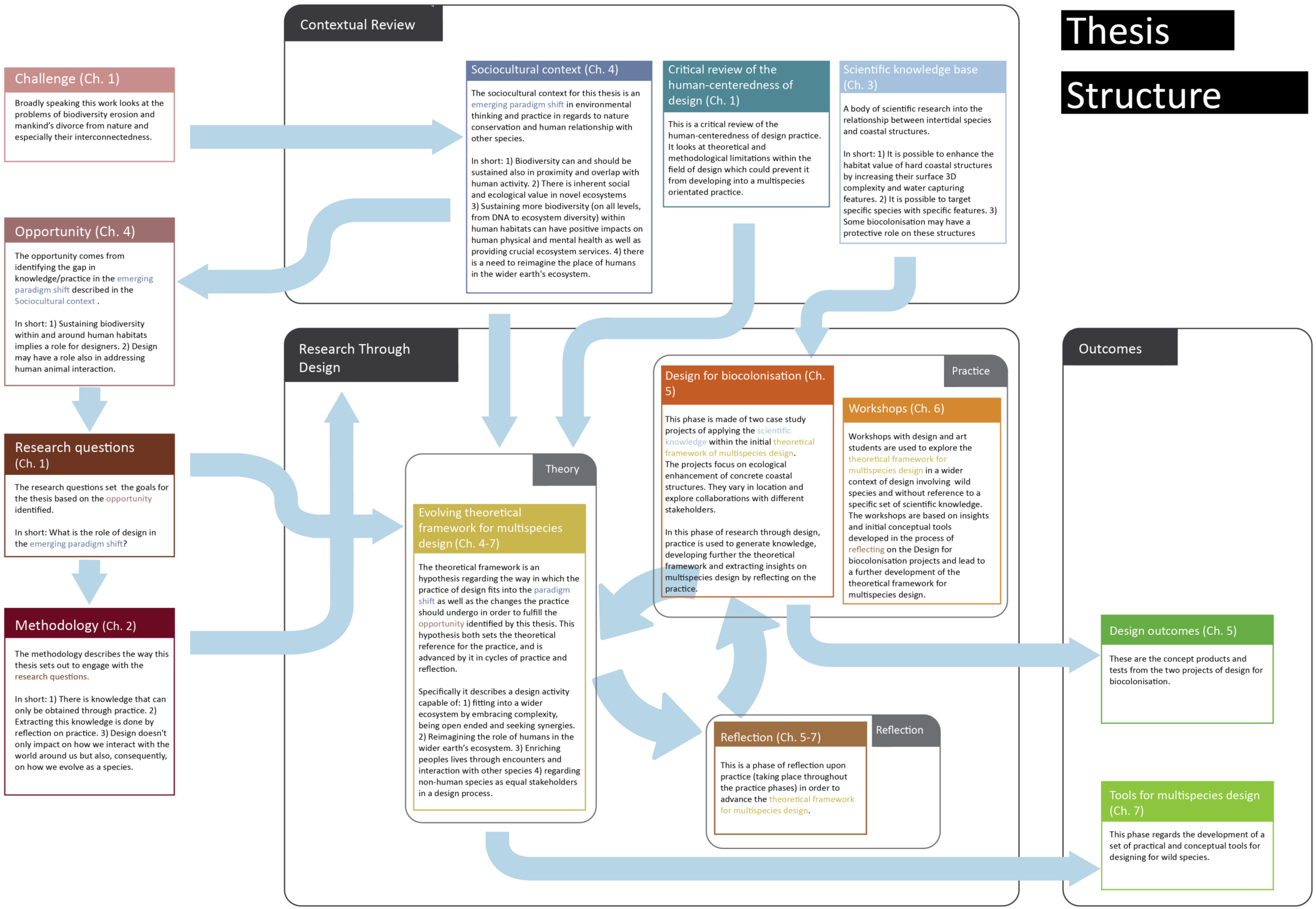

Fig 2.1 Thesis structure

2.7. RESEARCH STRATEGY AND METHODS

The research is structured into three main stages:

1. A stage of preliminary research to review the scientific knowledge base and to set out an initial theoretical framework for the practice.
2. A research-through-design phase involving the case study project and additional practice, the workshops, and the further development of the theoretical framework for Multispecies Design based on insights from the practice.
3. A final phase of reflection and synthesis, bringing together insights from the previous stages as well as insights from reviewing other people's work involving wild animals, and grouping these together as *Principles of Multispecies Design* and *Tools for Multispecies Design*.

Following is a description of the different methods used in each phase.

2.7.1. STAGE I: PRELIMINARY RESEARCH

REVIEW OF THE SCIENTIFIC KNOWLEDGE BASE

This stage is a review of the scientific literature regarding the biocolonisation of coastal structures that is the scientific knowledge base for the practice in stage 2. It consisted of a literature review, meetings, talks and site visits with experts in the field, leading to an extraction of the ecological principles to be used in the design process.

INITIAL THEORETICAL FRAMEWORK

As discussed earlier, any design activity has links to theory whether this is explicit or not. It places some values over others, follows a moral and ontological position and can be highly political. In some cases, the design mirrors the values of the society it resides in, or the community for which it is being designed. In others, it sets out to challenge existing behavioural norms or to introduce new values to an existing value system.

Scientific knowledge can be applied in different ways according to different objectives, giving precedence to some values over others. For example, knowledge of how marine species colonise coastal structures can be used to minimise this colonisation (as is done in the case of boats or tidal energy turbines), or it can be used to maximise colonisation on a structure, in which case decisions have to be made as to what species are promoted: local species, species at risk, species with benefits for humans, etc. A theoretical framework can help navigate these decisions; it does not necessarily point to one universal decision but gives context and markers for evaluating different design options.

In this stage, an initial theoretical framework for the practice is proposed. The aim is to put the scientific knowledge base into context and propose a setting within which to engage with it in order to address the aims and research questions of the thesis. This theoretical stating point is used as a provisional knowledge regime, setting an initial intention for the design, which then evolves and unfolds alongside the material design proposal into a grounded theoretical framework. In her practice-based PhD, Jönsson (2014 p. 18) uses a similar model for developing theory and practice in conjunction. The author cites Brandt et al. (2011) who suggested this method is useful when design is used to critically reflect on the present, and make suggestions about alternative possibilities (much like the goals of Metadesign). Brandt et al. stress that in this approach, design experiments do not *follow theory* to test, prove or disprove it, but are a way of *developing theory*, by focusing on the exchanges between what they call the program (theory) and the experiments (design manifestations) (ibid).

2.7.2. Stage 2: Research-through-design

The focus in this stage is on practice and research through design. It includes one main case study design project, as well as two additional projects, involving the scientific knowledge base and initial theoretical framework proposed in stage 1, as well as a series of workshops with design and art students.

Case study research is an empirical inquiry that investigates a contemporary phenomenon within its real life context (Yin, 2012). It is especially useful when studying new topic areas where little literature is available, and to gain a holistic view of complex phenomena (Eisenhardt, 1989).

The aim of this stage is to gain insights, through my own practice in the first stage and work with students in the second, on the process of designing for wild animals. It seeks to explore and further develop the theoretical framework by reflecting on the methodological implication of Multispecies Design.

Hannafore project

The main case study focused on ecological enhancements of an outfall pipe on Hannafore beach in West Looe (Cornwall). It was aimed at exploring the ecological enhancements of the structure within the framework of Reconciliation Ecology by looking at the human function and the potential ecological function in an integrated way rather than separating them. A structure was chosen without an existing goal or requirement for ecological enhancement, to leave the brief open to the design response, rather than working to specific regulatory requirements. This was done to allow an exploration of various aspects of the theoretical framework with a higher degree of creative freedom than would be found in a project with already-set goals. Additional consideration was given to choosing a structure with a potential for ecological enhancement in an area of high human activity, in order to explore notions of interaction and synergy between human and nonhuman functions.

Specifically, the project explores:

- Designing for ecological enhancement while maintaining the direct use of coastal structures by humans.
- Seeking synergies between the different uses of the structures (ecological and by humans) and allowing for cross-species encounters to occur.
- Working with scientific inputs.
- Working with a business partner (the company owning the outfall pipe) in installing test samples on location.
- Working with local partners in implementing and monitoring the test samples.
- Collecting feedback from a range of stakeholders regarding the prototypes.

Attention was given to taking into consideration different stages of the design process as they would appear in a design project, to see how each of them changes when regarding nonhuman species in addition to humans. These are described in detail in the next chapter.

Additional practice

During my PhD studies, additional practice was carried out that explored some topics that did not fit into the main case study. Topics including: designing for specific ecological requirements, designing for a scientific research project, designing for bio-geomorphological processes, and using digital technology to reproduce experiments that were previously done manually, allowing for a new focus on repeatability and aesthetics. In collaboration with Dr. Larissa Naylor from the School of Geographical and Earth Sciences at the University of Glasgow, two tiles where developed and manufactured for a five-year research study, currently in development, that would investigate different aspects of barnacle colonisation. Being tied to a specific research study with set goals, the brief for these tiles was more specific than that of Hannafore and allowed a reflection on the process of working in tighter collaboration with a scientific partner. However, the lengthy timeframe for this project meant that results were not obtained before the end of my own research period, making it possible to reflect on the design process but not on its outcome.

Designing these tiles had some influence on the development of the theory and principles of Multispecies Design; these will be discussed later on in the thesis. Overall however, their importance was minor in comparison to the main case study, due to the lack of test results. The description of this additional practice has therefore been included in the appendix rather than in the main body of the thesis.

Workshops

Design workshops have become a popular method in design research (see for example Ceschin, 2012; Lockton, 2013; Ross, 2008). In design workshops, designers (or design students) are asked to brainstorm and generate concepts responding to a design challenge by following some guidance from the workshop facilitator. This can involve the application of a toolkit to test its effectiveness and practicality as in the case of Ceschin (2012) and Lockton (2013), or to test a hypothesis as in the case of Ross (2008) who wanted to see how different ethical frameworks affect design outcomes. Workshops are a form of action research[6] where the researcher introduces an idea, procedure or artefact, which attempts to change the way participants act (Lockton, 2013, p. 100). They can be used to generate new ideas or to test the relevance of artefacts or concepts on the process of generating ideas, and the kind of ideas being generated.

In this stage, four workshops with design and art students were carried out to test the applicability of the theoretical framework in a different setting from my own case studies, involving different species and different contexts. The students were introduced to elements of the theoretical framework (as it was developed) and asked to respond with a conceptual project regarding a wild animal of their choice. In other words, they were asked to come up with a design intervention for helping an animal of their choice better subsist within human habitats, while focusing on regarding both humans and animals as clients of the design, and promoting interaction between the two. Analysis of the workshops was done both through participant observation and feedback forms filled in by the participants themselves. The assessment focused on how participants responded to the theoretical framework, highlighting strengths and weaknesses, as well as areas in need of further development. In addition, the relevance and appeal of Multispecies Design as a practice was assessed through the feedback forms. The workshops, as well as their assessment, are described in appendix 3.

2.7.3. Stage 3: reflection and outcomes

This stage involves a retrospective reflection and analysis of the entire research project, a refinement of the theoretical framework presented as Principles of Multispecies Design and development of the Tools for Multispecies Design based on insights gained throughout the PhD period.

[6] Action research describes situations where the researcher has an active involvement in the phenomenon being researched, promoting change in it rather than solely describing or attempting to understand it (Lockton 2013). For more on action research as a social science methodology, see Crotty (1998).

3. DESIGN EXPLORATIONS

This chapter recounts the course of a case study design exploration focusing on the meeting points and interactions between humans, intertidal species, and coastal structures. This case study design project is used to reflect upon specific and situated aspects of design involving nonhuman species and highlights areas of this activity that need further development.

3.1. INTRODUCTION

Work on the case study design project, which makes up the main practical portion of this practice-based PhD, started very early on in the course of my research, in the first weeks of my enrolment as a PhD student at Falmouth University. This was done for both methodological reasons (as engaging in practice has been my main tool for learning about the prospects for designing for wild animals and their interactions with human systems), as well as practical reasons (such as finding a location, setting up a field project and having enough time to obtain an ecological response to the design).

At the time, the only fixed anchors I had for the project were a body of scientific knowledge regarding the biocolonisation of hard coastal structures, given to me by the science partners of this research, and my own wish to learn more about the process of designing with, and for, wild animal species. The design project was a way of exploring and highlighting different aspects of the unfamiliar practice, which would later develop into Multispecies Design, and how it may differ from designing solely for humans. In this respect, the following chapter will anticipate and lay the foundation for some of the themes explored later on in the thesis that will include a deeper reflection on practice as well as a more general contextual review of fields relating to Multispecies Design.

Although the design explorations and contextual review were developed in parallel during the course of my research, I have chosen to include the practice before the contextual review in the writing of the thesis. This was to allow the contextual review to expand on themes emerging from the practice that may not have received full attention during the design explorations. The two exceptions to this are the review of the field of ecological enhancement, which is the scientific background to the case study project and has therefore been included in this chapter, and a preliminary theoretical framework setting out the initial objectives of the practice.

3.2. ECOLOGICAL ENHANCEMENT OF COASTAL STRUCTURES

The scientific literature in the field of ecological enhancement of artificial coastal structures has been developed over the past decade and a half, mainly within the fields of marine ecology and, more recently, also geomorphology. This literature describes ways of enhancing the habitat value of coastal structures by manipulating their surface texture and/or material properties to attract colonisation by a diversity of marine species.

The importance of biodiversity and healthy ecosystems in supporting human life on the planet, through various ecosystem services, is particularly important regarding coastal and estuarine ecosystems. Around the world, these ecosystems, which cover only 6% of the global surface, contribute to about 38% of the total estimated value of ecosystem services (Costanza et al. 1997 cited in Francis, 2011). However, these coastal and estuarine ecosystems are under constant pressure of urbanization that leads to substantial ecological degradation (Francis, 2011). This pressure is likely to increase as further flood defence and erosion control infrastructures are built to maintain current levels of protection against the effects of climate change such as a rise in the sea level and increased storminess (Naylor et al., 2011). In addition to the disturbance to the ecology during the construction phase, once completed, artificial coastal structures do not support the same diversity of plants and animals as natural rocky shores (Bulleri and Chapman, 2010). Francis, (2011) argues that mitigating the pressure caused to coastal ecosystems due to these constructions is more difficult than dealing, for example, with problems of pollution, which can be addressed through appropriate legislations. He argues that the dominant conservation paradigm of preserving natural or semi-natural ecosystems, or restoring them in the case of coastal-built environments, would not be practical in economic terms and may also not prove resilient in ecological terms. Instead, he suggests "the pragmatic approach is to consider urban ecosystems (including estuarine and coastal systems) as further constructed components within a manufactured environment" (ibid) and sites this proposition within the framework of Reconciliation Ecology.

The need to address the impact of coastal engineering on local ecologies has led to growing interest in ways of enhancing the ecological function of these artificial constructions. Until recently, research in the field has been carried out mainly by ecologists, with the various work of Naylor and Coombes (for example Coombes et al., 2011) representing additional inquiry into the topic from a geomorphological perspective. Ecological enhancement studies typically focus on identifying the characteristics of coastal infrastructure that would maintain or, in some cases, enhance biodiversity. They have been grouped under the term Ecological Enhancement that, as explained by Naylor et al. (2011), "does not seek to achieve complete re-creation of natural conditions but instead aims to improve the ecological 'quality' of a structure already being built for other purposes." Ecological enhancements aim at creating multifunctional structures which perform both a human function and an ecological one.

To identify which features of structures could be manipulated for ecological gain, researchers often make reference to existing natural ecosystems with comparable physical qualities (Thompson et al. 2002 cited in Naylor et al., 2011). When designing ecological enhancements for a hard concrete structure, for example, researchers would look at ecosystems present on hard natural environments, such as rocky shores, as well as the specific material properties of the rocky shore, with the aim of replicating some of these on the artificial structure.

There are different scopes and motivations for enhancing biocolonisation on coastal structures as can be read (sometimes between the lines) in scientific papers on the subject. Enhancing the ecological value of coastal structures can be undertaken to promote general biodiversity (Coombes et al., 2015; Firth et al., 2014), to compensate for damage caused by the construction, or to meet regulatory requirements regarding compensation for lost habitat (Naylor et al., 2011). It can be undertaken to provide a habitat for targeted species (Moschella et al., 2005), such as endangered species or, in contrast, commercially valuable species (Martins et al., 2010). It can be undertaken with ecosystem services in mind (Francis, 2011), such as water filtration by encouraging filter feeders (Wilkinson et al., 1996). Recent studies are also looking into promoting colonisation for bio-protection by promoting species capable of protecting the structures they colonise (Coombes et al., 2013).

3.2.1. General principles for ecological enhancement

Though many of these studies are specific to a location or specific species (for example Martins et al. 2010), some have tried to apply more general ecological principles that can be used on coastal structures in different locations. An example of this is the process guide *Including Ecological Enhancements in the Planning, Design and Construction of Hard Coastal Structures*, created by Naylor et al. (2011), for the UK Environmental Agency. Moschella et al. (2005) also propose several criteria that can be integrated into the design and construction of low-crested coastal defence structures.

One of the main reasons artificial structures support less biodiversity than natural rocky shores has to do with the complexity, in both geometric and composition terms, of their surfaces. Artificial structures are typically built of smooth, homogeneous surfaces such as flat concrete. Kostylev et al. (2005) have shown that the importance of surface complexity for biodiversity goes beyond just the increase in surface area created by this complexity. The principal reason that complex surfaces are more beneficial is that they offer a variety of microhabitats, of different spatial scales, that can provide the needs of different species or different stages of the life cycle of a species (Naylor et al., 2011). These different microhabitats have been created as a result of different conditions of dampness, exposure to sun, wind and waves (ibid). Complex surfaces also provide a range of refuge habitats offering protection from predators and environmental conditions (ibid).

The presence of features on a structure which are capable of trapping water at low tide is also important for the diversity and abundance of species on artificial structures. This is even more important above mean tidal level where threats of desiccation are higher (Moschella et al., 2005). Artificial rock pools (scale of 10-100 cm) can "provide suitable habitats for recruitment and settlement of species such as limpets, winkles and crabs" (ibid). Here the authors point out an interesting possible synergy between the use of the structure by people and its ecological function: "Promoting settlement of limpets can be a very useful, cost effective and environmentally sensitive tool for drastically reducing the abundance of nuisance green algae that generally flourish on disturbed habitats such as frequently-maintained manmade structures or slipways" (ibid). On a smaller scale (<1 cm) Coombes et al. (2015) have found that surface roughness increases the colonization of barnacles and that material choice influences the biologically favourable properties of rock materials for colonisation over time (Coombes et al., 2013; Naylor et al., 2012). In addition, it has been suggested, in conversations with Dr. Coombes and Dr. Naylor, that encouraging barnacle colonization of structures used as walkways may make them less slippery to walk on and therefore of benefit to human users by increasing safety.

Some studies also detail different ways in which surface complexity can be integrated into artificial coastal structures. Chapman and Blockley, (2009) show how to integrate artificial rock pools into vertical walls, while Naylor et al. (2011) and Moschella et al. (2005) talk about different ways of achieving surface complexity post construction (by drilling holes into the structure for example) and pre-construction (for example by combining soft carbonate rocks into concrete structures that would weather and bio-erode faster than the concrete).

To sum up, there is recognition of the importance of enhancing the ecological function of artificial coastal structures to support more biodiversity and insure ecological services. Research in the field has been focused mainly on ecological aspects, and more recently, also into geomorphological aspects. An example of this is the Bio-protection research project that looks at the protective role of colonizing species on hard coastal structures (Coombes et al., 2013).

It has been recognised that there is a need to further integrate these findings into the design phase of coastal defences rather than adding them as retrofits (Naylor et al., 2011). Furthermore, it has been recognised that there is a need to look at the societal aspects of ecological enhancements such as aesthetics, perception and interaction with people (ibid). Approaching this field from a design perspective may help address some of the undeveloped aspects of the field and possibly highlight new applications and prospects in the field. The case study design exploration described hereafter was an attempt at doing just that.

3.3. Initial theoretical framework for the design

Presented with a body of scientific knowledge and taking into consideration its potential applications, as well as its currently underdeveloped aspects, I decided on a setting within which I would explore the field of ecological enhancement of hard coastal structures. As is often the case with other scientific experiments, studies in the field have to-date tried to distance themselves from human activity in order to assume control over variables in the experiment. In contrast, my intention was to explore where this world of biocolonisation meets and mixes with the world of everyday human activity. The goals for promoting biocolonisation have been to sustain biodiversity in areas of high human activity. As we shall see, these initial goals became entangled and transformed at the meeting point with human worlds, producing new, synergetic ways of addressing questions of biocolonisation and interaction between humans, marine life and concrete structures.

3.4. Hannafore project

The Hannafore project revolves around a concrete outfall pipe located on Hannafore beach in West Looe, Cornwall. It explores ways of redesigning the surface of the pipe to enhance its ecological function (through the creation of habitat for marine species) while maintaining its secondary use as a walkway by people, and its primary function as a sewage outfall pipe. Two different design proposals where developed, incorporating different divisions of the space between ecological and human functions as well as each providing habitat for a slightly different range of species. Test samples of the two proposals were manufactured from concrete and attached to the surface of the pipe, to observe the human and ecological response to the designs over the course of a five-month trial.

As discussed, the design exploration is grounded in the scientific knowledge base of the biocolonisation of marine structures. It involves a desire to explore the field from a design-thinking perspective and address some of the gaps already identified by scientists working in the field. In addition, it is an attempt to view the ecological and human functions of the structure in a holistic way, rather than as isolated functional entities.

The growing body of existing scientific knowledge, the support of experts in the field, as well as a few examples of designs in use operationally around the world, made ecological enhancement a good case study for reflecting more broadly on the process of designing for wild animal species. It was also a chance to explore designing for a less recognized animal clientele, often overlooked by the design community. As is often the case, those less engaged with animals are foundational in an ecosystem and often provide habitat, which other, more charismatic or commercially important, species use.

The following pages tell the story of this case study and highlight how the *initial theoretical framework* unfolded and developed into the foundation for the Principles of Multispecies Design. The theoretical and methodological insights from the design process have been grouped together and described in detail in the chapter dealing with these principles, in which I shall return to reflect more broadly on the process of designing for wild animal species. In this chapter, they are embedded within the context of my own design process from which they emerged.

3.4.1. Finding a location

The first step in the project was to find a setting in which to develop the design exploration. Specifically, I was looking for a concrete structure (existing or in the development phase[7]), located in an intertidal zone, with access to people and a potential for ecological enhancement. The outfall pipe on Hannafore beach was suggested by Abby Crosby of the Cornwall Wildlife Trust (CWT) in a meeting we had in her office at Five Acres near Truro.

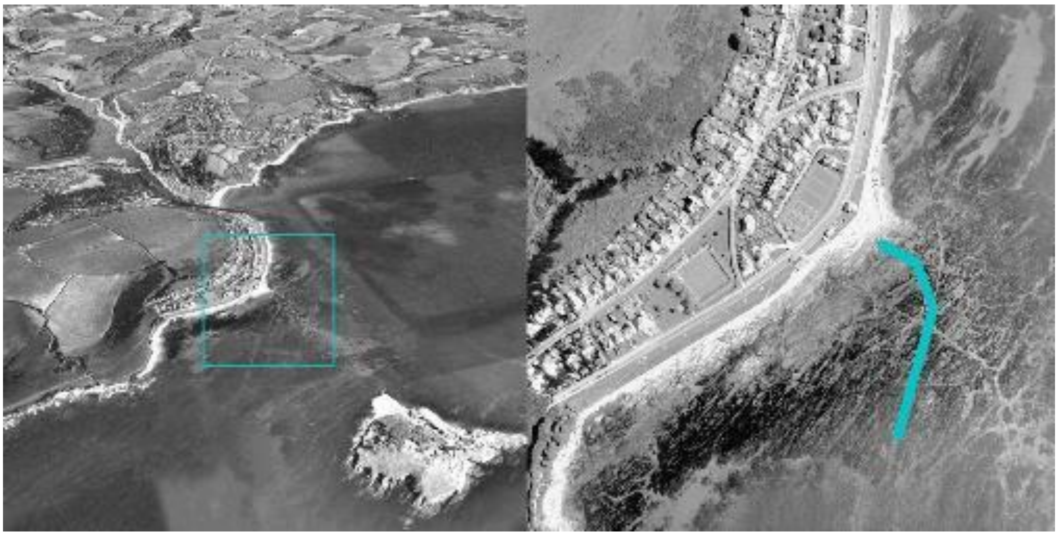

Fig 3.1 Location of the pipe on Hannafore Beach (left) and approximate progression of the pipe (right)

Hannafore beach is located in West Looe, Cornwall. It is predominantly a rocky beach with shingle and small patches of sand. In 1970, a 300 mm cast iron pipe was installed on the beach to divert storm overflow into the sea and prevent flooding of the nearby town.

By 2008, the system was inadequately sized for dealing with the volume of sewer flows combined with surface water runoff from the roads and pavements added to the network in 1999 (Cornwall Wildlife Trust, 2009). Overflows and spillages had become a fairly frequent occurrence and raised concern due to some potentially toxic substances they contained, which could harm the delicate local ecosystem, as well as pose a public health threat to what is a popular and well-used coastal area (ibid).

[7] Tapping on to a project in the development phase was ruled out as it would have imposed too many limitations on the design exploration and could have taken longer than the time I had available for the research project.

In October 2008, a new, higher capacity system was installed on the beach by the civil engineering company BAM Nuttall. The new system was made of precast concrete blocks, sunk into the ground and levelled with the rocks on the beach. BAM Nuttall's original strategy was to cover the pipe with rocks and shingles so as to hide it from sight and integrate it into its surroundings. However, the covering material was washed away by waves and shifting tides shortly after completion of the work, and the bare surface of the pipe was left exposed.

Fig 3.2 The new pipe at low tide in 2012

My objective for the design at this point seemed straightforward: to make up for the lost habitat on the pipe by adding complexity to the flat concrete surface. However, one of the unexpected consequences of the covering material being washed off was that the exposed flat surface of the pipe, which resembled a walkway, was now being used as one by visitors to the beach. The pipe was used to access the lower shore, launch kayaks, and reach rock pools lower down on the beach that are richer in biodiversity than the ones higher up.

Turning the surface of the pipe into a habitat for marine life might change the use of the pipe as a walkway, or expose colonising species to a risk of being trampled on. In addition, it turned out that having a designated walkway on the beach had benefited the local ecosystem in ways possibly more significant than added habitat on the pipe would. As explained to me by Abby Crosby in a later meeting, there was a shared feeling by local marine conservation volunteers that the concentrated human activity on the pipe had taken pressure off other areas of the beach and benefited the local ecosystem.

Fig 3.3 Visitors to the beach using the pipe to walk to Looe Island at low tide (2012)

In addition, I learnt, some biocolonisation had in fact begun on the pipe, despite its flat surface, and the problem now seemed to be related to the genre of species that had settled on the pipe and not in the lack of biocolonisation per se.

Fig 3.4 Algae growth on the surface of the pipe (2012)

A post-construction survey carried out by the CWT in September 2009 found that colonization had been underway primarily by the marine algae Ulva lactuca and Ulva intestinalis, and the brown seaweed Fucus serratus (Cornwall Wildlife Trust, 2009), and concerns were raised regarding the slipperiness of the surface caused by these colonising marine plants. By the time I visited the pipe for the first time, in March 2012, algae had covered significant areas of the pipe and were starting to pose a potential safety hazard to walkers. Biocolonisation was inadvertently compromising the use of the pipe as a walkway and I was learning a lesson in "*wicked" problems*.

The intention of the case study design exploration shifted from designing purely for biocolonisation to addressing the tension between the wish to better integrate the structure into the surrounding ecosystem and the wish to maintain it as a viable walkway for the use of people (and the surrounding ecosystem). In other words, it was becoming a project about *rethinking the outfall pipe as a multispecies structure*. This more complex reality, which exposed the tension between the needs of different species, is typical to Multispecies Design. It raised a central question regarding the design of environments aspiring to address the needs of more than one species: ***Can humans and other species be treated as equal stakeholders in a design process*?** My focus here was, as with the rest of this thesis, on animal species rather than plant species, for reasons I discussed in the introduction, although I recognise that plants play an important part in this story as well. To explore this question, I decided to experiment with giving animals the same attention as humans throughout the entire design process. This raised, in turn, a whole set of related questions regarding the application of design processes and techniques intended for humans, on animals; For example, ***how do you perform ethnographic design research on animals?***

3.4.2. FIELD RESEARCH

With the location for the project set, and a general intention for the design exploration decided, it was time to see how humans and marine species were currently interacting with the structure of the pipe, to gain insights into the needs of the various users of the structure and to better frame the problem I was addressing. This was done using methods of design ethnography (Koskinen, 2011, pp. 74–75; Wasson, 2000), including observation, visual diaries, interviews, and photo and video recordings[8]. Although these methods had been conceived for human subjects, I found it was possible to apply some of them to animals as well. Other methods needed adaptation to make them usable with nonhumans, and some new methods where needed to make up for the innate species-gap present when designing for non-human species. Over the course of five months, I visited the site and organised meetings with different actors in the story of the outfall pipe: Members of the local Looe Marine Conservation Group (LMCG), a group of conservation volunteers organised by the CWT, the asset manager from South West Water who own the structure, marine biologists studying intertidal species, experts on biocolonisation, the local coast guard who has an office on site, and local residents and holidaymakers frequenting the beach.

On every visit to the beach I dedicated time to learning about the local ecosystem. By observing, drawing, photographing and making sound and video recordings, I was learning a lot about the animals and plants I had previously read about in the scientific literature; more importantly, I was now learning about them in the local context of the pipe on Hannafore beach. Although I could not talk to and interview these animals and plants, I noticed that with some of the people I met, the conversations were more about the nonhuman than the human. This was especially notable with members of the conservation group and some marine biologists. These people saw themselves as spokespersons for the local ecosystem or had been studying specific animals for years and could, to some extent, speak on behalf of these animals. Later I would learn that researchers in the field of Multispecies Ethnography do just that, they “speak with biologists, nature lovers and land managers about the species they represent” (Kirksey, 2014, p. 3), in order to introduce new, non-anthropocentric, perspectives into their research.

Still, I felt that something was missing from my understanding of my animal clients compared to my human ones. Not because I was spending less time studying them but because there was so much more I knew about humans than I did about these other species; from being human myself, from being able to walk on the outfall pipe and experience it as a human does. Although I knew this discrepancy would never be fully resolved, I was nevertheless committed to trying — to see what new insights this trying

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[8] A list of the methods used and the findings can be found in the appendix.

might bring forward. This was, after all, an exercise in *trying* to treat animals and humans as equal stakeholders in the design process. This was for me uncharted territory and there was not much design literature I could refer to; I had to experiment and rely on practice

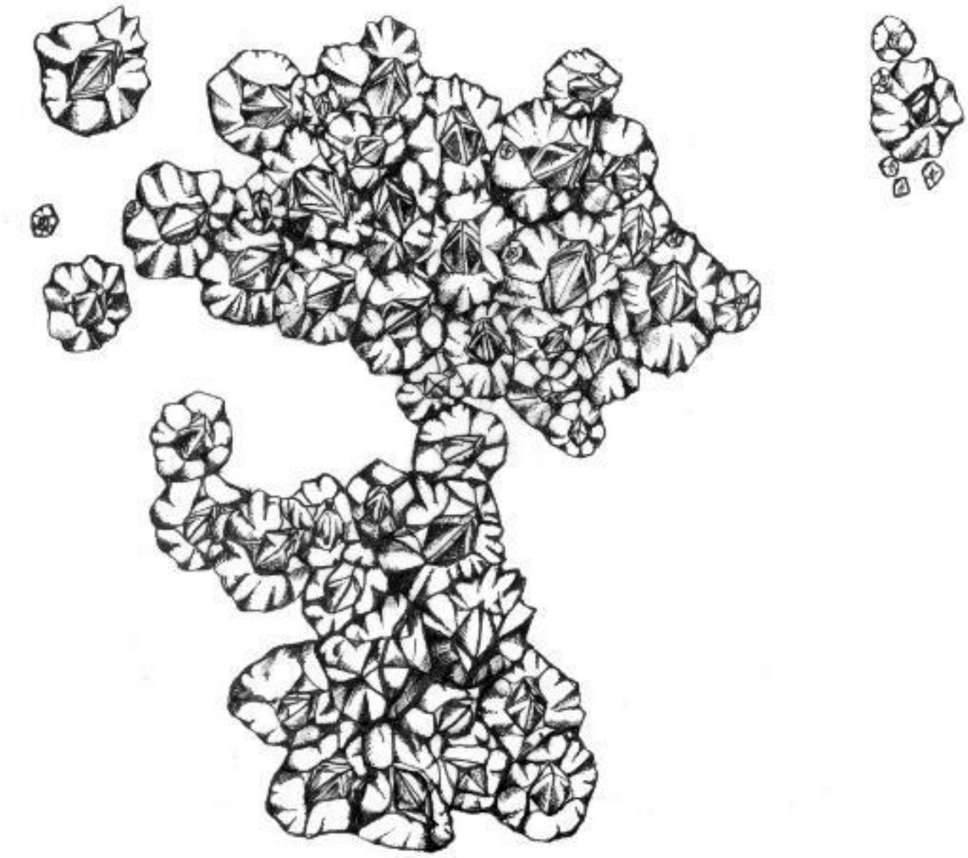

Fig 3.5 Drawing of barnacles (2012).

from other fields such as somatics and movement practices to find new ways of gaining a more intimate understanding of my animal clients.

Designers often use role-playing in their research to learn about their human clients (McDaniel-Johnson, 2003). The field of Inclusive Design has seen the development of props and tools to aid designers in situations where clients have different physical abilities than their own. The University of Cambridge's Engineering Design Centre, for example, has developed special gloves that simulate reduced functional ability of the hands, as well as glasses that simulate reduced eyesight (University of Cambridge, ca. 2015). Various toolkits and guidelines exist for making design more inclusive. However, none that I have seen offer ways of gaining a nonhuman perspective in the design process.

Inspired by a 1934 monograph by Von Uexküll (1992) where he suggests ways of viewing the world through the perceptive organs of other animals (including molluscs), I tried to imagine the world from the point of view of my animal clients. I found these experiments particularly useful while snorkelling, when my own perceptive organs were already challenged by the surrounding sea and the diving equipment I was using. Snorkelling also gave me a glimpse into the lives of intertidal species (which I was used to seeing only at low tide) during high tide when they were more active. While it was physically impossible for me to *be* an intertidal creature, I found different embodied and somatic activities could help get me closer to the feeling of *viewing the world as one*, as a limpet for example. Experimenting with experiencing the world from the perspective of an intertidal animal also helped me articulate and contextualise the scientific literature, and assisted in the cognitive learning of the scientific facts regarding the animal. As Rambusch and Ziemke (2005) point out, "cognition is deeply rooted in and inextricably intertwined with bodily activity". Rehearsing animal behaviour read about in ecology books through role-playing helped me embody and memorise this behaviour.

The process of learning scientific facts through a cognitive process and consequentially using a bodily activity such as movement or drawing to embody that knowledge is sometimes used in dance practice. Specifically, it is used in the field of BMC (Body Mind Centring), developed by Bonnie Bainbridge Cohen, as a way of, amongst other things, teaching dancers the anatomy and physiology of the human body (Cohen, 1993).

Fig 3.6 Exploring the feeding behaviour of barnacles through movement improvisation (2013)

Dance improvisation can also be used as a form of embodied research. In her piece *Twig Dances,* Malaika Sarco-Thomas improvises with the idea of becoming a tree, a practice she calls "reflective paradox" (Sarco-Thomas, 2012). Paradox in this sense is used as a way of allowing seemingly impossible or contradictory propositions to coexist, to avoid (even if just momentarily) exclusionism and binary thought (such as the possibility of me becoming a limpet for example). This active paradox for Sarco-Thomas is a "tactical disengagement with familiar modes of thinking in an effort to ignite basic sensory capacities... active paradox can be used to undermine hierarchical notions and re-examine preconceptions, and to operate as a 'plane of consistency' whereby procedures of working do not pre-determine products" (ibid). In a series of experiments with a group of dancers, I used dance improvisation as a way of gaining insights into the movement possibilities of the animals I was working with as well as the ways they interact with the surfaces they colonise and with each other.

Fig 3.7 Limpets can manifest territorial behaviour and are known to 'fight' over grazing grounds by attempting to flip each other over. In the photo, dancers are studying this behaviour during a workshop (2013)

There is a certain sense of anthropomorphism in these dance experiments, in pretending to be another species. However, as Bennett (2010, p. xvi) suggests: "We need to cultivate a bit of anthropomorphism—the idea that human agency has some echoes in nonhuman nature—to counter the narcissism of humans in charge of the world". These embodied experiments helped cultivate a sense of respect and responsibility towards my animal clients; a sense of responsibility that was another step forward in my attempt to treat animals and humans equally in the design process.

3.4.3. Framing the scope for the design intervention

I wanted to bring this sense of respect and responsibility into the design itself; to redesign the walkway as a shared landscape where human and animals would have equal claims over the use of the structure and where its different functions would not be separated by hard borders but would blend into each other and leave room for cross-species interactions. My aspiration was to make the pipe a safe walkway for people, as well as a safe habitat for a diversity of intertidal species, and to look for possible synergies[9] between the human function and the ecological one. From a technical point of view, the proposed design would be made of concrete like the existing structure, and although the way of testing these designs on site would be by retrofitting them onto the pipe, I wanted the design to relate to the top surface of the structure in a way that could potentially be integrated into the original precast in the future.

3.4.4. Keeping the animal present during concept generation

The next step was to develop design proposals to meet these design criteria. The challenge I encountered in this phase was in how to keep the animal perspective present during the sketching and prototyping which I felt had the risk of taking me back into a world that was more human than nonhuman. Keeping the animal present in this phase was done partly through my memory of the embodied knowledge gained in the research phase and partly through close collaboration with the science partners of the project and the individuals identified in the previous phase as potential spokespersons for the animal clients, who provided feedback on the prototypes on behalf of the animals.

Two final design proposals emerged from this process, each with a different ecological design and manufacturing advantages and disadvantages. Both proposals are made of concrete and both include features for trapping water at low tide and incorporating

[9] Seeking synergies is one of the principles of Metadesign as expressed by metadesigners.org (2001).

ecological principles for enhancing general biodiversity. In addition, both designs incorporate features for attracting specific species, the presence of which on the walkway could potentially make it safer for humans to walk on. Approaching the safety of the walkway through biology rather than through the physical geometry of the design was a way of finding synergies between the different functions of the pipe, and also has the advantage of creating additional habitats, as well as demonstrating the direct value of promoting biodiversity within human habitats.

3.4.5. Wave

The first proposal, Wave, focuses on introducing a habitat for molluscs on the structure. In addition to offering a habitat and protection for these species, it looks to cultivate the grazing power of sea snails, and especially limpets, to reduce the algae levels on the walkway and make it safer for people to walk on. The use of limpets for this end has been suggested in several scientific papers (for example Moschella et al., 2005) although to my knowledge, no applications of this nature have been tested to date. Limpets are prominent grazers of algae and so-called *grazing halos* can often be seen around adult limpets in the wild, indicating the radius in which they feed. Moschella et al. (2005) advise that in order to attract limpets to a structure it needs features capable of trapping water at low tide. In addition, limpets would have to be already present on the site (the site visits confirmed they were).

Although extremely tough, limpets would still need protection from trampling by walkers, especially during the first stages of their establishment. Creating features for trapping water on the surface of the pipe would also have the advantage of enhancing general biodiversity, and protection from walkers would make it habitable also for other, more fragile, species.

The need for protection of the habitat means that some separation of the surface between the walkway and habitat was inevitable. However, in order for limpets to be able to graze on the algae covering the walkable areas there had to be the possibility of a flow between the two areas. I experimented with different ways of creating *soft and transient separations*, i.e. separations which can accommodate flow and allow for a certain degree of transgression.

A solution came in the form of a wave pattern, higher in the centre and lower in the margins, where the higher centre of the tile is intended for walking on while the sides are dedicated habitat for marine life (see Fig 3.8 below).

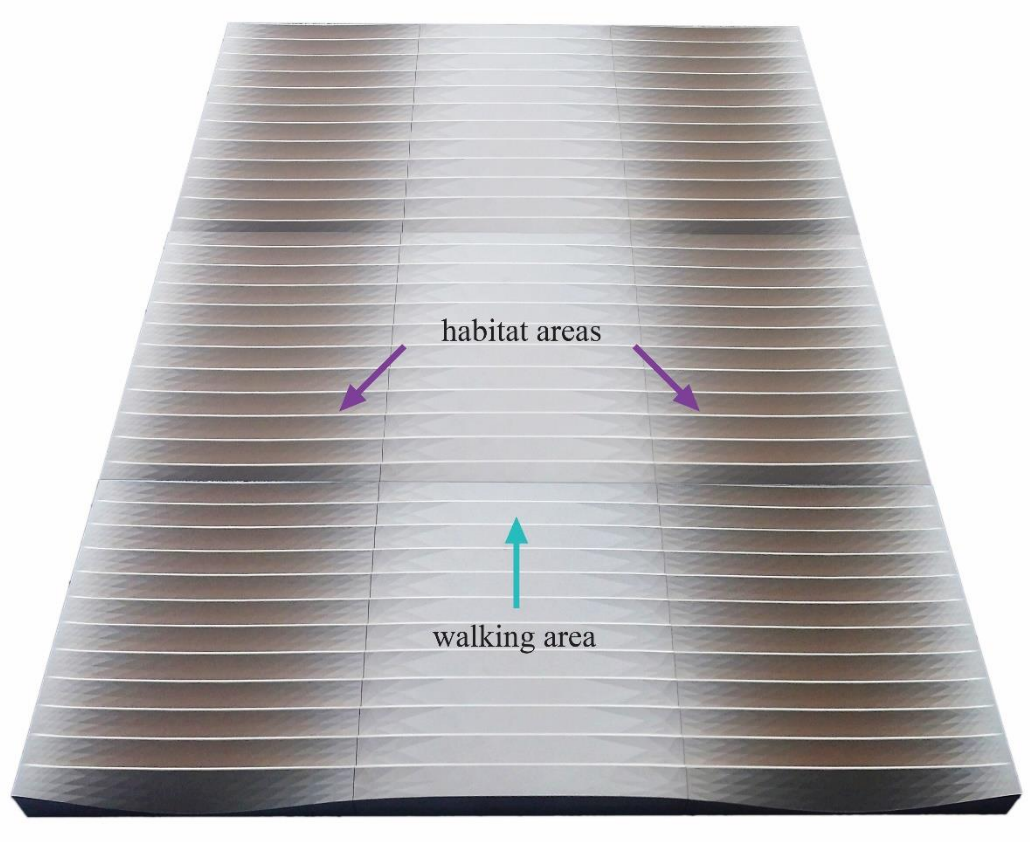

Fig 3.8 Model of the Wave tile indicating the division of the space between walking and habitat zones (2013)

This way of dividing the surface is based on three different notions of *soft separation* working together: the first is *behavioural***,** the second *temporal* and the third *structural.* The behavioural separation relies on the different behavioural attributes of humans and sea snails. Human activity is channelled to the centre of the walkway by the effect of the wave pattern, which makes the centre seem more comfortable to walk on (while not excluding walking in the margins). Sea snails on the other hand are known to move to where water is collected at low tide and are therefore channelled to the sides of the walkway by behavioural forces working in an opposing direction (see Fig 3.9 below).

This type of separation based on behavioural attributes leaves room for transgressions without serious consequences and is more a way of nudging[10] users in a certain direction than a way of forcing them. There is an attempt here to extend methods of behavioural design (see for example Lockton, 2013) to nonhuman species, a notion I will return to and expand on in the chapter about Multispecies Design.

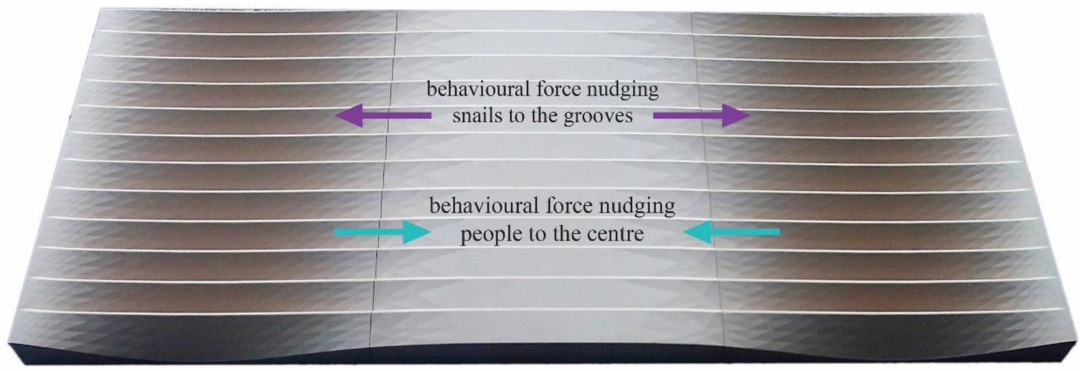

Fig 3.9 Behavioural forces working on people and snails in the Wave tile design (2013)

The temporal separation is based on the shifting tides. At high tide, when the surface of the walkway is under water, people have left the area and the structure is available entirely for the use of marine creatures. Limpets, snails and other mobile animals can move along its surface in search of food and attending to their requirements. As the tide retreats, they seek refuge and water in the side grooves where they are protected from returning walkers.

An additional structural separation is present to make sure delicate marine species are also protected when people walk on other areas of the pipe beyond the central raised element of the design. The size and depth of the grooves are planned to accommodate adult limpets and other sea snails and keep them protected even when people are using the sides of the walkway (when walking side by side or pushing a pram for example).

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[10] The notion of nudging and its use in behavioural design will be returned to and expanded on in the chapter about multispecies design.

Fig 3.10 Visualisation of Wave tile layout on pipe during receding tide (2013)

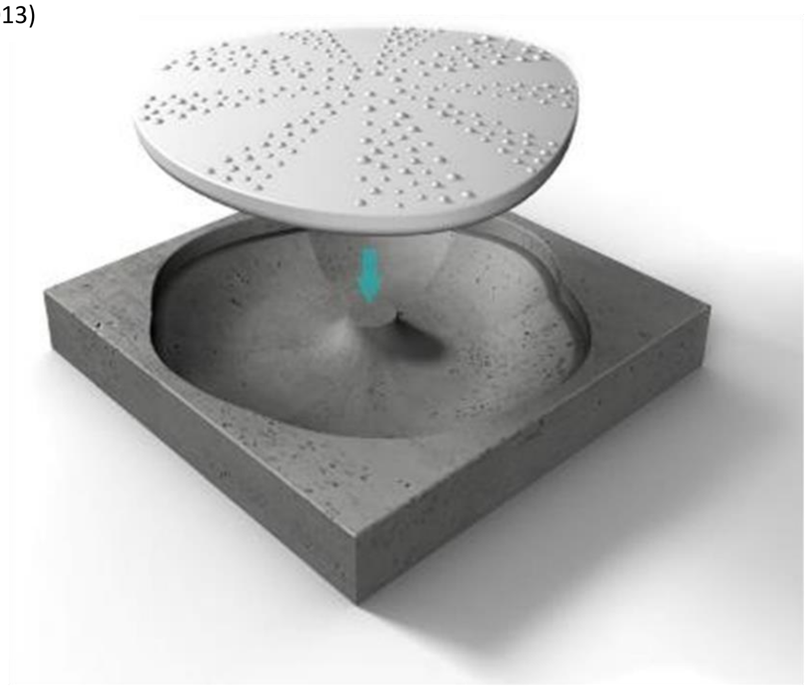
Fig 3.11 Visualisation of adult limpet protected in wave tile groove (2013)

Channelling most of the human activity on the pipe to a certain area at the centre of the walkway may also contribute to reducing alga levels, as smaller areas of contact with the pipe would mean more erosion in these areas and a lower chance of the algae being established.

3.4.6. URCHIN

The second proposal, Urchin, is a covered rock pool intended as a nursery habitat for small marine creatures such as crabs, shrimps, chitons, anemones and sea worms. The pool is covered in a way that levels it with the surface of the walkway and leaves small gaps for water and small mobile animals to get in and out. The pools can hold up to 1.7 L of water and creating a cover for them decreases evaporation and offers a refuge for small animals from predators and the elements. The covers are designed to resemble stepping-stones which encourages people to walk on them, and they are textured with small bumps to increase traction.

Fig 3.12 Assembled (top) and exploded (right) views of the Urchin tile (2013)



The surrounding areas of the tiles are textured with grooves designed to attract barnacle colonisation (Coombes et al., 2015). Barnacles are dominant ecosystem engineers and their recruitment can provide a physical habitat structure for other species (ibid). The attraction of barnacles has also been suggested in some of the conversations I had with both marine biologists and volunteers at the LMCG as another way of making the walkway potentially less slippery. It has been suggested that people seek out barnacles when walking on rocky beaches as they intuitively associate them with more stable footholds. This tacit knowledge was illustrated to me during a rock pool ramble when a five-year-old girl advised me to walk on the barnacles in order not to slip.

Fig 3.13 Detail of textured surface of Urchin tile. The fine grooves are designed to attract barnacle larva settlement while the recessed areas are designed to offer protection from walkers. CNC milled resin board (2013)

Barnacles are very durable creatures, but only once they have constructed their calcareous protective shells. It is not clear how much trampling they can actually withstand and how long they need to establish themselves before they can be walked on. To allow them time to establish, and reduce some of the pressure from the areas intended for barnacle colonisation, I took a similar approach of *soft separation* as with the Wave design. I was hoping that encouraging people to walk on the pool covers, by using their visual association to stepping stones, would aid in the establishment of barnacles on the other areas of the tile. An additional design element was the creation of height fluctuations within the grooved texture for the barnacles (see Fig 3.13 below), thus creating micro-safe-havens in which barnacle cyprid larvae could establish and start developing.

The cover stone for the pool is a rounded triangular shape slightly resembling an urchin. The shape of the pool was created by overlapping the shape of the cover stone twice, with a 45° rotation (see Fig 3.15 below). This creates the entrance gaps into the pools and allows for two different possible placements of the cover on the pool that, together with 4 possible orientations of the tile, allows for eight possible tile configurations offering a visual variety with just one design. The entrance holes to the pool vary from 10mm to 25mm, depending on the orientation of the cover.

Fig 3.14 Visualisation of Urchin tile 'stepping stone' layout on the outfall pipe at receding tide (2013)

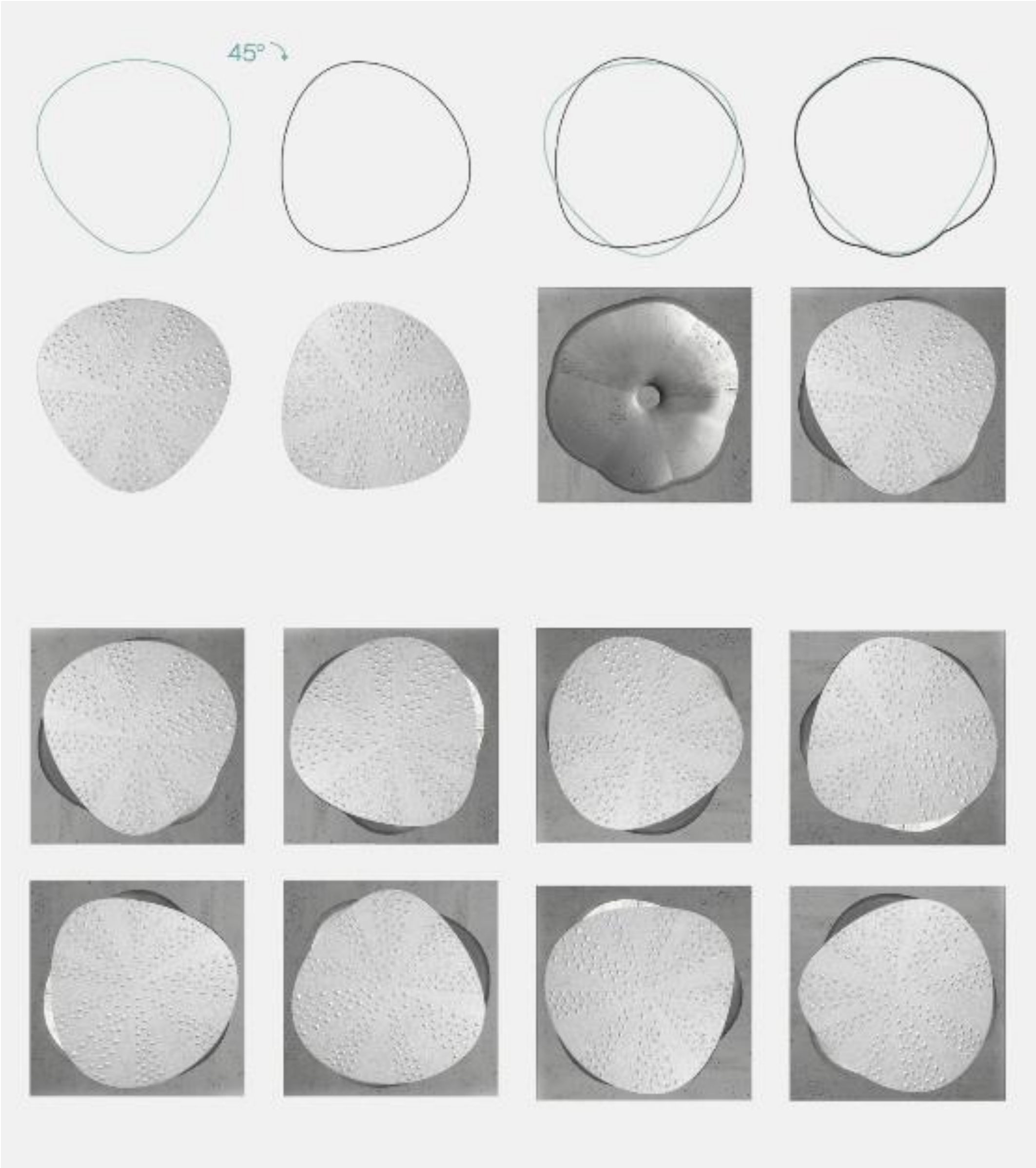


Fig 3.15 Study of the shape for the pool and cover and eight possible configurations of the Urchin tile (2013)

The urchin proposal was conceived to have a higher potential of increasing biodiversity than the Wave tile as it traps more water and offers a protected habitat, although being covered would also affect the type of species it would attract. In addition, this habitat would be hidden from sight and therefore may not be recognizable as such by people using the walkway. This may impact the degree to which this design communicates its ecological function to human users.

3.4.7. SETTING UP THE FIELD TRIAL

Both design proposals are speculative and left many uncertainties regarding their actual performance: Would they increase biodiversity in comparison to the current flat surface of the walkway? Would they attract the species they were intended for? Would the soft separation approach work? Would people walk in the centre of the wave tile and on the stepping stones? Would the designs feel safer to walk on? Would limpets reduce algae levels? Would the ecological function of the tiles be communicated via the design? Would people appreciate the designs? Which design would perform better ecologically? Which would people prefer? All these questions could only be answered by an on-site field trial of the designs.

To set up the field trial, resin board prototypes of each design were made using a CNC router, and used to create silicone moulds for casting concrete samples of the tiles. In May 2014, four test tiles of each design were fitted onto the outfall pipe with the help of South West Water and NJC Building, for a test trial of five months.

Fig 3.16 Silicone moulds of the Wave tile and both parts of the Urchin tile ready for concrete casting (2013)

Fig 3.17 Concrete tile being glued onto the surface of the outfall pipe (2014)

Fig 3.18 The test site on installation day. Concrete ramps were constructed on each end, to facilitate walking on and off the tiles (2014)

The objective of the trial was to try to answer some of the above questions and test the ecological and human response to the design, alongside the performance of the two designs in relation to their intended function. The test tiles were attached onto the concrete surface of the pipe just above mean tide level and left there for five months, during which their performance was assessed.

3.4.8. Assessing the design proposals

The challenges of designing for the animals encountered in the research and design phases were mirrored in the assessment phase. Traditional methods of interviews and questionnaires have obvious limitations when involving nonhuman species. In this phase, I wanted to observe and record how people and marine species interact with the test tiles and with each other, through the tiles. To this end, a mixture of qualitative and quantitative methods was combined to capture both the ecological response (in scientific terms) and the human response (in ethnographic terms) and how each of these influenced the other. In this regard, the scientific assessment was not that of a controlled experiment where measures had been taken to reduce external interference. In contrast, the site was purposely chosen for its high numbers of human visitors, and the ecological response observed has to be understood in this context of high human activity. In fact, some of the ecological findings can only be understood in this context. The assessment was carried out through periodical visits to the site (once/twice a month), and through observations, measurements and questionnaires, details of which follow.

In addition to assessing the functionality of the final design proposals, the entire design phase was also considered from a conceptual viewpoint, in order to identify and reflect on different emerging aspects of designing for animal and human clients alike. The design exploration was reflected upon in terms of its ability to generate useful concepts, highlight complexities and opportunities, and articulate new perspectives:

Have animals and humans been considered equally in the design process? What methods can be used to overcome the species gap in designing for nonhuman species? How is this different from designing solely for people?

BREAKDOWN OF ASSESSMENT METHODS

QUESTIONNAIRES

The questionnaires were designed to see how people relate to the concepts behind the designs, as well as other design features such as aesthetic perception, experience of walking and perceived ecological function. They focus on comparing three different treatments to the pipe: 1. the Urchin tiles (A1-4 in Fig 3.19) 2. The Wave tiles (B1-4 in Fig 3.19) and 3. The original flat concrete on both sides of the test area (C1 and C2 in Fig 3.19). Twenty-five questionnaires were handed out and filled in on different occasions at the test site. Sixteen were filled in by people attending one of two rock pool rambles organized by the Looe Marine Conservation Group and the rest by other visitors to the beach. A template of the questionnaire can be found in appendix 1 (page 166-169).

Fig 3.19 Treatments A, B and C (2014)

OBSERVATIONS

Observations were made during periodical visits to the beach to see how people and other species interacted with the tiles in the real world compared to their intended use. These were captured in notes, photos and video recordings. An endoscope camera was used to look into the covered pool of the urchin tile.

The observations proved a very important tool for linking the ethnographic information with the scientific ecological information, and helped highlight some interesting eco-socio-technical aspects of the local setting.

Oral feedback

The information panels explaining the project on site, as well as the blog set up to document the project, invited people to send in feedback about the project by email. In addition, I received myriad oral feedback from locals and visitors on the beach, curious about these strange objects that appeared on the outfall pipe one day, as well as during and after talks I gave about the project.

Species counts

Quantitative species counts were carried out at low tide during the test period to measure the ecological response to the design in terms of biocolonisation. A 25 x 25 cm quadrant was used to survey and compare species on the three treatments of the surface (Fig 3.20 below). On each survey day, ten quadrants were sampled of each treatment, once as the tide just left the test site, and once again after four hours. The survey examined what species were present, as well as the abundance of each species.

Fig 3.20 The quadrant used for species counts (2014)

Temperature measurements

On two hot days, temperatures in the grooves of the Wave tile and in the pools of the Urchin tile were measured. This was done at one and a half hour intervals, to compare how the two designs function in terms of temperature fluctuations of the trapped water over time.

3.4.9. Results and discussion

The outcomes from the assessment period were a combination of ecological recordings, written and oral feedback, observation notes, photos and video recordings. Taken together they shed some light on how the two prototypes functioned in the real world over the course of the test period—from an ecological perspective, a human one and the intersections between the two. They exposed areas where the designs had failed to perform as intended, and others where new and unexpected eco-socio-technical interactions came to life in the presence of the tiles. They exposed gaps between my intentions as a designer and the reactions of the human and nonhuman users to the structure; they helped clarify conceptual notions regarding the process of designing for humans and nonhumans, and they helped articulate the relevance of the work from the viewpoint of both locals and visitors to Hannafore beach. These results are discussed below in relation to the intended functionality of the tiles as well as additional curiosities revealed during the test period.

Habitat value

As expected, both designs offered improved habitat and hosted a higher biodiversity than the flat concrete. On each site visit, the animal diversity as well as their abundance on the tiles rose, while they stayed more or less the same on the flat concrete (see Table 1 on page 164).

While the Wave design hosted higher numbers of individual animals under low tide conditions (mainly snails such as periwinkles, top-shells, limpets and dog-whelks), throughout the trial the Urchin tile hosted a slightly higher diversity of species in the pools by offering a habitat also to species absent from the Wave tile, such as shore crabs, hermit crabs, shrimps and keel worm (observed using an endoscope camera). However, towards the end of the trial, following a few stormy weeks, the pools in the urchin tile started to fill up with sediment and the animal diversity in them dropped.

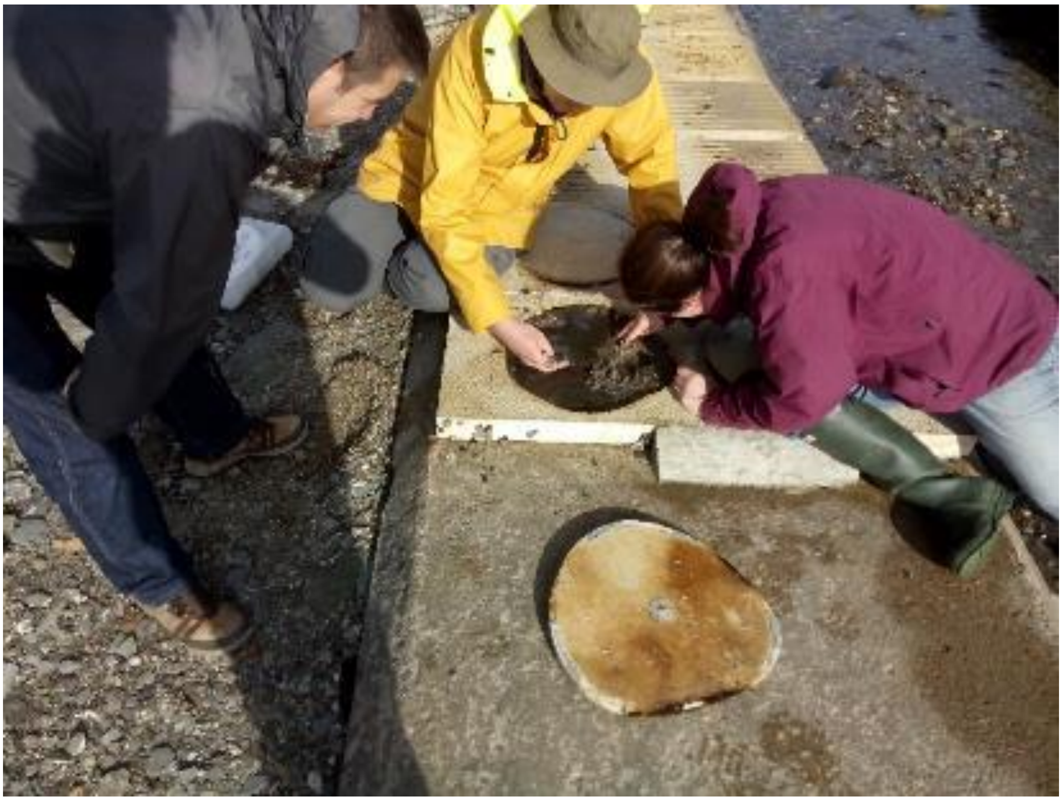


Fig 3.21 Prof. Thompson and Dr. Firth going through the
sediment in the Urchin pool at the end of the trial period (2014)

By the end of the trial, when we lifted the covers off the Urchin tiles, we found one shore crab, as well as a moderate coverage of polychaete worms attached to the cover. Despite the presence of these species in the pool, it was asserted by the marine biologists present that the sediment in the pools would not have hosted much life in the long term, as it seemed to be acutely deprived of oxygen. This meant that by the end of the trial the main habitat offered by the Urchin tile was in the crevices by the entry holes of the pools (see Fig 3.22 below).

While this was still more than the habitat offered by the flat concrete, the point of the covered pool had been undermined by the sediment and the Urchin design failed to perform as intended.

The clogging up of the pool would suggest that the Urchin design is not well suited for a shore where sediment is present, and would need to either incorporate a system for flushing out the sediment, or be used in areas with low or no sediment, such as manmade environments or rocky shores with no or only a limited presence of sand (however, it is possible that in such areas the tile would just take longer to eventually fill up).

Fig 3.22 Snails and seaweed assembled by the entry hole to the Urchin pool (2014)

Throughout the trial, the habitat value was measured in terms of animal abundance, by counting animal organisms[11] visible in ten randomly placed quadrants (25cm x 25cm) on each of the three treatments (A, B and C). These measurements were carried out by me and repeated on five different occasions at approximately one month intervals. On each visit, measurements were taken, once as the tide just left the test site, and again at around four hours later (for reasons I will discuss shortly). These measurements ignored species observed inside the Urchin's covered pool, as identifying these species was hard using only an endoscope camera. In addition, as mentioned above, the habitat offered by the

[11] Animals observed were mainly snails, with the exception of one Hermit crab. The snails were identified to the family level and not the individual species level since some species require removal from the surface for correct identification as well as expert identification skills, which I did not trust myself as having.

covered pools was short-lived seeing that by the end of the trial the pools had altogether lost their habitat value due to clogging.

The results of these measurements are summarised in Table 1 in the appendix (page 167). They show a clear rise in habitat value, in terms of animal abundance, on both the Urchin and Wave tiles as the trial progresses, although with a distinct advantage to the Wave tile. The Wave tile on average hosted around five times more individual animals than the Urchin tile and around thirty times more than the flat concrete. On the last count, 146 snails were counted in ten quadrants on the Wave tile compared to 27 on the Urchin and only two on the flat concrete (see Fig 3.23 below).

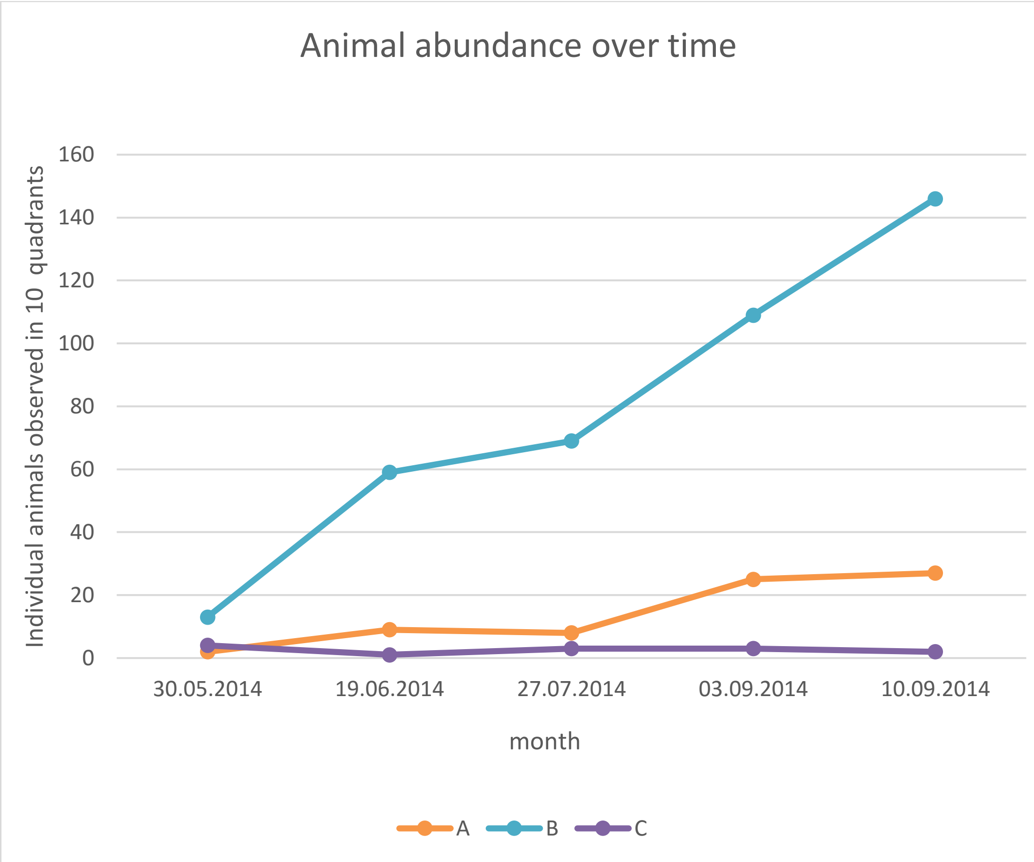


Fig 3.23 Animal abundance over time. The graph shows the total number of animals counted in ten 25cm x 25cm quadrants four hours after the tide had left the test area on treatments A, B and C (2014)

SPECIES DIVERSITY AT THE END OF TRIAL

Species diversity at the end of the trial was measured to the species level by counting all the species visible on both treatments and a comparable area of the flat concrete surrounding the test site. These counts were carried out with the help of two marine biologists from Plymouth University, Prof. Richard Thompson and Dr. Louise Firth, who joined me and my supervisor, Dr. Justin Marshall, on the last day of the trial.

On the final day of the trial, the diversity of animal species was similar on the Wave and Urchin tiles, and was triple that found on the flat concrete (full list available in the appendix, page 169-171). On the Wave tile, six different species of snails were found, while on the Urchin tile, there were three species of snails, two species of polychaete worms (stuck to the cover, Fig 3.25) and one species of crab. On the flat concrete, only two species of snails were observed. However, as mentioned above, it is not clear if the worm and crab species would have survived much longer on the Urchin tile due to sediment collecting in the pool, which gave an advantage to the Wave tile also in terms of species diversity at the end of trial. In addition, on the Wave treatment, four species of algae were observed compared to two species on the Urchin tile and the flat concrete.

Fig 3.24 Polychaete worms stuck to the cover of the Urchin tile (2014)

Barnacles were absent from both designs. This was probably due to the timing of the deployment of the trials, which was at the end of the barnacle settlement season.

Fig 3.25 Snails and seaweed in the grooves of the Wave tile (2014)

While we were counting species and opening the covers of the Urchin tiles, the discussion on site with Prof. Thompson and Dr. Firth was also very insightful. It revolved around how very small changes in the morphology of the tile or in the species assemblage led to substantial changes in the micro-ecosystem that was created on the tiles. For example, the red algae Hildenbrandia spp. was clearly settling more on the vertical walls of the grooves in the Wave design compared to the slopes and bottom (see Fig 3.26 below). This was probably due to these being more shaded than the angled walls of the grooves.

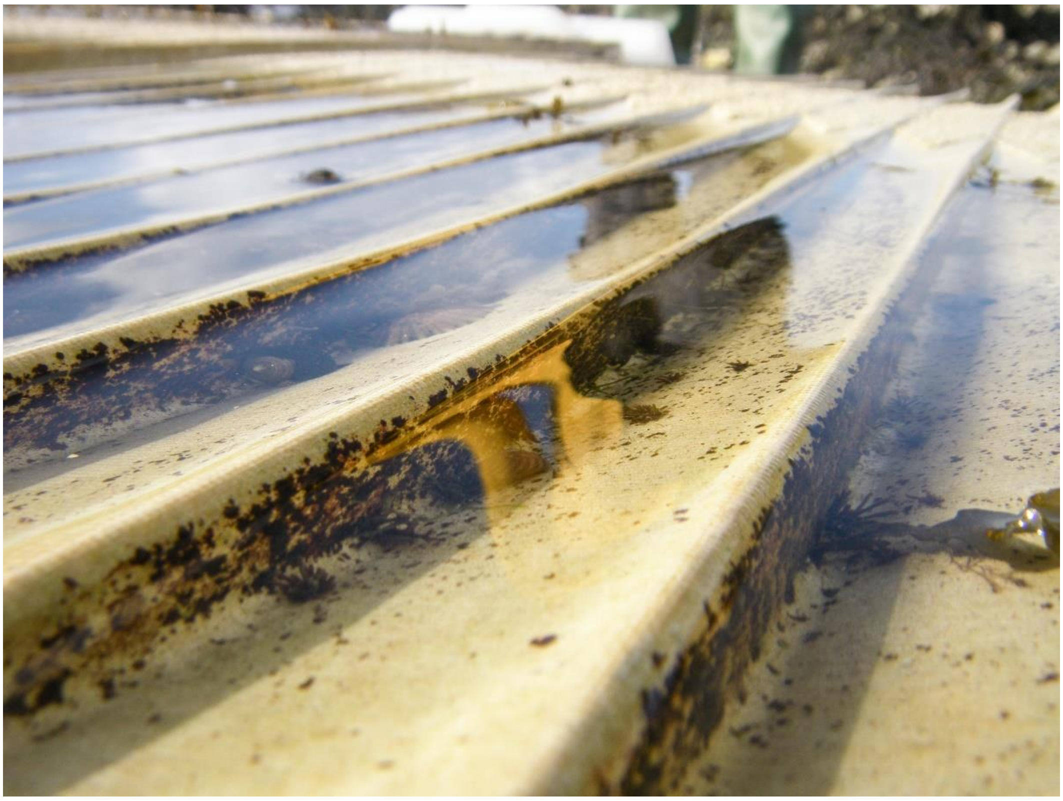


Fig 3.26 Close up of grooves in the Wave tile showing denser assemblage of red algae on the vertical walls compared to the slopes (2014)

Also, the orientation of the walls had an influence on the algae growth, with north-facing walls becoming more heavily colonised than south-facing ones. Another example of the effect of small changes in the microclimate was seen on one of the Wave tiles, which had cracked during installation and was losing water from some of the grooves. This tile had significantly less biocolonisation in the dry grooves compared to the water-holding ones.

The micro-ecosystem also showed rapid changes, with the appearance of a new species: in grooves where limpets had settled (sometime in the last month of the trial) algae levels had dropped substantially despite the fact that these limpets were still juvenile (Fig 3.27 below). Also, the colour of the tile may have an influence on biocolonisation, with lighter coloured tiles staying cooler and evaporating less water on hot days.

Fig 3.27 "Grazing halo" surrounding a limpet in the Wave grooves (2014)

These observations highlighted the close link between the ecology, morphology and design of the tiles. The discussion was a useful reminder of the fact that ecosystems are complex and ever-changing and there are decisive limits as to how much we can aspire to shape or control them. On the other hand, it also emphasised the fact that if we study these ecosystems attentively and understand the factors influencing them, small interventions could lead to big changes. Ever-changing systems pose a challenge to a discipline which seeks fixed and controllable outcomes, although they also present opportunities for new ways of designing which are more in synchronisation with natural processes.

Perceived habitat value

It was important to look not only at the actual habitat value of the two tiles but also at how their ecological function was perceived by people interacting with them. The perceived ecological function can give an insight into how well the designs communicate their function, which was one of the goals of the design. The perceived habitat value was measured by asking people in the questionnaire which of the treatments (Urchin, Wave or flat concrete) they thought did a better job in creating habitat for marine life. No prior information about the designs was given to the participants before they filled in the questionnaire, apart from the fact that they were designed to create a habitat for marine life.

Both designs seemed to be successful in communicating their ecological function, as all the participants responded that they believe that either the Wave or Urchin did a better job at creating a habitat for marine life in comparison to the flat concrete. There was a slight advantage to the Wave design in communicating its habitat value. From reading the comments in the questionnaires, it seems that this advantage was due to the fact that the habitat created by the Wave tile was visible, while in the Urchin tile it was hidden. Most of the participants who believed that Urchin did a better job at creating habitat seemed to have known that there was a hidden rock pool in the tile (many referred to it in their feedback forms), while most participants who responded that Wave had a higher habitat value seemed not to have known about the hidden habitat offered by the Urchin tile (in their explanations many participants stated they could see more snails on the Wave tile).

Communicating the ecological function of the design extends further the notion of a shared structure and may help raise awareness of the influence of manmade structures on other species, as well as the possibility of designing these to meet the needs of nonhuman species. Raising awareness and demonstrating that multispecies structures can be created with little or no compromise to human use is an important aspect of facilitating a shift towards more bio-diverse human habitats as it would help to generate acceptance of such structures. Ideally, the perceived ecological function would match the actual one, but there is a case to be made also for an intrinsic value to the perceived ecological function in a project where education is one of the goals. In the case of the Hannafore tests, all the participants without exception stated on their forms that they believed there is an importance in creating habitat for marine life on structures like the outfall pipe, giving additional importance to the perceived notion of this habitat.

SNAIL ABUNDANCE AS TIDE RETREATS

On my site visits, I aimed to arrive at the beach shortly after high tide, to witness the tide leaving the structure of the outfall pipe. This allowed me to observe the test site before people arrived, and witness the changes that occurred as people started interacting with it. One local phenomenon caught my attention in particular: On my first visits (before installing the tiles) I noticed that as the tide retreats, the outfall pipe is regularly left with many snails on its surface—most of which disappear a few hours later as the pipe dries out. During the test period, I was interested in learning more about this phenomenon, as well as seeing if and how it would change with the test tiles. For this reason, I performed the ecological surveys, once as the tide left the test site, and once again four hours later, to see how the data changed over time and how they compared across the three treatment sites.

The graph below (Fig 3.28) shows the average abundance of snails as the tide retreats throughout the test period. It relates to the average number of snails from five different site visits counted in ten quadrants, once as the tide left the site, and once again after four hours.

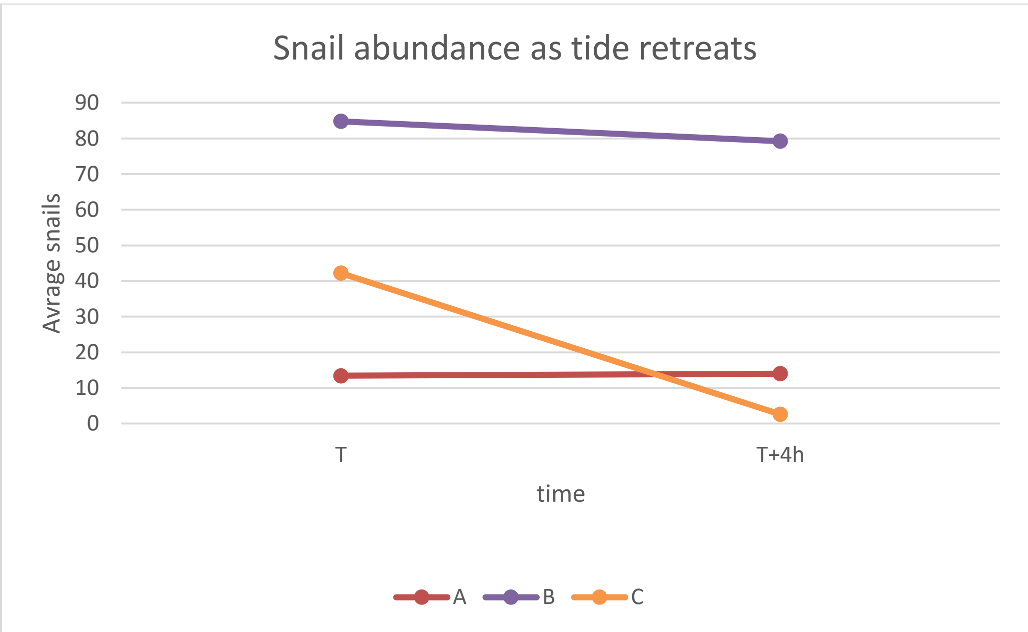


Fig 3.28 Average abundance of snails as the tide retreats on Urchin (A), Wave (B) and flat concrete (C) (2014)

The data showed a substantial decline in snails over time on the flat concrete (C) while it stayed more or less constant on the Wave (B) and Urchin (A) tiles. The reason for this phenomenon is partly to do with the behaviour of snails, which were observed moving off the pipe as it got warmer and dryer, especially on hot days. However, the disappearance of the snails from the flat concrete also has to do with human behaviour. On several occasions, I witnessed people removing snails off the pipe with their feet as they walked. Amongst the people so doing were the local life guard who stated that he does so often, as well as local members of the LMCG. When asked about this behaviour I got two main replies: Some were removing the snails out of concern for people's safety (so people would not trip over the snails). Others did so out of concern for the safety of the snails (so the snails would not be crushed by people). It is important to note that all the people I observed doing this, did so with caution, apparently making an effort not to harm the snails.

To some extent, both designs reduced the intensity and need for this phenomenon (see Fig 3.28 below). The Urchin tile, for unclear reasons, was left on average with much fewer snails on it than the two other treatment sites as the tide retreated, but held a similar numbers of snails four hours after the tide had left. There did not seem to be much movement of snails on the Urchin tile after the tide had left, and the snails tended to concentrate in small areas near the entrance holes to the pool.

The Wave tile was more interesting in this respect. It started off with high numbers of snails, similar to the flat concrete, and maintained these numbers over time. Unlike the Urchin tile, there was still a movement of snails on the Wave tile after the tide had retreated, however, this movement seemed to stay within the boundaries of the tile and was generally directed from the centre towards the grooves. Snails seeking refuge and water had a much shorter distance to travel on the Wave tile than they did in getting off the flat concrete.

Occasionally I witnessed people assisting snails in their movement from the centre into the side grooves on the Wave tile—by gently kicking them to the side or lifting and relocating them. Although a small gesture, I found it interesting, as it highlighted some unforeseen qualities in the design. The first is the ability of the Wave tile to communicate its function. In most cases, these were people with whom I had not discussed the project previously, suggesting they intuitively understood the purpose of the centre as a walking area and the grooves as a habitat for snails. The ability of the design to communicate its function, in this case, had consequences that went beyond comprehension, to inciting action. It enabled and possibly encouraged the act of relocating the snails to safety. The *soft* approach I had imagined for separating the walkable area from the habitat area on the pipe was infused with a new meaning with this act of relocating the snails. The fluidity of the system meant that people could make small adjustments to it, setting it back on course, when a transgression occurred. More importantly, this act of setting the system back on course was not just in favour of the human use of the pipe but was mutually beneficial. The second point I found interesting was that this act of cross-species interaction, which encompasses a certain degree of empathy towards the snails, highlighted for me two possible manifestations of multispecies structures. In the first, the human and ecological functions exist side by side with little or no exchange and interaction. In the second, they blend into each other, in a way which could be supporting or limiting but nevertheless affords interaction and exchange. Both these notions found resonance in the contextual and theoretical development of my research and will be returned to in more detail in the following chapters.

The abundance of snails as the tide retreats is an example of an ecological phenomenon (the disappearance of snails over time) which can only be fully understood in its sociocultural context (observed through ethnographic methods). This is an example of the importance and need for research methods capable of studying the complexities of eco-socio-technical interactions as well as the appropriate design tools for addressing such interrelations.

Algae control

One of the aims of the designs was to control algae levels and slipperiness on the outfall pipe. In the case of the Urchin design, this was planned for by the provision of an ecological niche suitable for barnacles. Unfortunately, assessing the potential and validity of this approach would have required a much longer test period, as it would involve the establishment of adult barnacles which would be able to withstand some degree of being walked on. On the Wave tile, algae control was planned by the promotion of limpets which would graze on the algae. In this case also, the test period was too short to arrive at definitive conclusions about the intended function of the tile, although some initial evidence suggests a potential for algae reduction in the presence of limpets on the tiles. Limpets arrived on the Wave tile sometime in the last four weeks of the trial. On the final day of the trial, three small limpets were found in the grooves of the Wave tile. All three were surrounded by *grazing halos*, i.e. an area with visibly less algae surrounding the limpet, compared to the rest of the groove and the adjacent grooves (see Fig 3.27 above). These grazing halos around the three limpets would suggest a potential for more significant algal reductions in the presence of larger and more numerous limpets. However, there are a few important things to note in considering this potential: 1. While the design encourages the presence of limpets that can reduce algae, it also encourages the additional colonisation of algae (in fact this is one of the reason it attracts limpets in the first place). 2. The grazing halos of the small limpets did not extend to the centre of the tile, suggesting they did not graze there. This could be due to the size of the limpets, which were still small, as well as the fact that the centre had virtually no algae coverage at the end of the trial (see Fig 3.29 below). Since the limpets where there for only a very short time, it is hard to say what would have happened in the course of a longer period.

Fig 3.29 The Wave tiles by the end of the trial. While the grooves were heavily colonised, the walkable center remained free of biocolonisation (2014)

One lesson I learnt from the attempt to reduce the algae levels on the tiles relates to the designing of dynamic systems. Algae colonisation on the Wave tile, much like the biocolonisation in general, was concentrated in the grooves, and therefore did not, during the test period, pose a limit to the human use of the structure as a walkway. However, it is possible to imagine how, without control, the algae might have spread further to the walkable areas. On the other hand, evidence of possible algal control came with arrival of the first limpet. Since the tile is part of a dynamic ecosystem, algae reduction should be thought of in terms of ecological balance rather than complete reduction. A complete reduction would compromise the ecological function of the tile as it would affect the food source of the limpets and other grazing snails. In contrast, over-colonisation of algae might compromise the use of the structure as a walkway if the algae took over areas intended for walking. Maintaining the right balance might, in some cases, require some intervention, such as the intentional introduction of limpets to the tile. This could be the case in places where biological control of algae is preferred (instead of bleaching for example) and the surface needs to be carefully maintained for human use (such as a slipway for example). The example of the slipway is mentioned here since the Wave tile has raised some interest from people looking for an eco-friendlier way of reducing algae on slipways and might be more thoroughly examined for this purpose in the future (see "other considerations" below).

Perceived safety of the designs

In addition to biological algae control, which did not produce a clear conclusion, the safety for humans on both designs was addressed by geometrical features, such as the roughness of the surface. The overall perceived safety of the designs was measured by asking people who walked on all three treatment forms to state which of the three felt the safest to walk on. The surface which scored highest on safety was the Urchin tile, with 52% of participants stating that this design felt the safest to walk on, followed by 40% for the Wave design and 8% for the flat concrete.

How pleasant is the surface to walk on?

Similar results were obtained to the question of which treatment form feels the most pleasant to walk on, with 52% of participants stating that Urchin was the most pleasant to walk on followed by 32% for Wave and 16% for the flat concrete.

Overall preferred design

Despite the advantage to the Urchin tile in perceived safety and pleasantness of walking upon, the overall preferred design was the Wave tile. About 64% of participants chose Wave as the overall preferred design followed by circa 32% for Urchin, while only about 5% preferred the flat concrete. These figures, as well as the comments made by participants, suggest that the perceived habitat value, as well as the aesthetics of the Wave design, had a strong effect in making this the overall preferred design in spite of Urchin feeling safer and more pleasant to walk on. Participant's comments also suggest that the Wave design was generally perceived as more natural looking and therefore integrated better into the local landscape.

Other considerations

The sample tiles on Hannafore beach appeared to raise curiosity and interest and on my site visits I would often be asked about their purpose and the scope of my research. The idea of integrating habitat for marine life onto the outfall pipe seemed to resonate with values that both locals and tourists identified with. Children were particularly attracted to them and often stopped to play with the snails in the Wave grooves or try to lift the cover off the Urchin tile. On a few occasions, the design facilitated some interaction between people and marine animals, especially children, but also in the previously mentioned act of shifting snails from the centre of the Wave tile to the grooves.

The design also raised some interest in the scientific community and I was contacted by a few researchers interested in learning more about the project and the results I was getting. Particularly, the use of limpets to control algae seemed to be a topic people were interested in, a topic upon which, unfortunately, I could not give much information because of the relatively short duration of my trial. For this reason, it was decided when we removed the tiles from the site at Hannafore, they would be relocated to a site in Plymouth where they could stay longer and be monitored by marine biologists from Plymouth University to view their function during a longer term.

3.4.10. Conclusions

The designs for the Urchin and Wave tiles tested on the outfall pipe are the first iterations of design concepts which could be further developed based on the insights gained during the trial. There are a few changes that are required in any redesign of the tiles, the first of which would be solving the issue of the Urchin pool filling up with sediment. In addition, it would be beneficial to design the surface texture of the walkable area on both tiles in such a way that would offer grip but still drain water. This could be done via small grooves leading down and away from the centre, into the larger habitat grooves in the Wave tile or into the concealed pool in the case of the Urchin. Having the walkable areas drain water would further reduce the chance of algae building up on areas intended for human walkers (although this did not occur during the test period).

While there were interesting localised insights emerging from the assessment of the two designs on site at Hannafore, the main motivation for embarking on this design exploration was to reflect more generally on the process of design involving nonhuman species. In this regard, the process has helped to highlight different aspects of such a design activity, including the need to address the species-gap in designing for wild animals, along with experimentation with methods for so doing in the research, design and analysis phases. It highlighted the need to develop “soft” approaches to separating the space between human and ecological uses, as well as the need to address these different uses in an integrated way and investigate the potential of finding synergies between them. These broader insights from the design process will be returned to and further developed in the chapter about Multispecies Design.

4. WILD ANIMALS AND ANTHROPOGENIC SYSTEMS

This chapter seeks to put the case study projects into a wider eco-socio-cultural context. It is a rather long answer to the question ***why would we want to promote biodiversity on structures like the outfall pipe in the first place?*** *In doing so, it also provides a theoretical background for the emergence of Multispecies Design as a practice. The case study project is examined as part of the wider challenges it addresses, i.e. biodiversity erosion and the alienation of humankind from nature, and a view of these interconnected challenges is proposed. The chapter tracks shifts within both the humanities and the natural sciences that call for a better inclusion of wild animals within human-dominated habitats, and offers ways of thinking about and facilitating this transition in a design context.*

4.1. Biodiversity erosion and alienation of humankind from nature

Most of the people I spoke to about the project at Hannafore, as well as the people who filled in a feedback form, stated that they believed it is important to integrate habitat for marine life onto structures like the outfall pipe. Amongst the reasons people stated that they believed this was important, the most common one was a concern for the wellbeing and safety of marine species, together with a concern for the health of the wider ecosystem. Many also raised the notion of mitigating and compensating for damage to the ecosystem created by humans. One participant wrote, for example: “Habitat creation can only be good! Especially as habitat is in decline.” Another wrote: “I think all human-made structures should aim at being as harmless as they can for the ecological system, that means to not disturb its balance and/or affect it as much as possible”.

Digging deeper into the feedback reveals another possible reason that people liked the idea of marine life colonising the outfall pipe: Participants explaining why they preferred the Wave design over the Urchin one often stated that they favoured it because here, the colonising species were more *visible* and somehow more accessible. The notion of feeling closer to an element of nature on an artificial structure (even if this structure is itself immersed in nature) seemed to hold significance to people. As we shall see, bringing nature closer to people’s lives may have multiple positive benefits in built environments, linked to a deeply engrained impulse to interact with other species, which Wilson (1984) termed “Biophilia”.

These two concerns, for the erosion of biodiversity and natural habitat and for the disappearance of nature from people’s lives are becoming more widespread in society. They have been aptly captured in the opening lines from Emma Marris’ *Rambunctious Garden* (2011, p. 1):

> We have lost a lot of nature in the past three hundred years—in both senses of the word lost. We have lost nature in the sense that much of nature has been destroyed… But we have also lost nature in another sense. We have misplaced it. We have hidden nature from ourselves

This section explores biodiversity erosion and humankind’s alienation from nature from different points of view. It looks at them from an ecological point of view, seeking to understand the extent and consequences of loss of biodiversity on the world’s ecosystems. It looks at their effects on the physical and mental well-being of humans. In addition, it briefly explores them from a moral and philosophical point of view. This is to try to understand the motivations behind the growing call for the inclusion of more biodiversity within human-dominated environments.

4.1.1. The boundaries of our planet

In 2009, a group of 28 scientists working with the Stockholm Resilience Centre introduced the concept of *planetary boundaries* (Fig 4.1 below) (Rockström et al., 2009). These are a set of thresholds for nine key environmental processes, within which the scientists expect humanity can continue to develop and operate safely. Transgressing one or more of these boundaries would trigger non-linear environmental change within the system, compromising its ability to support human life on the planet (ibid). For three of these systems, the scientists suggest that the threshold has been crossed (for two others the thresholds have not been defined yet).

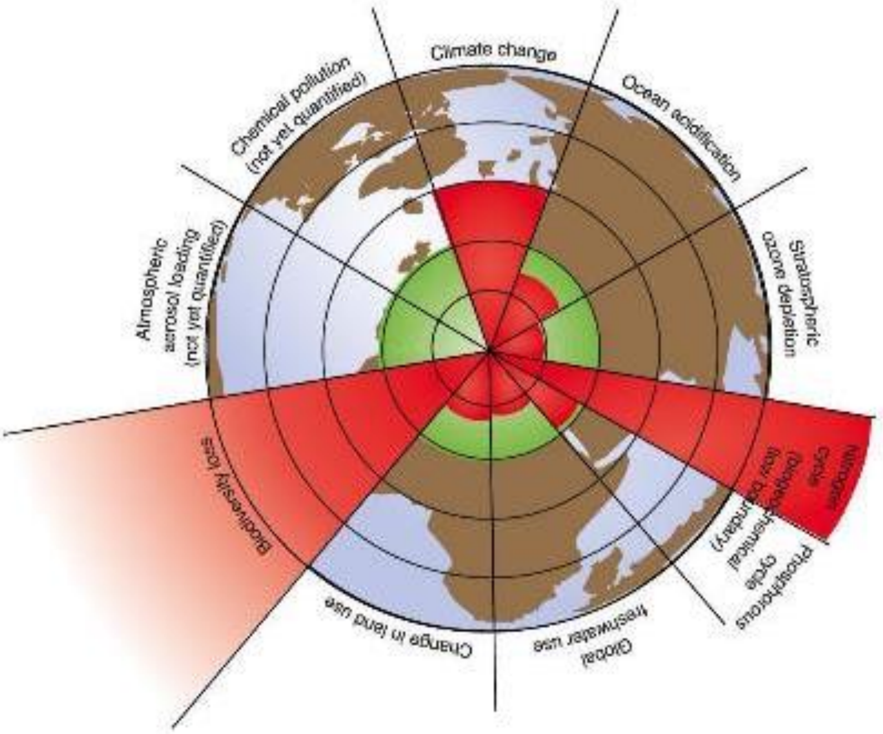


Fig 4.1 Planetary boundaries as defined by the Stockholm Resilience Centre (2009)

These are climate change, nitrogen cycle and biodiversity loss. Out of the three, the loss in global biodiversity is the boundary most extensively exceeded. Biodiversity is defined as the totality of genes, species, and ecosystems of a given region. This definition includes diversity at all levels, from genetic diversity within species to the diversity of ecosystems in a landscape (Chapin et al., 2000) though the term is also often used to refer to species diversity alone.

Humans have extensively transformed the global environment, leading to the sixth major extinction event in the history of life on earth (ibid). Transforming land for agriculture and development; changing the global biogeochemical cycle; land, water and air pollution; and enhancing the mobility of other species around the planet, have all contributed to loss in global biodiversity. Currently about 25% of species in well-studied taxonomic groups are under threat of extinction (Rockström et al., 2009) with the prediction rising to as high as 95% loss in species diversity once the system reaches dynamic equilibrium, if current trends in land use remain constant (Rosenzweig, 2003, p. 140). The current rate of extinction is higher than 100 E/MSY (extinctions per million species per year), more than 100 times greater than the background extinction rate, which is the rate of extinction that occurs in nature as new species come to life and others disappear in the process of evolution (Rockström et al., 2009).

The scientists at the Stockholm Resilience Centre have included biodiversity as a system vital for sustaining human life on the planet, because of its important role in providing ecosystem services and maintaining the resilience and capability of the planet to withstand pressure and regulate itself (ibid). Ecosystem services are defined as the "processes and conditions of natural ecosystems that support human activity and sustain human life" (Chapin et al. 2000). Ecosystem services include, for example, the regeneration of fertile soils, natural pest control, climate regulation, absorption of pollutants, fresh water flows etc. (ibid). Biodiversity is therefore vital also to the resilience of other planetary boundaries such as global freshwater supply, climate change and chemical pollution, that are all affected by loss of biodiversity.

Conservation Biology

Recognition of the impending biodiversity crisis dates back to the early seventies, and attempts to minimize the crisis have been studied mainly within the field of conservation biology. Conservation biology is unique within the natural sciences in that it does not aim to portray itself as value-neutral but clearly aims to promote the values and ethics of conservation and nature protection (Tsovel, 2015). It is an applied extension of biological and ecological studies with clear aims of protecting species, habitats and ecosystems. In 1995 Gary K. Meffe and Stephen Viederman called upon conservation scientists to shift towards policy-oriented science. These were the early days in the field of conservation biology and the two scientists feared that good science alone would not have the desired effect on the impending biodiversity crisis. The two wrote: “All the theories, all the ecological and genetic models, and all the data amassed will have little effect if we do not influence policy and human behaviour towards the protection of biological diversity” (Meffe and Viederman, 1995).

Conservation scientists have had some success in orienting their field towards influencing policy but less success in having a wider influence on human behaviour. As Miller notes twenty years after Meffe and Viederman’s paper: “conservationists have failed to convey the importance, wonder and relevance of biodiversity to the general public, preaching to the choir rather than reaching the unconverted” (Miller, 2005). To some extent, conservation efforts have remained separated from the public intentionally. Since the early days of the field, the prevailing approach to conservation biology has been that in order to protect nature we have to *keep people out*. This approach has led to the dominant strategy for protecting biodiversity, being what Rosenzweig (Rosenzweig, 2003, pp. 143–144) terms *Reservation Ecology,* i.e. the confinement of nature within closed areas protected from human activity. More recently, there is also growing attention to restoring degraded habitats to some resemblance of their original state (Holt 2004). Together, these strategies of reservation and restoration ultimately led to sets of parks and nature reserves scattered in landscapes dominated by human activity (ibid).

Fighting for crumbs

Criticism of these strategies, as insufficient in dealing with the extent of the problem of biodiversity erosion, have come from different perspectives. One criticism, coming from within the field of conservation biology, is linked to one of ecology’s most general empirical principles: the *species-area relationship*. The species-area relationship describes the correlation between the size of an area and the number of species it can sustain in the long term. The correlation between these two parameters allows scientists to predict the number of species that can survive in a given area once dynamic equilibrium is reached. In his 2003 book, Rosenzweig uses the species-area relationship to predict the percentage of global biodiversity that can be protected within existing nature reserves. His conclusions leave little room for optimism: “If the sum of the areas of all the world’s reserves amounts to only 5 percent of her original land area, the species pool itself will dwindle over a long period. And it will keep on dwindling until, at 5 percent of its pristine diversity, it is small enough to be self-sustaining” (Rosenzweig 2003: 146).

Rosenzweig’s research is unique in that it uses mathematical models to calculate future biodiversity once dynamic equilibrium is reached, rather than measuring current biodiversity loss through observed extinction trends (which are a fraction of actual extinctions). Other research uses different models for studying biodiversity loss, producing different but equally alarming figures. The international Convention on Biological Diversity (CBD) uses the decline in populations of wild species as a proxy for extinction risks. In their 2010 *Global Biodiversity Outlook 3* they state for example that the population of wild vertebrate species declined by 31% globally between 1970 and 2006 and that species in all the groups studied are on average being driven closer to extinction (Secretariat of the Convention on Biological Diversity and Hirsch, 2010).

Other studies predicting biodiversity loss exist, such as Pimm and Raven (2000) who talk about 40% biodiversity loss in tropical forest areas designated as biodiversity hotspots. However, many scientists acknowledge the limitations of their predictions, which often do not take into account other factors influencing biodiversity such as the impact of global warming and the introduction of alien species (ibid). Global warming, for example, exposes additional limitations on reservation strategies, as reserves confined to manmade borders have a limited capacity for changing along with their surrounding climate. Scientists have found that during periods of climate change, ecosystems shift their location in response (Rosenzweig, 2003, p. 145). Natural reserves confined by manmade borders do not have this privilege. In effect, reserves would have to be moved on average 110 meters a year just to stay within their original climate (Starzomski cited in Green, 2013).

Predicting biodiversity loss is not easy, and the figures presented by Rosenzweig should be viewed less as foreseeing future extinctions, and more as a way of shedding light on where our current conservation efforts lie and what this can achieve in terms of actual species conservation. In his words: “We must abandon any expectation that reserves by themselves, whether pristine or restored, will do much more than collect crumbs. They are the 5 percent. We need to work on the 95 percent." (Rosenzweig 2003: 152).

Finally, reservation and restoration strategies are also problematic in the type of relationships they form between humans and other species. As Francis (2011) notes: "while reservation and restoration may be useful conservation strategies, they have the disadvantage of increasing the contrast between *green space* and the *built environment*." In other words, reservation ecology, while remaining an important tool for dealing with the erosion of biodiversity, may have indirectly contributed to the process of mankind's alienation from nature.

4.1.2. Lost Nature

The disappearance of nature from the everyday lives of people has diverse effects on human society as well as human psychology and wellbeing. This is driven by rapid urbanisation and the fact that for most people there is objectively less *nature* in their surroundings to interact with. However, it is also due to changes in lifestyles. People, and notably children, spend less time outdoors than they did in the past (Dickinson, 2013; Louv, 2010). Amongst the drivers behind these changes, Louv (2010) names: parental protectionism, media-induced anxiety and phobias, as well as well-intentioned (but usually unnecessary) environmental regulations.

As we have seen, part of the reason for the separation of nature from people is a wish to protect natural ecosystems from human activity. However, this may also have had a negative effect on nature conservation. Separation from nature affects people's motivation to protect it by leading to what has been termed *the extinction of experience* (Pyle, 2002). The extinction of experience refers to a decline in everyday interactions in people's lives with the natural world. Pyle, who coined the term, stresses the negative effect loss of a familiar species can have on our experience of nature: "To those whose access suffers by it, local extinction has much the same result as global eradication" (Pyle, 2002, p. 261). Pyle believes that the motivation to protect nature comes, first of all, from an intimate connection with natural ecosystems and other species, not just from cognitive understanding of scientific facts on the matter. Other studies confirm that emotional affinity toward nature, created through past and present experiences in natural environments, increases nature protective behaviour (Kals et al., 1999). In other words, humankind's alienation from nature has an influence on the erosion of biodiversity through people's intrinsic motivation to protect nature, and affects decision-making when it comes to policy and action.

Experiences in nature are particularly important during childhood as they become the baseline against which environmental degradation is measured later in life (Miller 2005). Pyle's theory is part of a wider discourse about child-nature relationships which have become popular in recent years, especially following the publication of Richard Louv's popular book *Last Child in the Woods* in 2005. In the book, Louv introduces the term *Nature Deficit Disorder* (NDD) as a way of describing the negative effects that reduced experience of nature has on the emotional, spiritual and social development of children. These effects, Louv believes, include behavioural and learning problems, stress, obesity and dulled senses. Louv quotes scientific studies demonstrating how our mental, physical and spiritual health depend upon a contact with nature. Alienation from nature leads to the estrangement and fear of wild species, propelled by education systems, social norms and the media, making wider the rift between humans and natural systems.

At the same time, there is a growing body of evidence showing how even small increases in exposure to nature have positive benefits on human physical and mental wellbeing. In a Dutch study involving over ten thousand participants, researchers concluded that a 10% increase in green space in a living environment leads to a decrease in health symptoms comparable with a decrease in age by 5 years (De Vries et al., 2003). Another study has shown that exposure to views of nature provides restoration from stress and mental fatigue as well as improved feelings of local safety and decreased aggression and crime rates (Groenewegen et al., 2006). Green areas lead to more physical activity by local residents (Schantz cited in Beatley, 2010) which in turn benefits health and wellbeing. Other studies show the benefits on human health in coastal areas (Wheeler et al., 2012). Here again the researchers hypothesise that this is due to increased opportunities for stress reduction and increased physical activity.

Biophilia

While most studies focus on the health benefits associated with nature in general terms of access to green and blue areas (without addressing how different elements of these natural areas contribute to increased health)—some also focus more specifically on the benefits to human health and wellbeing from interaction with other animal species. Researchers have shown how interaction with animals can reduce stress and anxiety (Friedmann, 1995; Wilson, 1991) and that the presence of an animal has calming effects which can change the way people perceive a social situation and how they regard other humans present (O'Haire, 2010). Although most of these studies have focused on companion animals, they have been used to support Wilson's (1984) *Biophilia hypothesis* that humans have a biologically rooted need for connection with other species for our physical and mental wellbeing (Gullone, 2000; O'Haire, 2010; Wilson, 1991), and that this need extends to wild species as well (O'Haire, 2010; Wilson, 1984).

To support his hypothesis Wilson relies on the long history of our species as hunter-gatherers and farmers living in close connection with the natural environment, which must have shaped our cognitive and emotional apparatus (Wilson, 1984). His thesis is that during human evolution, our ancestors were rewarded (in evolutionary terms) for learning to react to various natural stimuli by approaching or avoiding them (Gullone, 2000; Kellert and Wilson, 1995). Different attempts have been made to support the *biophilia hypothesis* empirically, including studies that show that our natural phobias are more deeply engrained in our sociobiology than fear of (far more dangerous) modern threats like handguns for example (Gullone, 2000).

Even without definitive scientific evidence for the *biophilia hypothesis*, many writers and nature-lovers speak about the awe and wonder added to people's lives through contact with nature and wild animal species (Beatley, 2010; Louv, 2010; Monbiot, 2013; Wolch, 1996 to name a few). In the words of one of the most influential environmentalists of our times, Rachel Carson:

> Those who dwell, as scientists or laymen, among the beauties and mysteries of the earth are never alone or weary of life. Whatever the vexations or concerns of their personal lives, their thoughts can find paths that lead to inner contentment and to renewed excitement in living. Those who contemplate the beauty of the earth find reserves of strength that will endure as long as life lasts (Carson, 1998, p. 100).

The positive effects of experiencing nature, as well as the negative effects associated with detachment from the natural world, have been the scope of a growing number of studies in the last two decades. These studies are a major driving force behind calls to redesign human environments to support more biodiversity and more cross-species interactions and connections (see for example Beatley, 2010; Wolch, 1996).

4.1.3. The animal turn

In recent years, the separation between artificial and natural habitats, between culture and nature, and between human and animal, are being increasingly examined from sociocultural, moral and philosophical perspectives. If, in the past, the sciences have primarily been relied upon to “speak of and for nonhumans” (Hinchliffe et al., 2005), the turn towards animals in the humanities represents a shift in this, with new interest coming from multiple fields that, until recently, were concerned mainly with humans and their activities (Ritvo, 2007). The shift comes out of a recognition of the limits of relying on science as the sole source of knowledge concerning animals, particularly when it comes to morally relevant knowledge (Tsovel, 2006), as well as an appreciation of multiple ways in which animals affect and are affected by human society (Kirksey and Helmreich, 2010; Tester, 2014).

A major impetus behind this shift is the undoing of human/animal separations in contemporary philosophical thought, pioneered by thinkers such as Bruno Latour, Donna Haraway, Jacques Derrida, Timothy Morton and others. Since the time of Aristotle, and for most of the western philosophical tradition, animals have been regarded as mindless creatures, created solely for human use (Calarco, 2015, p. 8). René Descartes’ view of animals as automata, capable of reacting to external stimuli but essentially lacking the ability to be aware of these reactions (Calarco, 2015, p. 9), as well as Immanuel Kant’s resolution that animals lack autonomy and moral agency—rendered them ontologically distinct from humans in their view, removing their treatment from moral consideration (ibid). Even today, the view that humans are ontologically distinct from all other creatures, and that ethical considerations apply only to humans, is deeply ingrained into modern society and can be found in cultural, legislative and industrial systems as well as in design and planning practices of the built environment. However, the radical and systematic breakdown of these distinctions is also a defining characteristic of our times (Calarco, 2015, p. 6).

Perhaps the most notable challenge to human/animal separations starts with Darwin’s theory of evolution (Calarco, 2015; Morton, 2013), which places humans on a continuum with other animals, making definitive ontological distinctions meaningless. As Morton (2013) eloquently puts it: “A single life form is a set of things that are not that life form – I am made of lungs, for instance, which are evolved swim bladders of fish”. Darwin’s work suggests that differences between species (including humans) are better understood as differences of degree rather than of kind (Calarco, 2015, p. 12). Other ways of distinguishing humans from animals are also failing, as one after the other, traits believed to be possessed solely by humans such as tool use, self-awareness, complex social structures and communication, as well as grieving and altruism, are being observed in animals (Griffin, 2013).

Also challenging the notion of human-exceptionalism are studies showing how similar we actually are to other animals, not just genetically but also in our neural mechanisms and brain functionality (ibid), as well as studies stressing our co-dependency on other life forms living in and around our bodies. Studies have demonstrated, for example, how our micro-biomes affect our physical health as well as our mental health, moods and behaviour (Foster and McVey Neufeld, 2013). These scientific discoveries fuel a philosophical re-examination of what it means to be human, as well as our relationship with other species (Kirksey and Helmreich, 2010).

One of the political consequences of the animal turn, reflected in the field of critical animal studies, is a re-examination of ethical questions in relation to animals (Calarco, 2015, p. 2). Often building on from Darwin's work, theorists in this field bring attention to similarities between animals and humans that they deem ethically relevant, such as the ability to feel pleasure and pain (see for example Singer, 2001, pp. 7–17). Work in this field has fuelled a widespread movement of animal rights and animal liberation activism which has had considerable successes in influencing policy and regulation internationally (for example the European Commission's ban on animal testing for cosmetics (European Commission, 2015), as well as promoting a more common view of animals as sentient beings.

The animal turn also sees the emergence of new ways of studying and articulating the meeting points between animals and human. One example is the emerging field of Multispecies Ethnography, which "centres on how a multitude of organisms' livelihoods shape and are shaped by political, economic, and cultural forces" (Kirksey and Helmreich 2010). Multispecies ethnography represents a shift in the way animals are considered in social and anthropological studies. Rather than focusing on symbolic and reflective concerns regarding animals, there is a focus on everyday material entanglements and interactions between humans and animals (Haraway, 2007), i.e. on "living with" animals (Kirksey and Helmreich, 2010). Studying the notion of "living with" animals takes on many forms. It can focus, for example, on the relationships between companion species

(Haraway, 2007) such as the relationship between zoo keepers and zoo animals (Chrulew, 2011), and lab scientists and lab animals, or focus on affection and love towards animals as well as “unloved others” (Rose and Van Dooren, 2011) or on the relationship between human affection and the chances of survival of a species in the Anthropocene (Mooallem, 2014; Rose and Van Dooren, 2011).

To sum up, the animal turn represents the breaking down of the lines separating nature from culture and a study of the contact zones created along these broken lines (Kirksey and Helmreich, 2010). As Haraway puts it: “If we appreciate the foolishness of human exceptionalism, then we know that becoming is always becoming with—in a contact zone where the outcome, where who is in the world, is at stake” (Haraway, 2007, p. 244).

4.1.4. Summary

There is a growing recognition of the need to view the problems of biodiversity erosion and mankind’s alienation from nature as interlinked problems that should be dealt with together (Miller 2005, Holt 2004). This comes as researchers from different fields realize the mutual influences of these two phenomena and the insufficiency of existing approaches of conservation science in dealing with the complexity of the problem. This leads to a call for the broader inclusion of animals in human habitats and human lives as well as examining ethical considerations regarding animals in society. New ways of understanding how animals shape and are shaped by human culture and society are emerging, transforming not just the way animals are studied in various disciplines but also how they are considered and treated in society as a whole. All these shifts could have a profound impact also on the way animals are considered in the design and planning of the built environment, as we shall see in the following pages of this thesis.

4.2. NEW PARADIGMS – REDISCOVERED NATURE

4.2.1. CONSERVATION EVERYWHERE

From its early days, the philosophical and practical bedrock of the nature conservation movement was largely based on a certain notion of nature; nature understood as pristine wilderness, untouched and unaffected by humans. As discussed earlier, this notion has unintentionally contributed to humankind's growing alienation from nature. However, it has also done something else; it has set a very narrow focus for conservation attempts and inevitably rendered them fragile in a rapidly changing world triggered by human activity.

The idea of a pristine nature, untouched and unaffected by humans is crumbling, as such places become harder and harder to find on earth. Anthropogenic changes, such as rising CO2 levels, affect the most remote places on the globe, even when these are not physically frequented by people. The notion of preserving or somehow restoring wild patches of land to resemble an ancient natural baseline is creating much disillusion among conservationists, as evidence is being compiled demonstrating the shortcoming of some of the basic assumptions behind these strategies. In fact, there are today entire nature reserves that no longer experience their original climatic conditions (Starzomski cited in Green, 2013). Does this mean they are no longer natural?

All around the world, natural systems are changing. They are changing because the natural world always has changed and they are changing more rapidly because of human impact on the planet (Hannah, 2015). Witnessing and mourning these changes has fuelled much of the apocalyptic rhetoric of environmental thought of the second half of the 20th century, from Rachel Carson's, Silent Spring (1962) to Bill McKibben's, The End of Nature (1989). However, a new, optimistic and pragmatic environmentalism seems to be appearing, emerging from the cracks of a shattered and disillusioned conservation movement which has been for many years, in Rosenzweig's words, "fighting for crumbs" (2003, p. 143). In its heart is a rediscovered sensitivity for seeing nature in unexpected places:

> Yes, nature is carefully managed national parks and vast boreal forest and uninhabited arctic. But nature is also the birds in your backyard; the bees whizzing down Fifth Avenue in Manhattan; the pines in rows in forest plantations; the

> blackberries and butterfly bushes that grow alongside the urban river; the Chinese tree-of-heaven or "ghetto palm" growing behind the corner store; the quail strutting through the farmer's field; the old field overgrown with weeds and shrubs and snakes and burrowing mammals; the jungle thick with plants labeled "invasive" pests; the carefully designed landscape garden; the green roof; the highway median; the five-hundred-year-old orchard folded into the heart of the Amazon; the avocado tree that sprouts in your compost pile. Nature is almost everywhere. But everywhere it is, there is one thing that nature is not: pristine. (Marris 2011:2)

With this shift in the understanding of what nature is, come new strategies of protecting it. Considered together, these strategies represent a shift in focus regarding nature conservation, from a narrow focus looking just at pristine wilderness to a focus on *conservation everywhere*. New strategies are being developed to improve the ecological value of different habitats previously ignored by conservation studies: from novel ecosystems and agricultural fields, through private land and abandoned and ex-industrial land, all the way to the most intensively built environments in terrestrial and marine landscapes. All these areas can be improved in ecological terms, and all of them have a conservation value (Rosenzweig 2003, Marris 2010 and Conniff 2014). The case study project at Hannafore beach is a small example of how the most mundane of structures, like the outfall pipe, can be redesigned to have a better conservation value.

Like many restoration projects, these new strategies are still based on a '*we broke it and therefore we must fix it'* approach, but unlike previous attempts they do not try to revert these areas to some historical, pre-human baseline but rather try to look at alternative possible futures. They are less concerned with the pureness of the emerging natural systems and more with their function and resilience. In this sense they can be regarded as design projects that seek to create something new rather than recreate a past ecosystem. These new strategies challenge not only the notion of what is and is not natural but also other basic cornerstones of traditional conservation such as the approach towards invasive species or the degree of human interference acceptable in a natural system. In a way, these strategies view the Anthropocene (Zalasiewicz et al., 2015) not as a failure of environmentalism but as a "stage on which a new, more positive and forward-looking environmentalism can be built" (Marris et al., 2011). They focus on the responsibilities that come with understanding the true impact of human activity on other species and denote a sense of stewardship of nature and a duty to protect, restore and redesign her back into people's lives.

Rewilding

Conservationists are traditionally cautious about the amount of human intervention acceptable in maintaining or restoring a natural system. Especially when it comes to introducing new species to an area where they are currently absent. Evidence to how this is changing in recent years can be found in the popularity that *Rewilding* is gaining (see for example Monbiot, 2013; Scheper and Widstrand, 2014).

Rewilding is a strategy for restoring large areas of wilderness through the introduction of missing keystone species, usually from the top of the food chain (Soulé and Noss, 1998). It builds on the understanding that ecosystems are often shaped from the top down by predators which influence the behaviour of other species in the ecosystem, a process called tropic cascades (Monbiot, 2013, p. 9).

Rewilding projects tend to be less concerned with recreating a historical ecosystem and more with setting natural processes in motion and letting the ecosystem shape itself (Monbiot, 2013, p. 8). It is born out of a criticism of traditional conservation projects which tends to "freeze living systems in time" (ibid) and is made possible by trends of urbanisation and land abandonment which free up large areas of land (see Rewilding Europe, 2010). Advocates of rewilding do not stop at introducing missing species to areas where they are currently missing; in cases where missing local species have since gone extinct, proxy species are being considered which could perform a similar ecological role as the missing species (Monbiot, 2013, pp. 124–135).

Criticism of Rewilding comes from different angles; from worries about interfering with natural processes, as well as the fear of reintroducing potentially dangerous species in proximity to human settlement (Monbiot, 2013, p. 113).

Assisted Migration

Another conservation strategy that involves moving species around is *Assisted Migration* (AM). Climate change creates enhanced migration among species which follow the climates they have adapted to live in (Hannah, 2015:57-81). In 2003, Parmesan and Yohe studied data from 1700 species and found that habitat ranges shifted on average 6.1 km per decade towards the poles. As species move around, they often come up against barriers they cannot cross. These may be manmade, such as cities and roads, or natural barriers such as a seas or rivers. If the species in question cannot cross the barrier themselves or adapt to the new conditions, their fate may be dire. Mountain species encounter similar problems. As they gradually move up hill, their habitat gets smaller, and eventually they reach the top of the mountain and can no longer migrate.

Assisted migration has been conceived as a strategy for helping species in such situations overcome the barrier by relocating them to areas where the climate suits their needs. There is a vivid debate in the scientific community regarding AM, and little consensus on whether to adopt it as a policy (Hewitt et al., 2011). As Marris (2011, pp. 77–78) and Hewitt et al. (2011) both point out, at its core, the debate is value-based. Promoters of the strategy are more concerned about species extinction, while the opposition is more concerned about the integrity of the ecosystems and worry about creating invasive species in the new locations. Nevertheless, it seems the change is already on its way; experiments with AM are already being performed in different places around the globe (Marris, 2011, pp. 78–85) and guidelines are being developed for policy (McLachlan et al., 2007).

Invasive species

The shift in focus to new approaches to conservation sees also a shift in attention towards invasive species as Del Tredici (2014) comments:

> The concept of ecological restoration, as developed over the past 20 years, rests on the mistaken assumption that we can somehow bring back past ecosystems by removing invasive species and replanting native species. This overly simplistic view of the world ignores two basic tenets of modern ecology—that environmental stability is an illusion, and that an unpredictable future belongs to the best adapted.

Evidence from around the world is showing that ecosystems containing a mixture of exotic and native plants can be as rich in biodiversity as pristine ones (Marris, 2011, pp. 111–117). However, it is important to note that this is not always the case and often the same exotics tend to show up in different parts of the world, impacting overall diversity. Nevertheless, overcoming the *pureness* bias in studying novel ecosystems allows researchers to focus on their function, both in terms of biodiversity conservation and ecosystem services, rather than on their resemblance to a historical ecosystem.

Reconciliation Ecology

Perhaps the most notable attribute of this new approach to nature conservation is the turn to human-dominated environments as potential areas for biodiversity conservation. Michael Rosenzweig refers to this practice as *Reconciliation Ecology* (RE). He defines it as "the science of inventing, establishing and maintaining new habitats to conserve species diversity in places where people live, work or play" (Rosenzweig 2003: 2). Rosenzweig introduces the term in his 2003 book Win-win Ecology as a way of dealing primarily with the problem of the species-area relationship, explained above, which he also outlines in the book.

While Rosenzweig's original focus was on the conservation of species at risk, Francis (2011) expands the definition to include ecosystem engineering, stressing the importance of healthy ecological systems to sustaining human life. He gives his own definition for RE as "the modification of anthropogenic systems to support biodiversity without compromising direct use" (Francis, 2011) and describes it as a pragmatic approach which considers ecosystems within human habitats as further constructed components within a manufactured environment.

Francis views novel ecosystems, co-existing in and amongst human ones, as capable of "increasing both sustainability (as ecological quality will increase without compromising other forms of sustainability) and resilience (as a shifting habitat mosaic will be formed, allowing species to move in response to environmental change)" (ibid). Francis also stresses that the focus in RE should be less on recreating lost ecosystems and more on creating "new ecologies" that fit within constructed habitats.

For Rosenzweig, the starting point for RE is in understanding the conditions various species need to subsist within human habitats, then finding ways to provide these conditions. In this sense, the project at Hannafore beach is an example of Reconciliation Ecology as it builds on scientific studies looking at the conditions required by marine species to subsist on manmade coastal structures, and looks to put these studies into practice. Reconciliation Ecology calls for collaboration between scientists, urban planners, architects, designers and policy-makers, as well as the public, to create a diversity of human habitats that support a greater diversity of life (Rosenzweig, 2003, a. 20).

Greening Grey

While most of Reconciliation Ecology focuses on the green and blue areas of human habitats such as fields, parks, green corridors and various water bodies, some recent research also looks at the potential habitat value of grey infrastructure, i.e. constructed features such as hard engineering structures, buildings and roads. This approach has been dubbed *Greening Grey* by Naylor et al. (2014) in a paper describing the nature and role of Green Grey Infrastructure (GGI).

Grey infrastructure covers significant areas of human environments and although there are attempts to revert some of these back to green areas (see for example Depave.org, 2015), this is not always possible or desirable. The authors suggest that rather than regarding the grey areas of cities and towns as valueless (in ecological terms), it is possible to enhance their ecological value in various ways, creating habitat and flows of ecosystem services in urban landscapes (Naylor et al., 2014).

GGI's help to breach the binary separation in built environments between blue-green and grey areas and address habitat defragmentation by allowing flows over grey areas to connect separated blue-green areas (ibid). The most notable examples of GGI are green roofs and living walls on buildings, but, as the authors of the paper argue, there is a potential for improving the ecological function also of other grey.

Grey infrastructure is often regarded as less valuable in ecological terms than green and blue areas. This is due to its hard, often impervious qualities and synthetic nature. To unlock its potential ecological value, it is useful to think about grey infrastructure in terms of parallel natural habitats such as rocks and cliffs and to seek the plants and animals which have evolved to live in these areas. Del Tredici (2014) refers to this process as "preadaptation" i.e. species whose evolution to exploit a certain niche in the wild gives them an advantage within built environments. Once again, insisting on native species may be counterproductive; built environments are different from the surrounding or historic ecosystems in many ways; they are typically a few degrees warmer, have different soil compositions, are subject to more frequent disturbances and have large areas of impervious surfaces (Del Tredici, 2014). If we want to enhance their ecological value, they must be studied for what they are, not what they used to be.

GGI's are intrinsically multifunctional; they are constructed components within the built environment, designed primarily for human use but also taking into consideration the needs of other species that may interact with them during their life cycle. This ecological function can be either retrofitted or included in the original design. GGI's are a new and underdeveloped branch of Reconciliation Ecology (Naylor et al., 2014) that offers a high potential for the involvement of designers and architects. For this reason, they are the focus of this thesis, and the case study explored at Hannafore has, in fact, been an exploration of greening a grey structure which otherwise had little habitat value for nonhuman species.

Summary

Taken together, these new approaches represent a new and optimistic approach to environmentalism and nature conservation, looking to the future rather than to the past. They are based on the notion that Biodiversity can be sustained also in proximity and overlap with human activity. They represent a dynamic view of nature which is affected (not pristine), cosmopolitan and ubiquitous. They re-imagine the human role in the ecosystem, a role of stewardship and responsibility, accepting different degrees of management and interference, managing to set a course rather than maintain a frozen state, recognising that we live in an intensively managed world and being proactive about how we want to manage it. They seek to enrich people's lives by enhancing the presence of nature around them. They allow for new encounters with nature within human habitats; encounters in which there is an element of rewilding also of the human soul and a rekindling of a connection to the natural world.

At the same time, these new approaches are also enticing a vivid debate within ecology and conservation groups. There is much controversy surrounding the shift in focus towards novel ecosystems and away from pristine and historical ones. Some warn that by raising the issue of novel ecosystems we are paving the way for a more permissive attitude to biodiversity conservation (Hobbs et al., 2013). Even promoters of this approach beg cautiousness when regarding novel ecosystems and warn about regarding them as the future of restoration ecology (for example Higgs cited in Green, 2013). Nevertheless, the feeling is, that with all the strategies presented above, the horse has long left the barn; novel ecosystems can no longer be ignored and a more widespread debate about them is needed (ibid).

Likewise, the main criticism of Reconciliation Ecology is that it could become the pretext for "resignation ecology" (Holt 2004), i.e. that it could be used as an excuse for further spreading the anthroposphere into areas that could in fact be reserved or restored to their natural state. This is a serious concern and one that applies also to some of the other strategies presented. Adopting the framework of Reconciliation Ecology does not mean abandoning reservation and restoration, it simply suggests paying attention also to what Rosenzweig refers to as the remaining 95%. It does, also, mean that a much wider public debate is needed on the matter, and that a wider range of disciplines must be involved in these efforts, as both Miller (2005) and Rosenzweig (2003, p. 9,22) note.

4.2.2. Conclusion - A multidisciplinary effort

While the field of ecology provides knowledge regarding the conditions needed to support greater biodiversity within built environments, a wider multidisciplinary effort is needed to implement this shift. As we shall see, this requires practical design and building knowledge in addition to human, social and behavioural knowledge—as an increased presence of nature, especially that of wild animals, within human environments, calls for modifications not just of the physical qualities of these habitats but also of their socio-behavioural ones.

Ecologists and biologists think about Reconciliation Ecology in terms of physical infrastructure. In Francis' (2011) definition of RE, *anthropogenic systems* refers to the physical conditions within human habitats. The practice both he and Rosenzweig (2003) describe does not say much about the sociocultural aspects of reintroducing biodiversity to human habitats. However, this kind of physical shift should be accompanied by a supporting sociocultural one. We could expand the term *anthropogenic systems* in Francis' definition to more than just physical systems, i.e. to systems of culture and belief, norms and behaviours. At which point, the framework of RE could be expanded to also address human alienation from nature and its associated problems and more broadly the nature/culture divide discussed earlier.

This is the meeting point of RE with the Animal Turn of the humanities and a key point for successful implementation of such endeavours. RE can be used as a way of promoting more meaningful interactions between people and the natural world, by expanding the presence of nature within human habitats, as Miller (2005) notes. Miller sees it as a way of addressing the extinction of experience (discussed earlier) caused by the disappearance of nature from people's lives, therefore also addressing people's motivation to protect nature.

In *Biophilic Cities,* Beatley (2010, p. 45) advocates the incorporation of biophilic values into urban design and planning. He describes a biophilic city as one that "puts nature first in its design, planning and management" and "recognizes the essential need for daily human contact with nature" (ibid). Like Miller, Beatley sees the city not just as a place with hidden ecological potential (as is the focus in RE and GGI), but as a place where more meaningful interactions with nature can take place on a daily basis.

The notion of the Biophilic City brings together the biodiversity conservation potential of human habitats with the health and wellbeing benefits associated with increased contact with nature in people's daily lives. It highlights the need to view these two objectives as interconnected and address them in the design and planning of human habitats. Although Beatley's book focuses more on flora, and talks in more general terms of access to green and blue features in a city, the author also makes reference to wild animals and their presence in cities. This is seen both in the recognition that greener cities would provide habitat and attract more wild animals into them, and in the importance he gives to animals in infusing people's lives with wonder, awe and fascination and a deeper connection to the places they co-habit (Beatley, 2010, pp. 14–15). This last point echoes Wolch's (1996) notion of the Zoöpolis where she talks about re-enchanting the city with the presence of wild animals: "To allow for the emergence of an ethic, practice, and politics of caring for animals and nature, we need to renaturalize cities and invite the animals back in, and in the process re-enchant the city. I call this renaturalized, re-enchanted city Zoöpolis".

And yet, as we shall see in the next section, the meeting point between wild animals and human environments is not a utopian place. Encounters are messy, borders are crossed and interactions may lead to conflict. Reconciliation demands flexibility, and behaviour on both sides is bound to change in the process. These encounters and interactions demand careful consideration and sensitivity. They must be *designed* to meet the needs of both humans and animals and not be left to chance.

4.3. WHEN ANIMAL MEETS CITY

There are, we have seen, different reasons why more attention and thought should be given to the meeting points of wild animals and human-dominated habitats, from philosophical and ethical reasons to ecological ones. However, there is also a more straightforward reason for doing so, to paraphrase mountaineer George Mallory—*because they're here*. The abundance of wild animals, especially mammal and bird species, within cities is on the rise (Luniak, 2004) and yet, not enough attention is given to the way they interact with these synthetic habitats from a design and planning perspective.

Wild animals find themselves in urban areas for different reasons. Most evident is the rapid expansion of cities around the world. The area of the planet characterized as urban is on track to triple from 2000 to 2030 (Conniff 2014) and as the majority of human settlements are in areas of high biodiversity (Luck, 2007), they are expanding at the expense of other species' habitat; other species which find themselves having to adapt to dramatically different environments from their natural ones.

It is not just the city which intrudes into the animal's habitat, but also the reverse. Propelled by climate change, habitat ranges all around the world are shifting (Hannah, 2015) and as animals follow their shifting habitat they often find themselves arriving in cities and other human-dominated environments. Moreover, conditions for wildlife in urban areas are improving and can sometimes be superior to surrounding areas due to their milder microclimate, more stable food resources, and lower abundance of predators (Jokimäki et al., 2011). City green areas, including private gardens and parks, often represent higher biodiversity than surrounding managed countryside (Biemans cited in Thackara, 2013a).

Conditions in urban areas for wildlife are also getting better due to changes in policy and emphasis on the use of local and diverse plants in city planning (Conniff, 2014). This is represented not just in the turn towards native plants in urban planning and private gardens (see for example Rosenzweig, 2003, pp. 20–25) but also in a careful selection of plants which support a higher biodiversity than others. Various research institutions publish lists and rankings of trees and shrubs according to how many species they support (see for example Tallamy, n.d. or The Royal Horticultural Society, n.d.) to help planners, designers and private garden owners make informed choices of the plants they use. Legislation in some areas is also changing to make sure that trees which support greater biodiversity are used within urban areas (Conniff 2014). In addition, there is growing attention to the role private gardens and planted boulevards play in connecting larger urban green areas through green corridors, and how this impacts on urban biodiversity (Rudd et al., 2002).

Taken together, we see a growing trend in public and private initiatives focusing on creating conditions for increased biodiversity within urban areas, such as biodiversity corridors, natural landscaping, wildlife gardens or converting paved surfaces back into liveable soil. Most of these initiatives focus on plants and invertebrates, which have the potential to form the basis for richer ecosystems by supplying food for species higher up the food chain. However, the attention native and biodiversity-supporting plants are receiving in design and planning is not matched by planning for the integration of the larger animals they attract into the fabric of the city. In other words, we are inviting the animals in (either directly or indirectly) but not planning how they will fit into our built environments.

What actually happens at the meeting point of animals and the city? One of the things that happen from an ecological point of view is *Synurbization*. Synurbization denotes changes in behaviour and adjustment of wild animal populations to the new conditions they encounter in urban environments (Luniak, 2004). These changes in behaviour include: Living at higher population densities; reduced migratory behaviour linked to better possibilities for wintering in the city; prolonged breeding season; greater longevity; prolonged circadian activity; changes in nesting habits, including the use of anthropogenic objects such as shelters, nesting places and material for nests; changes in diet and a shift towards anthropogenic food resources, including feeding by people and refuse, which for some species can become the main component of their diet; changes in feeding behaviour aimed at finding or receiving human food, along with a dependency on feeding by humans; tameness toward people as well as increased intra-specific aggression (ibid).

One of the interesting things synurbization shows us is that animals use not just the green features of the city (gardens, parks and other green areas) but also the technical ones. They are affected by the synthetic features of the city, features which are part of a *designed* environment, created for human use but with implications for other species as well. For example, “In inner Warsaw, 81% of the overall bird population nests in technical objects, mainly in buildings” (Luniak, 2004). From a design perspective, this represents a major overlooked implication of designing these technical features and opens up possibilities of influencing how animals experience the city and fit into its fabric.

Other synurbization changes tell us something about how animals interact with people within built environments, exposing the positive and negative implications of such interactions, for both humans and animals. This highlights another area where designers could have an impact: by working directly on these interactions, designers can enhance the positive and address the negative aspects of human-animal interactions. Human-animal interaction can be taken into consideration as part of the designed experience of built environments, experiences that could be designed to enhance cross-species communication and connection. For example, many urban animals rely on feeding by humans for their survival, but there are also many problems associated with this feeding which can create dependency, may lead to conflicts and can have health implications for the animals being fed (Robb et al., 2008). Addressing these problems through the design of a bird feeder, for example, could help reduce these effects as well as help in educating people about better practices of feeding wild birds.

Expansion of urban wildlife and Synurbization also cause other practical problems such as population booms, reduced health, and risk from traffic (Luniak, 2004), all of which could be addressed as part of the design of urban habitats if wild animals were taken more into consideration. Luniak (2004) believes we now have sufficient scientific knowledge to manage urban wildlife by the stimulation and control of synurbization processes and that management should be aimed at supporting "natural functions and structure of the city ecosystem, with ecological and social needs of man and with the general strategy of nature conservation in mind."

In some cases, the assisted establishment of a species within an urban area has helped endangered species rebound. The best known example is probably the peregrine falcon. These crow-sized birds of prey have been successfully introduced to cities in North America and Europe since the 1980s. The process has supported the natural recovery of the overall population of the species and they have been removed from the endangered species lists (Luniak, 2004).

In addition to the ecological implications of urban wildlife, there is growing concern about the moral and ethical status of urban animals (see for example Beatley and Bekoff, 2013) and attempts are being made to integrate a consideration towards animals and animal welfare into city planning. One example is the Bird-Friendly Development Guidelines, developed by the city of Toronto together with architects and bird advocacy groups, which lay out strategies for making new and existing buildings less dangerous to migratory birds (City of Toronto, 2007). Buildings, especially those with large glass facades, pose major risks for migratory birds and it is estimated that a million die every year from collisions with buildings (ibid).

Beatley and Bekoff (2013) also call for a more compassionate approach towards animals in the resolution of human-animal conflicts within urban areas. In many cases, the authors argue, lethal measures are taken to resolve conflicts where in fact the conflict could be resolved without killing or even displacing the animals (ibid). For them, the way these animals are treated "becomes a litmus test for our larger ethical sensibilities, and in many ways how we treat other human beings". To contrast what they believe to be the needless killing of seven coyotes in Griffith Park in Los Angeles, the authors give the example of Vancouver's *Co-Existing with Coyotes program* (CWC). The program operates a coyote hotline and gives guidelines for resolving human-coyote conflicts in nonlethal ways (Stanley Park Ecology Society, 2011). Similar guidelines have been developed in Suburban Virginia for resolving conflicts with Canada geese "economically, humanely and without controversy" ("geesepeace.com," n.d.).

The growing presence of animals in urban areas, of course, does not lead only to conflict and nuisance. It transforms the city in many positive ways. It creates new opportunities for experiencing nature close to home, enriches the lives of people in these areas (Beatley and Bekoff, 2013; Monbiot, 2013; Wolch, 1996) and improves quality of life (Beatley and Bekoff, 2013). There are many reasons to welcome this presence and to strive to make it work—economic, ethical, ecological as well as positive impacts on human health and wellbeing. It requires some adjustment on both sides, and the success or failure of this co-existence depends, largely, on how the animal is perceived in the eye of the public. As Mooallem (2014) puts it: "In the 21st century, how species survive, or go to die, may have more to do with Barnum than with Darwin. Emotion matters. Imagination matters. The way we see a species can impact its standing on the planet more than anything covered in ecology textbooks". If the animal is perceived well, evidence suggests that people would appreciate and cherish its presence even with the involvement of some degree of danger or inconvenience (Beatley and Bekoff, 2013). This degree of danger from potentially harmful wild animals is, in Monbiot's (2013) view, something that many urban residents are missing from their lives and an important part of rewilding, i.e. the part which relates to rewilding the human experience in the world (Monbiot, 2013, p. 60).

Even if the transition is not always smooth, perceptions and approaches towards urban wildlife can change and, when they do, they can lead to surprising examples of mutually beneficial co-existence, as in the case of the Mexican free-tailed bats in Austin, Texas, presented by Beatley and Bekoff (2013), demonstrates. The bats, 1.5 million of which have made a home on the Congress Avenue Bridge in the city, draw to Austin tens of thousands of tourists every year and generate an estimated revenue of $10 million in ecotourism. Attitudes towards the bats have shifted from fearing them to celebrating them in numerous ways, from bat-watching tourist attractions to dedicated bat festivals (ibid).

There is an expansion in research studying urban wildlife and in guidelines and recommendations on how to support greater biodiversity within human settlements. Many of the studies focus on invertebrates and birds, which are often used as bio-indicators for other wildlife species because they are relatively easy to study (Conniff 2014). Nevertheless, research also exists focusing on less obvious species, suggesting ways they could subsist better within built environments if more attention were given to creating beneficial conditions for them. One example is the field of biocolonisation of coastal structures by marine species, explored in the case study. Whether we are talking about birds, bees or limpets, one thing that is missing is a widespread application of the findings from these research studies in the design and planning of the built environments.

4.4. DESIGNING THE SHIFT

I was first introduced to Rosenzweig's *Win-win Ecology* (2003) by a friend working in conservation while I was preparing my final project for my master's degree in 'Product Service Systems Design' at Politecnico Di Milano. My project examined ways of applying a distributed network model in the creation of a botanical gene bank, making use of vacant space in private gardens. I had told my friend I believed design has a role in biodiversity conservation and he suggested I read Rosenzweig's book in which the author introduces the term Reconciliation Ecology. My thoughts, while reading the book, were about how relevant Rosenzweig's work is to anyone engaged in the designing and planning of the built environment (despite the fact that the book clearly addresses mainly conservation biologists and ecologists). Similar thoughts recurred while preparing the contextual review for this thesis, while reading Louv's *Last child in the woods*, or Wilson's *Biophilia* or Marris' *Rambunctious Garden,* or the numerous papers stressing the importance of promoting nature in built environments both for biodiversity conservation and for the sake of people. Design, it seemed to me, was relevant to all these called-for shifts in the physical and social environments of people.

We have seen that the shift to more biodiverse human habitats requires modifications to *anthropogenic systems* (Francis, 2011) and have expanded the term to include both physical infrastructure and sociocultural systems. The case study at Hannafore was an attempt to address these two sets of anthropogenic systems in an integrated way, to explore their meeting points and to attend to them simultaneously.

Design proved to be aptly positioned to making these connections. Design has always been about modifying the physical environment around us and in recent years is more and more involved in also addressing sociocultural issues. This can be seen in the emergence of new design fields such as Behavioural Design (see Lockton, 2013), Design for Social Innovation (Manzini, 2010) or Transition Design (Irwin et al., 2015), all stressing the capacity of design in making sociocultural impacts. Moreover, design is increasingly appreciated for its role in shifting narratives and mind-sets within society, and with them promoting shifts in attitude and behaviour. Recent calls from prominent design thinkers, have called upon designers to use this ability to also address the erosion of biodiversity.

In *Languaging Change from Within; Can We Metadesign Biodiversity?* Wood (2011) suggests Metadesign as a tool for augmenting existing methods used by government in dealing with biodiversity loss. These existing governmental methods, Wood says, are based on listening to scientists and setting targets (targets that are unlikely to be met, he adds). In this paper, Wood focuses mainly on the concept of *Languaging*[12] as a tool for transcending existing paradigms and beliefs about what is, or is not, possible, by addressing the terms and concepts which sustain these beliefs and paradigms. Wood suggests that designers can use Languaging as a means for reflecting on and engaging with the problem of biodiversity erosion by helping, for example, to convey the unique

[12] Wood (2011) describes Languaging as a process of changing the metaphorical and syntactical structures of language to open up new possibilities otherwise limited by the current use of terms and language. This, consequentially, leads to changing attitudes, relationships and behavioural habits.

character of different species in ecological and evolutionary relationships with other beings (ibid).

Thackara also calls upon designers to engage with the problem of biodiversity loss and alienation from nature. In a blog post titled *Healing the Metabolic Rift*, Thackara (2013b) stresses the need for an overarching paradigm shift in our relationship to the natural world, and suggests that conditions are “ripe for a new narrative to emerge” (ibid). Thackara’s talk of changing narrative and myth echoes Wood’s case of how language, terms and stories shape our understanding of reality and the need to propose alternative realities through new terms and narratives.

One example of a recurring narrative regarding urban animals is the notion of the *pest* (which is a culture-induced term more than it is an ecological one). Architect Joyce Hwang (2013) argues that we need to re-examine this notion in relation to urban wildlife. Hwang predicts that as biodiversity and habitat are further depleted and the role urban wild animals play in providing ecosystem services in cities become clearer, our perception of the animals living among us, which we now consider pests, will inevitably change from them being a nuisance to being a “highly-valued resource” (ibid). Hwang believes that this change is mostly about shifting perception and overcoming prejudices in relation to urban wildlife and that design and architecture have an important role in facilitating this shift (ibid). What is perhaps interesting to note is that all three writers see an important role for designers in shifting narratives that are currently slowing down the protection of biodiversity, a role not often associated with design (especially not outside the design world). To further illustrate this connection, in the next chapter we shall look at some examples of how design can help shift narratives and attitudes towards other species and examine how this may affect local and global biodiversity.

The call for involving designers in attempts to mitigate the erosion of biodiversity is heard also from outside the design community. For example, in Root-Bernstein and Ladle’s 2010 paper in Conservation Biology titled *Conservation by Design,* the two scientists invite conservation researchers to collaborate with designers to improve the quality of products used within the context of conservation, such as nest boxes, feeders, barriers and corridors, as well as products aimed at influencing the interaction of animals with their environment (particularly when it comes to artificial environments). Amongst the benefits the authors identify in working with designers are: Improved product quality and value, improved functionality, harmonization of products used for conservation with local values, and using design to influence human and animal behaviour (to reduce human-wildlife conflict for example) (Root-Bernstein and Ladle, 2010). The authors view the role of designers in such collaborations as translating goals set by conservation scientists into high-quality functional objects (ibid). Although this represents a slightly narrower role for designers than the one presented by Thackara, Wood or Hwang—in that it sees the role of design mainly in executing goals set by conservation scientists[13] rather than being an open-ended process—it could still represent one possible mode of collaboration between designers and scientists in cases where scientists need specific design expertise to execute a pre-defined goal.

The design challenges associated with the shift to more biodiverse human habitats are many and diverse. They go from very specific technical modifications to physical infrastructure, to influencing broader narratives in society. They include providing habitat and shelter for wild animals within urban areas; protecting them from the risks of urban living; connecting green areas in the city to generate habitat continuity; communicating to people the benefits of living amongst other species; mobilising people to transform their surroundings into more hospitable environments for birds, butterflies, bees and other wild animals; negotiating the meeting points between humans and animals; designing encounters and interactions that are mutually respectful and empowering; helping people acknowledge and interact with the nature that is already present in cities, and preparing the ground for that which is yet to come.

Although still marginal, the engagement of designers (and others doing design) with issues of biodiversity loss and human alienation from the natural world is gaining ground as more and more designers, architects and artists realise the impact their professions have also on other species. Together they represent an *Animal Turn*, of sorts, also within design practices. Common to these engagements is a novel mind-set for doing design, one that transcends human-exceptionalism and embodies new sensitivities towards other species. The next chapter sets out to chart this emerging mind-set through the lens of Multispecies Design and its key principles.

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[13] The authors give an example of such a goal: “provide x nest boxes at price y that allow p but prevent q” (Root-Bernstein and Ladle, 2010).

5. PRINCIPLES OF MULTISPECIES DESIGN

This chapter returns to the concept of Multispecies Design as described in the introduction and explores its theoretical and practical ramifications. The aim here is to outline how a mind-set for designing with and for wild animals departs from designing solely for humans. To this end, I will propose a theoretical and methodological framework for Multispecies Design and highlight key principles in the field. These are organised into three defining views of Multispecies Design. The theoretical framework is constructed and described through insights from the case study project as well as a review of related work from other designers and artists working with wild animals.

5.1. *Introduction*

Multispecies Design (MD) is the practice of designing multispecies products and systems, for use by humans as well as other species. It focuses on addressing the needs of wild animal species living in and interacting with built environments. It is a practice with explicit conservation goals as it aims to sustain more biodiversity within human-dominated habitats. As such, it is a complementary practice to Reconciliation Ecology, i.e. a practice capable of translating ecological research regarding the needs of wild animals in areas of human activity, into design applications. In addition, MD is concerned also with the sociocultural implications of Reconciliation Ecology, with its integration into the social fabric of the city, with the meeting points between people and wild animals. It operates in the constant tension between wild and fabricated worlds, aware of the strong domesticating power of design and respectful of the wild nature of urban fauna. Below we shall elaborate on different theoretical and methodological aspects of this practice. While some of these may be relevant to other instances of design involving animals (regarding farm animals for example), taken together they set MD apart from other designed engagements with animals and, more importantly, set it apart from designing solely for humans.

I have grouped different aspects of the practice under three main categories, which represent three distinct views of Multispecies Design. These are: 1. Animals as clients of design; 2. Human/animal interaction as a designed experience; and 3. Manmade systems as further extensions of ecological systems.

The following is not intended as an exhaustive review of the theoretical and methodological implications of MD; such a review would not be possible at such an early stage of the shift to better include animals within design activities. It is intended as a starting point for discussion about the emergence of such a field and is offered as a set of general principles to take into consideration when designing multispecies products and systems.

5.2. Animals as clients of design

A key change that should take place when designing human habitats in a way that is more welcoming to other species, is for designers, architects and planners to learn to look at other species as stakeholders in the design process. i.e. as beings that use, interact with and are otherwise affected by manmade objects and systems. This requires the development of new sensitivities towards nonhumans within these designery practices, new ways of studying them and new ways of representing them in the process of designing and building our environments.

5.2.1. Knowing the animal

One of the first challenges I came across in the Hannafore case study was lack of available design methods for studying animal stakeholders, such as methods capable of complementing ethnographic design techniques used to study people; methods that would be able to shed light on the lives of nonhuman species interacting and affected by the outfall pipe. This methodological deficiency led to a search for appropriate tools, both within the field of design and in other fields, tools that could then be adopted or adapted to use with my own animal clients, and be used later in other instances of designing with, and for, wild animals.

The need to be able to think and observe from an animal's viewpoint is crucial for designing products and systems that respond to animal needs (see Mankoff et al., 2005). Researchers working in ACI (Animal Computer Interaction), working mainly with pets, often build on an owner's intimate knowledge of their animal (see for example Mankoff et al., 2005; Resner, 2001) or rely on studies in animal psychology to inform design requirements (Mankoff et al., 2005). When designing for ownerless, wild animals, the psychology of which has been studied less than that of companion species, there is a need to develop alternative methods of moving towards an animal's viewpoint of the world.

Various qualitative research methods used for humans proved valuable in my research for use with nonhuman species, without requiring any substantial modifications. Observation methods, photography, visual diaries, video and sound recordings were all used to learn more about animals in their environment and about how they interacted with manmade objects and systems, as well as with people. Most importantly, spending time on site with the animals I was studying was instrumental in contextualising and complementing the scientific information gathered from papers and ecology textbooks. It has provided many insights to my research, especially regarding the more complex relationships that were taking place on site: the relationship between snails, tides, humans and an outfall pipe, for example, interacting with each other in intricate and intertwined ways. These kinds of eco-socio-technical interactions do not often fall under one specific field of study and therefore tend to be under-studied or simplified. Nevertheless, they are often the most interesting from a design perspective and help link the social and technical with the ecological.

In place of personal interviews, often used by designers to uncover tacit knowledge regarding human users, I found it useful to interview people who could speak on behalf of the animals I was designing for: ecologists and biologists, for example, who have been studying the species, as well as other people with an intimate relationship with the animal in question, such as the local volunteers from the LMCG, for example. As design ethnography shows us (Wasson, 2000), it is important to try to capture not just the formal, factual knowledge regarding the species in question but also anecdotal and site-specific stories which could help shed additional light on behavioural aspects of the species and its interactions with humans and other species in a specific context. On several occasions, I found it useful to interview biologists not as scientists studying an animal but as if they were the animal itself. They were asked to talk for the animal, lending it their own voice. This opened up the interview to more subjective and speculative knowledge. Information that may not have been proven through the scientific method (yet), but that the scientists believed to be true from their intimate relationship with the subjects of their studies, which in some cases they have been studying for many years. As Tsing (2010) notes, passionate immersion in the lives of nonhuman beings is a privilege afforded to natural scientists, but only on the condition that this “love” doesn’t show (in their academic work). Unlocking this cross-species kinship and allowing it to be expressed through semi-structured interviews and conversations with scientists, not only opens up new layers of knowledge, it is also infectious.

In addition to ethnographic methods, other exploratory techniques exist for designers to learn more about their clients: designers often use role playing in the design process, acting out scenarios of interaction between various stakeholders in a system or trying out different ways of using and misusing a product (Johnson-McDaniel 2003). This may prove more difficult when acting out the role of an animal, but it is not impossible.

One person who is famous for being able to view the world through the eyes of other creatures is Temple Grandin. Grandin attributes this capability to her autism and visual thinking, which she claims is similar to the way animals view the world (Grandin and

Johnson, 2004). One of the most well-known outcomes of this capability of hers is her work on improving standards of animal welfare in slaughter plants and livestock farms, which has led to her winning the PETA (People for the Ethical Treatment of Animals) Proggy award, in 2004.

By getting down on all fours and crawling the route cattle follow on the farm, Grandin was able to identify perceived dangers along the route of the animals, such as a shining metal sheet, shadows and sharp turns. She then proposed new designs that would make the cattle's lives better and the farmer's job easier.

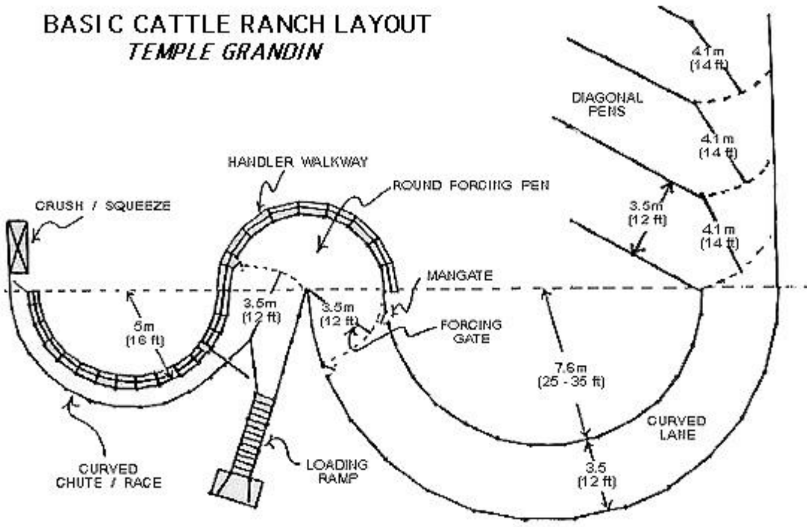

Fig 5.1 Grandin's basic cattle ranch layout. The wide curved lanes facilitate the movement of the cattle into the pen (ca.2008)

But what about animals that are more different to humans than cows and other mammals in the way they perceive the world? Animals who see different light spectrums, use sonar or magnetic fields to make out their surroundings, or who rely on different senses for orientation. Our evolutionary distance from such animals is greater. Assuming the role of such creatures in role play becomes more challenging as the species-gap widens.

A monograph written in 1934 by Jakob von Uexküll titled *A Stroll through the Worlds of Animals and Men* deals with the possibility of viewing the world from the points of view of species with a completely different set of sensory organs than us humans. In the monograph Uexküll invites us to take part in a thought experiment of experiencing the world through the sensory organs of other species:

This little monograph does not claim to point the way to a new science. Perhaps it should be called a stroll into unfamiliar worlds; worlds strange to us but known to other creatures, manifold and varied as the animals themselves. The best time to set out on such an adventure is on a sunny day. The place, a flower-strewn meadow, humming with insects, fluttering with butterflies. Here we may glimpse the worlds of the lowly dwellers of the meadow. To do so, we must first blow, in fancy, a soap bubble around each creature to represent its own world, filled with the perceptions, which it alone knows. When we ourselves then step into one of these bubbles, the familiar meadow is transformed. Many of its colorful features disappear, others no longer belong together but appear in new relationships. A new world comes into being. Through the bubble we see the world of the burrowing worm, of the butterfly, or of the field mouse; the world as it appears to the animals themselves, not as it appears to us. This we may call the phenomenal world or the self-world of the animal. (Uexküll, 1992)

The text is accompanied by illustrations that offer a view into the unfamiliar Umwelts[14] of other species. For example, an illustration showing the same village as it would be seen by a human, a fly and a mollusc (Fig 5.2 below).

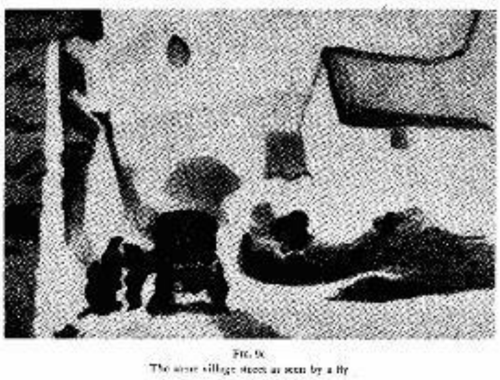

Fig 5.2 Uexküll's representation of the same village as seen by a human (top left), a fly (left) and a mollusc (top right). From *A Stroll Through the Worlds of Animals and Men* (1934).

Uexküll's monograph has inspired many writers and artists, as well as designers, who have attempted to create apparatuses that enable people a glimpse into the perceptual worlds of other species. One such project is Theriomorphous Cyborg created by Simone

[14]Uexküll (1992) refers to the perceptive and effector worlds of other beings as Umwelts.

Ferracina. Ferracina uses immersive augmented reality, together with locative media, sensors and portable devices, to create a game environment that would, in his words, "establish and activate new relations between human cyborgs and their 'sentient' environment." (Ferracina, 2011). In each level of Ferracina's game, players are equipped with different sensory capabilities, aided by wearable technology, that offer an insight into the Umwelts of other species, allowing players to "open up new perceptual realities and fields of experience—and reach previously invisible worlds" (ibid).

Another project inspired by Uexküll's monograph and concerned with equipping people with perceptual sensors of other species is Animal Superpowers by Chris Woebken and Kenichi Okada. The two artists have designed playful props that allow people to experience the world through what they describe as an animal superpower, i.e. the "extraordinary abilities allowing them to sense information and perceive the world through sensory experiences far beyond anything humans will know" (Woebken, 2008). One such prop is an ant apparatus that magnifies vision x50 through microscope antennas located in the hand piece, transmitting what they pick up to a screen in the headpiece. Their bird device uses GPS signals to trigger a vibration when facing a specific landmark, offering a glimpse into birds' ability to use geomagnetic fields to find their way south in the winter and north in the spring.

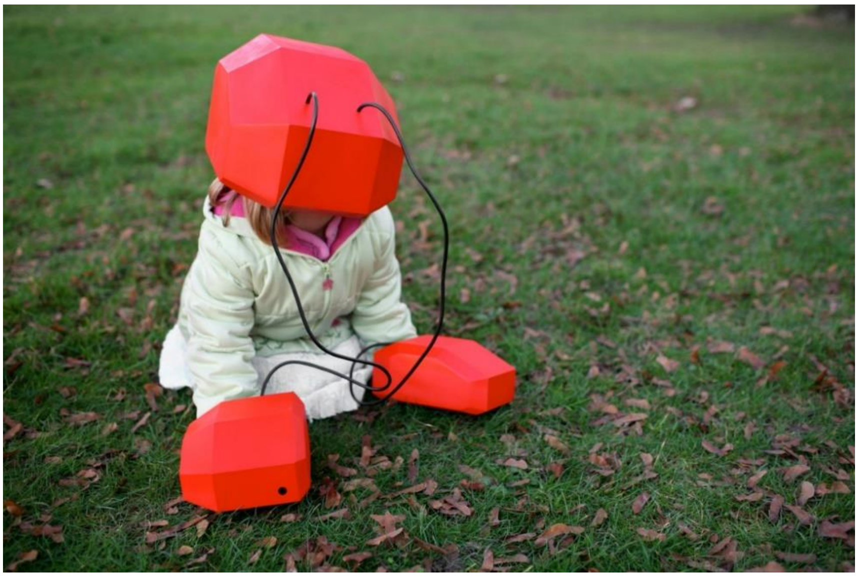

Fig 5.3 Woebken and Okada. Ant apparatus (2008)

In Theriomorphous Cyborg and Animal Superpowers, viewing the world from an animal's perspective is the end aim of the design. However, similar, less elaborate, props can also be used earlier on in the design process to gain a better animal perspective, props that limit or enhance certain human senses or use technology to add new sensory capabilities that animals possess and we may not.

Even without the use of props, it is possible to come closer to understanding how a different species perceives and interacts with the world using somatic and embodied practices such as BMC (as discussed in chapter 3), and role play. In addition to the potential of shedding light on the way other species view and interact with the world, finding new ways of knowing animals can help foster a more intimate relationship between the designer and the animal client. An intimacy that is transmitted further, to people using and interacting with the designed artefacts—bringing them, too, closer to the animal.

It should be stressed that these methods are not used in place of consulting scientific knowledge regarding the ecological and biological needs of the animal in question. They are a way of contextualising and complementing the science, and taken alone hold the risk of misinterpreting the animal and its wild needs. The unfamiliarity of animal worlds, as well as common misconceptions regarding animals, make misinterpreting the needs of animals an easy and common mistake amongst designers.

This tendency, to misrepresent animals in design, was observed both in the workshops held with art and design students on designing for animals (described in appendix 3) and in reviewing design projects for the Reconciliation Design blog (reconciliationdesign.tumblr.com, online since 2011), where I have been collecting and reflecting on design projects involving wild animals.

One risk associated with misunderstanding the needs of wild animals is the tendency to design products that create dependency of wild animals on people (for food, shelter or other survival needs) and reduce the animal's capability to provide for itself. We shall return to this issue when we talk about human/animal interaction. Misinterpreting the needs of wild animals may also lead to designs that may appeal to humans but are ignored by the animals they are intended for or, in a worse case, designs that inadvertently pose a risk to the animal (one example we shall return to are designs that promote the feeding of wild animals). Anthropomorphism is often a driver behind the misinterpretation of animals' needs, and consulting scientific literature may help avoid these oversights.

5.2.2. Representation

Viewing animals as clients of design is not just about learning to *know* them in more intimate and fruitful ways, it is also about being able to represent them within the design process and, through this, also within society. The word client, in fact, is used in this context not to denote a transaction but to evoke a responsibility. This is the same kind of responsibility designers in social design projects have for their human clients (see Vezzoli et al., 2014, pp. 67–75). The question of representation, i.e. the ability to *speak for* another being, is being constantly debated and re-examined in the field of cultural ethnography and becomes even more precarious regarding other species (Kirksey, 2014, p. 3). Multispecies ethnographers often turn to the arts to seek inspiration and help in articulating and representing nonhuman perspectives (Kirksey, 2014). Giving animals a voice in society is also a key prospect of critical animal studies (Calarco, 2015). In *Politics of Nature,* Latour (2004, pp. 231–232) suggests that nonhumans be represented by human spokespeople in a parliament, in order for them to be able to participate in human society more fully. His candidates for these spokespeople are scholars from the humanities and social sciences. However, artists and designers are also taking on the role of representing nonhumans in human society. They do this by rendering animals and their activities and needs more visible within human environments. Through this, they are promoting protection and empathy towards the wildlife present within human systems.

One method, explored by Frawley and Dyson (2014), for rendering animals more visible in the design process and consequently in the design outcome, involves applying the Service Design tool of *Personas* to animals. *Personas* are archetypes of a potential stakeholder in a system. They bring together the features of an existing social group within a system in order to represent it in a designed scenario (Tassi, 2009). Frawley and Dyson (2014) use this tool to give voice to chickens on a free range egg farm in Australia to contrast what they refer to as "factory farming methods that render the animal deliberately invisible from the public" (ibid).

Making animals more visible within human-dominated habitats is a key aspect of MD and one I shall return to when we talk about human/animal interaction.

One recent example of making animals more visible in areas of high human activity are the *Duck lanes* painted along the Regents Canal in central London by the Canal & River Trust. Trust rangers have painted narrow lanes with a stencilled silhouette of a duck at four locations along the waterway. The lanes are not intended to delimit ducks to zoned areas but more as a reminder to joggers and cyclists that the towpath is used also by more vulnerable creatures and to promote more consideration towards nonhuman users (Werber, 2015).

Fig 5.4 Canal & River Trust. Duck lanes along the Regents Canal (2015)

5.2.3. Broadening participation

Our responsibility as designers does not end with animals intended as the end-users of the designed artefact. It may also extend to animals that are affected by the design in a secondary way. Participatory Design has put an emphasis on taking into consideration a broader range of stakeholders, interacting with and affected by a design process and outcome (Simonsen and Robertson, 2012). Design is increasingly being considered for its wider impacts, extending beyond the intended end-user to include its effects also on the people involved in manufacture, end-of-life treatment or anyone otherwise affected by it throughout the product's lifecycle. Expanding this notion to wild animals can help reduce some of the risks to animals associated with built environments, as well as reduce potential conflicts arising from the unintended use of manmade objects by wild animals.

As we have seen, the use of the technical features of built environments by wild animals is ubiquitous (Luniak, 2004). Any piece of architecture, infrastructure and public space design would have impacts, extending beyond the intended human use, on other species. As more information is compiled on how technical features affect wildlife in urban areas, it would be possible to integrate more of these insights into the design process. A growing number of manuals and guidelines exist for taking into consideration the effects of human constructions on other species. For example, there are studies of the effect of buildings on birds (City of Toronto, 2007) and bats (Bat Conservation Trust, 2012); artificial lighting of offshore platforms on migratory birds (Poot et al., 2008); the effects of coastal structures on local marine biodiversity (Naylor et al., 2011); choice of plants on insect biodiversity (The Royal Horticultural Society, n.d.); as well as many others.

Even when not designing directly for animals, it is useful to consider how the design would affect other species interacting with it. This is not to say that every feature in built environments should be enhanced for an ecological value, or made into a habitat for nonhuman species. Effects on other species should be understood and taken into consideration even if the goal is to minimise wildlife interaction. There are many cases in which the presence of wildlife is not desirable and could be reduced by attentive design. An illustrative example are roads featuring wildlife crossings, such as tunnels and overpasses, designed to keep animals off the roads by allowing them safe crossings that help avoid collisions with cars (see for example Clevenger, 2005). Likewise, when regarding the intertidal animals involved in the Hannafore case study there are situations when biocolonisation is not desired, such as on boats or tide and wave energy turbines, where colonising biota may create drag and interfere with the proper function of the equipment. In other words, understanding biocolonisation can also help reduce it.

5.2.4. Assessing the design from an animal perspective

The knowledge of, and responsibility towards, animal clients gained in the research phase should be maintained throughout the entire design process. During iterative cycles of design and evaluation, there is a need to constantly assess prototypes also from an animal's perspective. This, again, may prove more difficult than asking human participants to report on their experience with the design, especially when it comes to subjective impressions (Resner, 2001). ACI (Animal Computer Interaction) researchers working with pets often rely on owner inputs for assessing an animal's response to a design project, building on the owner's intimate knowledge of their own pet (Mankoff et al., 2005; Resner, 2001). In other cases, other, more scientific methods, have also been explored for assessing a design from an animal perspective.

Lee et al. (2006) have developed a remote interaction system for chicken pets and their office-working owners for use during work hours when the owners are away from home. In the office space, owners have a three-dimensional representation of their pet that moves around according to the actual movement of the chicken in the home environment. Back at home, the chicken wears a vest incorporating vibrotactile actuators that are remotely activated when the owner strokes the representation of the pet in the office (ibid).

To evaluate the system from a chicken's perspective, the researchers conducted a four week controlled study wherein the chicken had a choice of entering one of two cages through a weighted door. In only one of the two cages would the chickens then be fitted with the vest[15]. This method is based on the assumption that the animal would intentionally avoid entering a situation which provokes negative sensations (ibid). A similar approach has been used extensively by Hughes and Black (1973) to test poultry preferences in farms regarding different cage configurations.

Cheok et al. (2011) also point out the importance of giving animals a choice in evaluating human-animal interaction systems in a report of their human-hamster play and exercise system *Metazoa Ludens*. In addition to offering hamsters the choice of taking part in the game or not, the researchers also evaluate the health conditions of their animal participants over the course of six weeks of play using a Veterinary Health Assessment Framework (VHAF) (ibid).

When working with wild animals in the field rather than in the lab, animal choice can be measured by means of response to the design. In the Hannafore test trials biocolonisation was measured on the tiles in comparison to the flat concrete. Even if the word *choice* may not be the best for describing the ecological response to the designs, the experiment gave an indication of the preferences of marine creatures regarding the three options presented on the outfall pipe (design A, design B and flat concrete). In addition, it was suggested by the science partners in the project, that in a case where biocolonisation did

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[15] Over a period of 28 days and 100 repetitions with two different chickens, the researchers found that 73% of the time the chickens chose to enter the cage in which they were fitted with the vest—concluding that: "at least there is no negative or bad feeling of the chicken towards the use of the vibrating jacket" (Lee et al., 2006)

not accrue in the relatively short period of the test trial, then microclimate measurements (temperature, humidity, oxygen levels) could be taken from the three design treatments and used as a proxy for biocolonisation. These proxy measurements would have been based on previous knowledge of different animals' preferred habitat.

To sum up, viewing animals as clients of design promotes increased sensitivity towards animals in the design process rather than rendering them invisible. It stresses the need to find new ways of knowing animals and representing them in the design process. It requires close collaboration with scientists and others capable of speaking on behalf of the animals, as well as the designers themselves adopting an animal's perspective throughout the design process.

5.3. Human/animal interaction as a designed experience

In his book *Wild Ones,* Mooallem (2014) follows conservationists and animal lovers interacting with the animals they are trying to protect; he tracks how our perception of wild animals has shifted over the years, how observing animals in a human-modified world often involves a whole system of factors mediating our experience. One of the strongest points made in the book is how important our perceptions of animals is to our motivation to protect them and how our perception of animals is shaped by our interaction with them. Beatley and Bekoff (2013), Pyle (1993) and Tsing (2010) all reach similar conclusions in their work. Positive human/animal interaction is paramount to the successful inclusion of biodiversity within human settlements and is the key for gaining public acceptance for such a shift.

Human-animal interactions are not predetermined by human or animal biology, they are shaped and influenced by the landscapes in which they take place, by products and services mediating these experiences, and they are greatly influenced by common beliefs and stories we tell ourselves about the animals with whom we come into contact.

A lot happens at the meeting point between human and animal. Empathy and wonder are sparked, conflicts arise, power relations are exercised. There is a process of mutual shaping and reshaping, an exchange of resources, and affection. There is caring and nursing and trampling and cruelty. There is fear and there is respect. As these cross-species encounters become more frequent in urban areas they can either be shaped by design and education, or left to chance. Designing these encounters has the potential of reducing conflicts, shifting perceptions and attitudes towards animals, and preparing the ground for more inclusive and biodiverse human habitats.

5.3.1. BRINGING NATURE TO THE FOREFRONT OF URBAN LIVING

Much of urban nature is hidden from sight, physically hidden in some cases but also unnoticed in urban politics (Hinchliffe et al., 2005) as well as in the everyday lives of people (Beatley, 2010). Bringing nature to the forefront and promoting more meaningful human/animal interaction is a key aspect of the paradigm shift described in the previous chapter. Hinchliffe et al. (2005) see the promotion of cross-species engagements as a way of blurring the lines between nature and society and as a starting point for the inclusion of "wilds things" in urban politics. Beatley and Bekoff (2013) point out that "we are not likely to care for or about the life forms we cannot see" and call for new ways of making animals more visible in urban settings. Tsing (2010) reminds us that "In these times of extinction… even slight acquaintance can make the difference between preservation and callous disregard", stressing the importance of positive human/animal interaction to nature protection (as we have also seen from Miller, 2005; Mooallem, 2014 and Pyle, 1993). In addition, Beatley (2010, p. 15) points out that learning to notice the "incredible and abundant nature around us even in dense cities represents an important antidote to the boredom and sameness that otherwise characterizes much of our built form and lives"; tying his argument to *Biophilia* and wellbeing benefits associated with exposure to nature in daily life.

How can design help make wildlife more visible in cities?

By treating wild animals as legitimate stakeholders in the design and planning of built environments, we can extend a notion of these spaces as *shared* environments—places we co-inhabit with a myriad of other life forms. The physical form and semiotic language of such designed environments can communicate the fact that it is part of a more-than-human world and bring forward creatures that otherwise remain in the shadows of human-dominated environments.

There are numerous examples of design interventions that increase awareness of the presence of wild animals in urban areas. Such as the *Duck-lanes* discussed earlier, which, as their creators state, are intended more as a way of drawing attention to the presence of water fowl rather than an attempt to control traffic along the canals (Werber, 2015). Similarly, there are the *Tiny Road Signs* (Fig 5.5) created by Clinic 212 featuring silhouettes of urban wildlife on road signs in areas where they may be present but are often unseen or unnoticed (Clinic 212, 2015).

Fig 5.5 Clinic 212, *Tiny road signs*. Vingis park, Vilnius (2015)

Birdhouse Rooftile by Klaas Kuiken (Fig 5.6) is a bird nesting box incorporated into a roof tile. Its iconic birdhouse form draws attention to its function as a nesting box while its integrated presence into the roof of a house extends a notion of a *shared habitat* and draws attention to the fact that birds often roost in roofs (Kuiken, 2009).

Live video streams of wildlife in urban settings, which are gaining popularity, are also a good way of connecting people with the surrounding nature. Another way is involving people in documenting and mapping wildlife in cities. The project Noah's *Wild Cities: Urban Biodiversity* Community, for example, has over 7000 members worldwide and some 40,000 documented spottings of wild life in urban areas around the world. These are located on an interactive map and include identified species, as well as photos of species with requests to the community for help in identification (Project Noah, 2013).

Vancouver's *Stanley Park Ecology Society* also have their own map for citizens to submit coyote sightings, as well as the possibility of indicating the state of the animal and the type of interaction with it (Stanley Park Ecology Society, 2011b).

Fig 5.6 Kuiken, *Rooftop birdhouses* (2009)

Protecting nature by making it more visible is sometimes contradictory to traditional conservation methods that aim to separate and protect nature from human activity. Nevertheless, it seems to be an emerging strategy in nature conservation as more and more conservationists realize the importance of public support and education in protecting the wildlife we share the planet with.

The main challenge in a conservation strategy based on visibility and increased human/animal interaction, is in protecting animals from the, sometimes overpowering, forces of human activity. Higher visibility exposes animals to more risks and may lead to increased conflict. Human/animal interaction should be promoted in a way that keeps animals and humans safe and should be combined with education projects that promote respect towards animals and focus on how to behave around them.

5.3.2. Soft reservation

The project at Hannafore beach provided a good case study on which to explore the balance between visibility and interaction on the one hand, and protection of the animals on the other. The project involved a structure with high human activity (the walkway) and relatively delicate marine creatures such as sea snails. By designing the tiles to attract snails, I had a responsibility for their safety, just like I had a responsibility for the safety of the people walking on the tiles.

Even though the project started off as a critique of reservation strategies based on human/animal separation, it was clear early on that some degree of separation was necessary in order to protect the snails from being trampled upon by people using the walkway. This lead to experimentation with the use of soft approaches to dividing the space, that did not seek a complete separation between human and animal activity; transient separations that allowed a degree of interaction while also maintaining a sufficient degree of separation to maintain animal and human safety. Human and animal zones were not defined by hard physical borders; rather they were based on the behavioural attributes of humans and animals i.e. designed to render human zones naturally more appealing to humans and animal zones naturally more appealing to animals. For example, on the *Wave* tile, people preferred walking in the centre, while the water-filled grooves were more appealing to marine animals. Separation of the zones could also be based on the different activity times of humans and animals. The centre of the *Wave* tile, for example, was a human zone during low tide but an animal zone at high tide when the structure was covered with water. Likewise, an urban feature could be designed to be used by people during the day and by nocturnal animals during the night.

It is interesting to note that both design and conservation science have turned in recent years more towards behavioural studies (see for example Buchholz, 2007 for behavioural approaches to conservation and Lockton, 2013 for behavioural design). Both fields are developing more sensitivity towards human and animal behaviour (respectively) and developing methods of influencing these behaviours. Combining these two approaches within the framework of Multispecies Design has the potential for overlapping human and animal activities in a way that reduces conflicts and danger but still allows for interaction and visibility.

5.3.3. Expanding empathy

The close connection between human affection and the chances of a species' survival in a human-dominated world has grim consequences for species that are not immediate candidates for human affection. In *Unloved Others: Death of the Disregarded in the Time of Extinctions*, writers from different fields explore questions regarding the fate of species deprived of human affection:

> "What of the unloved others, the ones who are disregarded, or who may be lost through negligence? What of the disliked and actively vilified others, those who may be specifically targeted for death? Then, too, what of those whose lives become objects of control in the name of conservation, and those whose lives are caught in the cross-hairs of conflicting human desires?" (Rose and Van Dooren, 2011).

The collection offers different possible answers to these questions. Amongst its pages are tales of human respect and affection involving some surprising creatures, such as ticks for example (Hatley, 2011), or tales of deep love and complex sociocultural relationships with mushrooms (Tsing, 2010). As well as a call to extend our affection, and indeed our ethics, to creatures unseen and unnoticed, by learning to appreciate "the not entirely comprehensible ways in which these individuals also constitute a part of a community of myriad beings which appear to each other in all kinds of ways, as commensal, as mutualistic, as parasitic, as a prey, as a resource, as co-evolved and as evolving beings" (Smith, 2011). The core lesson from these papers is that love of other beings is a muscle that can be exercised and expanded to include creatures beyond the furry and cuddly.

I have experienced this in my own work. One of the things that struck me most in working with marine biologists and especially with concerned nature lovers, was the depth of empathy and connection many of them hold in respect to even the tiniest animals they work with. A love that defuses from them outwards, through the events organised by the Looe Marine Conservation Group, for example. I have learnt that love of the living can be enhanced and cultivated through close connection and interaction with other species and through changing the stories we tell ourselves about other species and our relationship with them; and indeed also through science[16]. This is the "art of inclusion" that Tsing

[16] Dr. Naylor and Dr. Coombes' work on the bioprotection capabilities of barnacles is, in part, trying to combat the common belief in marine engineering that barnacles damage the surfaces they colonise.

(2010) talks about, a practice that crosses the boundaries between science and the arts: "The critical intervention of this new science studies is that it allows learnedness in natural science and all the tools of the arts to convey passionate connection" (ibid).

Artists and designers are helping to shift narratives in society by engaging with all manners of life forms, sparking wonder and fascination to even the tiniest and most unnoticed of creatures. Such is the work of artist Daro Montag (2015) who brings attention to microbes, ants and earthworms. Or the work of Fritz Haeg (2013) who created homes for over thirty native animal species in nine cities around the world, including frogs, snakes and beetles, amongst larger birds and mammals in his Animal Estates project.

5.3.4. Designing encounters

Multispecies Design sees the urban landscape as a site of human/animal encounters and interactions. Its success is greatly dependant on the nature of these encounters and on our ability to shape these interactions in a way that is mutually beneficial, enjoyable and empowering.

Encounters are organised and influenced by the landscapes in which they occur and as such, can be shaped by the design of these spaces. By extending the notion of the *public* to include nonhumans (following Latour, 2004), Barnett (2012) offers a view of public spaces as co-habited spaces that are primary sites of human/animal encounters and proposes landscape architecture as a way of organising these encounters:

> Landscape architecture is the art of organizing these encounters in such a way as to increase humans and nonhumans self and other empowerment. That is, to enable them the dignity and assurance of their right to self-determination, be they fish, plant, bird or beast. Landscape architecture puts species into the conditions they require to become what they are (Barnett, 2013).

In a project concerned with permitting and facilitating encounters between urban coyotes and humans, Barnett and his collaborators propose the design of a site they hope will appeal to humans and coyotes alike. The site, in Auburn Alabama, is designed to provide food for coyotes year round while also functioning as a leisure park for people. One of the main lessons brought forward by Barnett regarding the design of the site is the need to find a balance between rigidity and change in the system. A rigid system, not prone to ecological change, would exclude coyotes, while a system where everything seems to change all the time would alienate people (Barnett, 2013). For Barnett, the design of the site is an open-ended process; it is not clear what will occur in these encounters between humans and coyotes, and this is part of the point of the project: "to forge passages between concepts and species in such a way as to investigate just how humans live in the world and how they intersect with other, nonhuman, species" (ibid).

Other projects concerned with the meeting points between humans and animals are more specific about the desired outcomes. In a workshop involving designers and ecologists organized by Root-Bernstein et al. (2012), participants were asked to address the interaction between South American Sea Lions and humans on the site of a fish market in Valdivia, Chile. The fish market and surrounding river banks had become home to a small population of sea lions living off the left-overs from the fishing industry. Following concerns that the sea lions may pose a potential danger to tourists and locals at the fish market, a fence was installed to keep the sea lions out and prevent any direct interaction with people. However, as Root-Bernstein et al. note, the design did not take into account human behaviour, and the fence was often left open by fisherman to let the sea lions into the fish market and increase tourist activity.

The workshop revolved around developing design solutions that would allow different degrees of interaction between humans and sea lions, while also addressing the potential danger in these encounters. Amongst the proposals developed was a pocket-size flyer giving information about sea lions as well as illustrative guidance of how to interpret sea lion body-language to avoid conflict. Another was a fence incorporating feeding slots that would allow a more controlled interaction between humans and sea lions. Yet another solution was a bright yellow umbrella, distributed in key locations of the market, designed to be used to scare off the sea lions in case of perceived danger. The authors classify the proposals according to the amount of human/wildlife interaction they allow: from *complete separation* with no interaction, through *controlled interaction* which they compare to interaction with animals in a zoo, all the way to fully *free interaction* which they compare to encounters with squirrels in a park for example. Within these three scenarios of interaction, the authors recognize the ability of design to influence both human and animal behaviour to address the needs of both, and to meet local values and desires regarding interaction with animals.

In Barnett's case, human/animal interaction is facilitated through the design of the landscape within which it takes place. The main role of design here is to overlap the coyote assemblage with the human one by attracting both groups into the same space. The interaction itself is free to take on an emergent form, shaped by its participants. In the case of the Chilean fish market, interaction is mediated via designed objects (fences, flyers and umbrellas), which aim to control, to varying degrees, the outcomes of the interaction. While Barnett's approach is addressed to landscape designers, Root-Bernstein et al. refer specifically to industrial designers as ideal partners for conservation scientists wishing to design products for conservation projects.

A useful concept to take into consideration in cases where interaction is mediated via designed artefacts is that of *Asymmetrical Interfaces* developed by Resner (2001, p. 34). Resner reminds us that humans and animals communicate and interact with their environments very differently. Therefore, any device designed for use by both humans and animals would have to have different, species-specific, interfaces for use by humans and animals. Resner uses this concept to develop a remote communication device for people and their pet dogs he calls Rover@Home (Resner, 2001). The device is used to replace a phone which uses symmetrical interfaces on both ends (suitable for humans), with a species-appropriate human/dog remote communication device.

The concept of asymmetrical interfaces is useful, not just in cases of communication apparatuses, but also for multifunctional structures designed for use by both humans and other species. In the case of the outfall pipe at Hannafore beach, for example, the structure had to appeal to humans and marine animals in different ways. It did so by presenting itself to people as a walkway, while snails saw it as habitat and feeding ground. This is where the ability to view the world from the point of view of animal clients comes into play in the design process: it affords designers the possibility to look upon the designed artefact from a human perspective and from an animal perspective and see two different things. The integration of these two visions into one coherent design project is the essence of the creative process in Multispecies Design.

5.3.5. Design as a mode of translation

Stories and common beliefs regarding urban fauna are often fed by misconceptions and misunderstanding of wild animals. This can lead to unnecessary fear and negative interaction with animals. To narrow the communication gap between people and sea lions, the flyers designed by Root-Bernstein et al. (2012) translate sea lion body language into words and illustrations comprehensible by people. In this way they reduce the risk of people misinterpreting the state of an animal and help people know when to avoid individuals that are feeling threatened and may become aggressive.

This type of intervention sees the use of design as a mode of translation between species with different communication sets. One artist/designer whose work often revolves around translating animal inputs into human language is Natalie Jeremijenko. Her work is aimed at bringing people and animals closer together by narrowing the communication gap between the two groups. In a collaborative project with Chris Woebken, the two artists created *Bat Billboard*. The project combines a nesting habitat for bats within an electronic billboard serving as a communication channel between humans and bats. Sensors are embedded within the bat boxes. The sensors pick up bat calls and translate them (according to frequency and patterns) into text messages on the billboard. A message could read, for example: "Bats taking off for insect snacks" (see Fig 5.7 below), hinting at the important role bats play in pest control within human habitats.

Fig 5.7 Jeremijenko and Woebken, *Bat Billboard* (2008)

The project was created to help deal with the environmental health emergency faced by New York bats known as White Nosed Syndrome by offering the bats a controlled, disease-free environment (ibid).

In a different project, Jeremijenko and her collaborators created bird perches that trigger sound files when birds land on them. Each perch triggers a different recorded message designed to entice humans to share their food with the birds as well as stressing which human food would be nutritious also for the birds (Jeremijenko and Taylor, 2006). The perches are, in the words of the artists, designed to "facilitate human-bird communication, translating into human dialect some of the birds concerns and arguments" (ibid).

5.3.6. Respecting boundaries

The question of wildlife feeding (and birds in particular) is a highly controversial one and one that comes up often in conversations with conservationists and in workshops with art and design students. It aptly articulates the tension between the wild and the tame in relation to urban wildlife. Between the humanistic urge to "break bread" with other species (see Snæbjörnsdóttir and Wilson, 2011) and the conservationist wish to preserve their wild nature.

On the one hand, research shows that the practice of bird feeding increases avian abundance in the city (though it has no documented effect on species richness) (Fuller et al., 2008). On the other hand, bird feeding poses health risks to birds, from inappropriate diets and choking risks; as well as a risk to humans, as birds become more aggressive when they are fed by humans (Ballantyne and Hughes, 2006). Moreover, bird feeding is criticized for changing bird behaviour and creating dependency on anthropogenic food sources (Brittingham and Temple, 1992).

Jeremijenko's project addresses the health issues posed to birds by unhealthy feeding practices. It is presented as a tool for facilitating birds' control of human behaviour (Jeremijenko and Taylor, 2006). But, does it not also represent the risk of creating bird dependency on technology and human feeding? In fact, doesn't any design intended for use by wild animals pose this same risk?

Design has a strong domesticating power and this should be kept in mind when designing for nonhuman species. One way of addressing the issue of dependency was presented to me by a biologist studying bird behaviour (Kight, 2014, private conversation). It involves thinking about bird feeding in terms of *natural resources.* Food sources in nature appear and disappear sporadically; fruit trees and bushes once depleted will not generate more food until the next season. This way, wild animals are less prone to become dependent on one food source. Likewise, feeding birds in a sporadic way would reduce the risk of creating dependency on one source and the bird would be coerced into maintaining its ability to be self-providing.

The same principle can be applied to design at large. Thinking about design as a *natural resource* (with inherent variabilities) can help address the risk of creating dependency and minimise changes in behaviour. I shall return to this notion in the section on *manmade systems as further extensions of ecosystems.*

Though controversial, bird feeding is significantly less contentious than the feeding of other wild animals. In many cases, animal feeding is the main cause of aggression towards humans and presents health risks to the fed animals. Stanley Park's *Co-existing with Coyotes* website warns about the risks of feeding coyotes:

> human food is not healthy for coyotes but like any dog, they will eat what you give to them. Deliberate feeding is the sole cause of aggressive behaviour, which is why it is illegal under the provincial wildlife act to attract coyotes (Stanley Park Ecology Society, 2011a).

Feeding wild animals reduces their natural fear of people and leads to more conflicts. In *Feral,* Monbiot (2013, pp. 115–16) talks about the importance of maintaining a natural fear of humans in animals that are potentially dangerous. He demonstrates how countries where wolf hunting is legal often have a healthier relationship with their wolves than countries that have banned hunting. This is due to the fact that controlled hunting maintains the wolves' natural fear of humans and keeps them away from human settlements.

Animal behaviour is bound to change as they interact with anthropogenic systems, and we must be conscious of these changes. Feeding is probably the most studied aspect of these changes and is still the topic of much debate. More research, as well as more public debate, is needed to better understand these changes and set guidelines for what changes are deemed acceptable. As we invite more animals into human settlements, there is a case to be made also for maintaining boundaries between the wild and the cultivated elements of the city. As researchers studying animals in the wild know, there is an importance also to cultivating detachment in human-animal relations, and engagement and detachment do not necessarily sit on opposite poles of such relations (Candea, 2010).

In designing human-animal interactions, there are probably more open questions than there are answers. A new kind of relationship is needed for urban wilds, one that is different from our relationship with companion and domesticated species but also different from our relationship with animals in the wild. When establishing such a relationship, in addition to taking advice from science, we may also take advice from philosophers of human-animal relations, such as Donna Haraway:

> A great deal is at stake in such meetings, and outcomes are not guaranteed. There is no teleological warrant here, no assured happy or unhappy ending, socially, ecologically, or scientifically. There is only the chance for getting on together with some grace. The great Divides of animal/human, nature/culture, organic/technical, and wild/domestic flatten into mundane differences - the kinds that have consequences and demand respect and response - rather than rising to sublime and final ends (Haraway, 2007, p. 15).

5.4. Manmade systems as further extensions of ecosystems

Nature is, undoubtedly, the best provider for wild animals. The need to provide habitat artificially arises not from a deficiency in nature's provision but from a systematic removing of nature from areas humans have claimed for their own use. If the goal is to invite animals back in, and better provide for them in such areas, then there is a lot we can learn from the way nature does 'design'.

Design inspired by nature is a well-established and growing area of engagement for designers (see Benyus, 2002 and Oxman, 2010 for two different examples). It is not my intention to provide a review of fields such as biomimetics, biogenesis or other approaches to design inspired by nature (see Oxman, 2010, pp. 47–57 for such a review). Rather, my intention is to briefly touch on a few aspects of the field that are directly relevant to the discussion about Multispecies Design.

5.4.1. Open-ended and evolving design

When designing the tiles for Hannafore, it was clear that my control over the aesthetics of the design could only go so far. Any surface designed for colonisation is bound to change its appearance with time and the tiles certainly did look different on every site visit. When designing for wild animals we expect animals to modify and customize the artefact as they interact with it. This process blurs the lines not only between designer and client but also between process and outcome (a separation that does not exist in nature's design). As a tree grows, it provides different functions (for different species) in different stages of its life, and for many birds, mammals and insects it will only become a habitat once it dies and the processes of decomposition create cavities in its trunk.

Though unintended in their planning and design processes, we see a similar phenomenon in cities. It is often in the broken and abandoned elements of our cities that we find the most biodiversity. Cracks in the asphalt capture water and expose soil, creating the conditions for life to emerge; abandoned buildings and infrastructure become home to bats and birds just like dead trees do. Everything in nature is in constant change, in cycles of evolution, in cycles of decomposition and re-composition. There is no waste or end of life, just flows of energy and material.

Is it possible as designers to cultivate this quality of constant change and evolution in our designs? To let go of the wish to freeze the artifice in one *ideal* stage? Is it possible for us as a society to make room for these "imperfections" in our habitats: the cracked and broken, the rundown and abandoned, and view them for their own unique aesthetics?

Had I left the test tiles in place at Hannafore longer, the process of ecological succession would probably have continued; the limpets that had just move in would have changed the algal composition on the tiles, influencing, in turn, other species feeding on it. Some of the seaweed may have gained hold and grown larger, creating new microclimates and providing shelter for crabs and anemones. Maybe barnacles would have eventually established, changing the texture of the surface, blocking algae and seaweed growth and providing food for new species. Some maintenance possibly would have been needed to maintain the use of the tiles as a walkway. It is difficult to forecast the course of possible events, and such would be the case in many instances of Multispecies Design as we gain more knowledge of how wild animals interact with anthropogenic systems. We need to learn to view design as an open-ended process on which we do not have full control. And, we need to design systems capable of changing and evolving over time together with the ecological and geomorphological processes.

5.4.2. Complexity

We have seen that adding surface complexity to a structure increases the biodiversity of colonising species (Kostylev et al., 2005). Complexity and diversity of form are defining characteristics of natural materials and systems. According to Pearce (1990), nature creates the maximum diversity of form with the minimum component inventory. This provides a diversity of habitats where different species can find niches. The design of built environments, on the other hand, is often reductionist and uniform (Phemister, 2010). There are many places in which complexity can be added to features in the built environment to create habitat for diverse animals. Different bricks, for example are being developed to incorporate into walls, to provide a habitat for birds (see Dunkerton, 2015 for example, Fig 5.8 below) or bees (for example Green&Blue, 2015, Fig 5.9 below). In addition, in Australia, a group of researchers have developed a tile incorporating a habitat for lizards, to be used on living roofs (deGroot et al., 2010).

Diversity and complexity can be added in all levels of the design and planning of built environments, from choice of plants, to diversity of textures and features on hard surfaces. This will create new niches and opportunities for urban wilds.

Fig 5.8 Dunkerton, *Bird Nesting Brick* (2015)

Fig 5.9 Green&Blue, *Bee blocks* (2015)

5.4.3. Connectivity

When talking about greening the grey features of built environments, Naylor et al. (2014) discuss the potential of using grey infrastructure to connect defragmented green areas in cities. If enhanced to provide habitat and other ecological features, a sea wall, for example, can help create habitat continuity between natural beaches on both its sides. Similarly, if designed with appropriate wildlife crossings, a road does not necessarily have to separate the habitats it runs through. Green and living roofs, as another example, can be conceived as stepping stones, helping migratory birds and insects cross the city, and can be spaced and designed accordingly. The point here is to consider the larger ecosystem in which the design will be placed, and design for flow and connectivity.

5.5. Summary

The field of design, through its various domains and approaches, can contribute to different aspects of the paradigm shift described in the previous chapter. It can help address the needs of nonhuman species in human-dominated environments and it can help reconnect people with wild animals. Designers can work with scientists to translate their research into landscapes, products and services that achieve specific ecological goals, or they can make their own work friendlier to wild animals by reflecting on the impact their work has on other species and by integrating general ecological principles into it. In all cases, designing to address the needs of wild animals requires a shift in the mind-set of the designer and the development of new sensitivities towards nonhuman species in the design process.

The following is a summary of the processes and tools, used in my own practice and gathered from the work of others, which assist in entering this mind-set and cultivating sensitivity towards nonhumans in the design process. It is proposed as an initial tool-kit for instances of designing multispecies products and services, with the intention of developing it further into an online toolkit for Multispecies Design.

5.6. Tools for Multispecies Design

Principle	Process	Focus
Animals as clients of design		
	Extending responsibility	Extend to your animal clients the same respect and responsibility you would to your human clients. Respect their needs as well as their wild nature. Avoid interventions that pose health or safety risks or that might create dependency on humans or technology.
	Identifying needs	Identify the needs of the animal you are designing for. What is missing for them in human habitats that exist in natural ones? What risks are present in human habitats that can be addressed by your design?

	Participatory animal design	Animals will modify the designs as they interact with them. Take this into consideration and design for these interventions.
Getting to know your animal clients		
	Learning the science	Read papers and books, watch videos and talk to scientists studying the animal.
	Multispecies Design Ethnography	Spend time with your animal clients in the field. Use photos, videos, drawings and visual diaries to capture their interaction with their environments. Focus on eco-socio-technical interactions, i.e. interactions between animals, humans and manufactured objects.
	Proxy interviews	Interview people studying the animal in question. Ask them to talk *about* the animal and also *for* the animal (as if they were the animal).
	Identifying animal spokespeople	Where possible, identify animal spokespeople capable of speaking on behalf of the animal throughout the design process.
	Somatic design research	Experiment in seeing and experiencing the world from the animal's perspective. Use your imagination, role playing, movement, props or any other means you can think of to help you with this. Change your viewpoint to the height of the animal and move in the environment at the animal's pace. Try to enter into an animal's Umwelt i.e. into the environment as it appears to the animal through its perceptive organs. When using movement, first learn biological and ecological facts about the animal, then act them out in different interaction scenarios.
Representing animals		

	Representing animals in the design process	Create animal personas and include them in stakeholder interaction maps of your product/service. While prototyping, assess the designs also from an animal's perspective. Get help from your animal spokespeople for this.
	Representing animals in society	Can your design help make the presence of urban wildlife more visible in cities? Can it highlight their needs? Can it highlight the benefits of living amongst animals?
Designing for human/animal interactions		
	Focusing on mutually beneficial interaction	How does your design benefit animals and humans? Does it bring them closer together in a respectful way?
	Soft reservation	Some degree of separation between the animal and human uses of a structure is sometimes needed to keep humans and animals safe. Can this separation be achieved by addressing human and animal behaviour? Can hard barriers be avoided to leave room for interaction?
	Addressing existing cultural baggage	What is the existing relationship between humans and the animal in question? What are the stories we tell about the animal in the specific sociocultural context? Can your design challenge misconceptions and misunderstandings regarding the animal? Can they generate new narratives that focus on co-habitation and reconciliation?
	Avoiding domestication	Many wild animals can be turned into pets; this is not the goal in Multispecies Design. Respect the animal's wild nature and avoid design that may lead to domestication.
	Opening up communication channels	Can your design help open up communication channels between humans and animals?

		Can it translate animal language and behaviour into cues understandable by humans and vice versa?
	Seeking synergies	Animals can provide different ecosystem services in human habitats such as water filtering, pest control and weed removal. Try to look for synergies between the needs of humans and those of animals.
Design like an ecosystem		
	Open-ended design	Think of your design as part of an ever-changing system and accept that you will not have full control over all its outcomes. Can your design follow and change according to natural processes such as ecological succession, weathering and climate change?
	Ecology of reference	Some animals and plants are “pre-adapted” (Del Tredici, 2014) to certain conditions in urban environments because of their similarity to natural features (tall buildings and cliffs for example). When addressing a specific area or feature in a built environment try to find your ecology of reference, i.e. a natural ecosystem with similar morphological, chemical or climatic features.
	Connectivity	Grey features in urban areas are often adjacent or in proximity to green ones. Can your design intervention help connect separated green areas and increase habitat connectivity?
	Embrace complexity	Complexity on all levels often leads to more biodiversity. Include complexity of form and materials in your designs to offer more diverse options and niches for animals.

6. CONCLUSIONS AND CONTRIBUTIONS

This chapter brings together the conclusions from the theoretical and practical sections of the thesis to address the research questions, highlight theoretical and methodological contributions extending from this work and discuss areas for further development.

6.1. ADDRESSING THE RESEARCH QUESTIONS AND AIMS

The research questions considered in this thesis are concerned with the role of design in facilitating the shift towards more bio-diverse human habitats. Describing this role and outlining conceptual and practical tools capable of aiding in the development of the field of design in this direction have been the main aims of the work.

Practice has been central to addressing (and framing) the research questions. Through a case study design project concerned with incorporating greater biodiversity into a manmade structure, I experienced and explored various aspects of designing for nonhuman species and their integration into human systems. The case study project highlighted areas in which designing to meet the needs of nonhumans is different from designing for humans and exposed a gap in design methodologies for studying and representing wild animals in the design process. New methods have been explored and developed for addressing this gap, as well as different modes of collaboration with science in projects involving nonhuman species.

To better understand recent calls to include more biodiversity within human habitats, the research explored ecological, philosophical and societal aspects of this shift. A view of the challenges of biodiversity erosion and humankind's alienation from nature was proposed as being interconnected, and so a framework for addressing this interconnectedness was suggested based on an expanded understanding of the term Reconciliation Ecology (RE).

The framework of RE was expanded to address the gap in knowledge identified within RE and related fields. These fields promote physical modifications of anthropogenic systems (to support biodiversity) but tend to overlook the deeper sociocultural implications of such a shift. A specific example of this was observed in reviewing the field of ecological enhancement of coastal structures for the case study. Research in the field had focused on physical changes to coastal structures that make them more appealing to marine species but rarely addressed their interfaces with human culture and society. To address this gap, the case study focused on a structure with a high human activity, and the interactions between the ecological, the technical and the human were taken into consideration both in designing the structure and in assessing it.

Areas were identified within the framework of RE, that are relevant to the field of design. These included integrating the needs of wild species into the design and planning of built environments, facilitating the sociocultural shift into more biodiverse human habitats, shifting narratives in society regarding wild animals, and addressing human and animal behaviour through design.

Next, Multispecies Design (MD) was proposed as a conceptual and methodological framework for embracing this new role for design. Key Principles of Multispecies Design were proposed based on experience from the case study, additional practical work, workshops and a review of relevant work by other designers and artists, as well as theorists, writers and commentators working in the field. These principles were grouped under three categories representing three key concepts of MD: 1. Animals as clients of design, 2. Human/animal interaction as a designed experience and 3. Manmade systems as further extensions of ecosystems.

While there is a growing body of design literature concerned with the third category, i.e. how to design human systems more like natural systems (for example: natural design, biomimicry, biosynthesis and biogenesis), less work has been identified regarding the other two aspects of the MD framework. Some reference to human/animal interactions as designed experiences have been found and projects which embody this approach have been reviewed, but there seems to be a lack of theoretical and methodological tools for applying this approach in design theory and practice.

The same is true of the treatment of animals as clients of design. There are, no doubt, design projects which treat nonhuman species as clients and stakeholders, but because designing for nonhumans is in many aspects significantly different from designing for humans, there is a need to develop specific methodologies for supporting this process.

The methodological ramifications of MD have been developed through reflection on the practical elements of this research. Methods from participatory design, service design, design ethnography and Metadesign have been adapted for use with animal clients, together with new methods originating in other fields to form an initial set of tools for Multispecies Design. These tools aid in acquiring new sensitivities towards nonhuman species within design projects and help navigate the process of designing to meet their needs and integration into human-dominated habitats. These tools will need further development and testing over time but they have been shown to be useful in my own practice, and for engaging students and raising discussions in the workshops.

6.2. Main contributions of the thesis

The main contributions of this research are:

First, in proposing that design thinking and practice have an important role in the emerging paradigm shift calling for more biodiverse human environments, and in positioning this role at the intersection of RE and the turn towards animals in the humanities. In other words, design's role is not just to modify physical anthropogenic systems to support biodiversity, but also to address related sociocultural aspects of this shift.

Second, in proposing and developing Multispecies Design as a framework for design activities concerned with the intersections of wild animals and human systems. The work offers conceptual and practical tools for Multispecies Design, and specifically for the areas of the practice considered less developed, to support designers in engaging with nonhuman species and their interactions with humans and human systems.

And third, in describing modes of collaboration with science and scientists in projects of Multispecies Design.

6.3. Towards a Multispecies Design approach

The inclusion of a wider diversity of species within human-dominated environments represents a proposal capable of addressing different contemporary ecological, sociocultural and ethical challenges. However, while this prospect is, in many ways, a design challenge, the discussion has remained mostly outside the design world, taking place mainly within ecology and conservation circles and recently also within the humanities. Some of the reasons for this are external to the discipline of design; conservation biologists, for example, still see the main area of impact of their discipline in addressing policy. While this may be true for traditional conservation efforts, Reconciliation Ecology is an area where public opinion and changes on the ground can be implemented through innovative design and creative thinking with changes in policy following (i.e. design action on the ground drives policy, rather than implements it). Other reasons have to do with the nature of design as a human-centred discipline and the lack of methods and theory for including nonhuman species in the design process.

Addressing biodiversity erosion and people's alienation from the natural world through design requires the development and adoption of a design approach with increased sensitivity towards nonhuman species, currently seen only in the margins of the field. It requires highlighting areas where design may have an impact and defining new scopes for the field. It also requires new modes of collaboration with other fields relevant to this shift.

Multispecies Design offers a theoretical background for the emergence of such a design practice. It helps navigate the design process through this new territory by offering ways of studying wild animals and representing them in the design process. It helps avoid some misconceptions regarding wild animals in human-dominated habitats. It offers ways of addressing the meeting points between humans and wild species. It suggests ways of collaborating with scientists and working with scientific data. Most importantly, it offers a new mind-set for designers by expanding the practice of design to include nonhuman species; an approach which, although currently marginal, seems to be gaining popularity and interests among designers.

Below is a summary of the three key concepts of MD identified and described in this thesis.

Animals as clients of design

Treating animals as clients of design is proposed as a way of facilitating their integration into human-dominated environments by addressing their needs through the design and modification of anthropogenic systems. It refers not just to projects where specific *animal clients* have been identified, but rather aims to promote sensitivity towards animals in any design project by raising the question: *which other species may benefit or be otherwise impacted by the design proposal?* In this area, tools have been proposed for representing animals in the research and design phases of a project as well as in the assessment of the design proposal from an animal's point of view.

Human-animal interaction as designed experiences

As the presence of wild animals in human habitats grows, so does the need to manage and facilitate their integration in a way which respects the needs of both humans and other species. Viewing human-animal interactions as a designed experience is a way of reducing potential conflicts, protecting vulnerable species from humans and humans from potentially harmful wild species, and allowing space for meaningful and respectful cross-species interactions to occur. These have been shown to have a positive effect on human health and wellbeing, promoting biophilia and increasing the motivation of people to protect nature. In this area, tools have been proposed for making wildlife more visible in human environments, protecting wild species while keeping them visible, promoting empathy and wonder of the natural world, and addressing the meeting points between people and wild animals.

Manmade systems as further extensions of ecosystems

The third aspect of MD presents a theoretical and methodological shift in design practice by viewing human systems as further extensions of natural ones. Here we see the emergence of design approaches inspired by or mimicking natural processes, such as biomimicry, natural design (Oxman 2010) and natural landscaping. Common to these approaches is the desire to design human systems which are non-linear, dynamic, resilient and sustainable. Often the benefits for humans are highlighted in such approaches, such as in reduced material use, better ecosystem services and improved resilience, but such systems have benefits for other species as well and consequently end up attracting a wider diversity of species into human habitats. In this area, tools have been proposed for treating design as an open-ended and evolving process, as well as addressing the notion of complexity and connectivity in design.

6.4. Contributions to the field of ecological enhancement of coastal structures

To date, research in the field of ecological enhancements of coastal structures has remained mainly within scientific circles, and applications have typically been part of research studies or engineering solutions to meet regulatory requirements. One of the consequences of this has been that the ecological function has typically been considered in isolation from the human function of the structure, and is often applied as a retrofit. In addition, the interfaces of these enhancements with human life have been of secondary concern, limiting their visual appeal and ability to communicate their ecological function to people.

Considering ecological enhancement from a design perspective has aided in viewing the ecological and human functions in a holistic way, stressing their interconnectedness and synergetic properties, and promoting a cultural appropriation of the scientific data, as well as its reinterpretation, contextualization and connection to other contemporary phenomena. This approach, manifested in the framework of MD, may aid in communicating the value in involving designers in projects of ecological enhancements and, more generally, may allow stakeholders from beyond design to recognise the value of design thinking and processes beyond a superficial aesthetic activity.

The case study at Hannafore beach has demonstrated that it is possible to design ecological enhancements also in areas of high human activity. It has shown that it is possible to overlap the ecological and human functions of the structure in a way that enhances both, and this gives the sense of a shared structure used by both people and marine species.

6.5. Research limitation and Further developments

The main limitation of Multispecies Design is in the fact that it operates in areas of uncertainty and sometimes, high controversy. As with the case of wildlife feeding, there are often opposing views regarding the treatment of wild animals in urban areas that may lead to very different design outcomes. To address this, Multispecies Design has to remain open to constant public discussion involving different disciplines and different points of view. Different degrees of human/animal interaction would lead to different degrees of interference with both human and animal lives, and influencing these interactions requires, in addition to scientific inputs on the matter, a broad public discussion. How to facilitate and manage this discussion has not been fully explored in this thesis and would need to be a matter of further development.

Likewise, the tools proposed here for Multispecies Design are an initial set of tools that would need further testing, development and expansion to fit situations I have not foreseen in this thesis. It is my intention to make them available to the design community via an online platform and to collect feedback and suggestions to improve and continually develop them.

On a practical level, the relatively short test period and scale of the tests at Hannafore have not allowed me to fully test the intended function of the tiles. A longer test period would likely lead to different biocolonisation results, and adjustments to the designs may have to be made if an opportunity to use them commercially arises. Prof. Thompson and Dr. Firth, marine biologists from Plymouth University, have expressed their interest in further monitoring the tiles from Hannafore in a new setting in Plymouth. If this goes forward, additional data will demonstrate how the tiles perform over a longer test period. Additional information will also arrive from the Encrustation project (described in appendix 1) and a clearer view of the role of designers in the field of ecological enhancement may result.

Design's engagement with the worlds of wild animals and their intersections with human society is in its infancy. It is my hope to see it develop further and be manifested in the work of design practitioners, in design education and in closer collaboration between designers and conservation biologists.

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APPENDIX 1: HANNAFORE SUPPORTING DATA

This section contains additional data from the research and assessment of the case study design exploration at Hannafore beach.

1. PRELIMINARY RESEARCH

The first few visits to Hannafore were dedicated to preliminary research. Below is a list of techniques used for this research and the main findings.

1.1. TECHNIQUES USED

- Semi-structured conversations with people in the field, including Martin Coombes (University of Oxford), Larissa Naylor (Exeter University), Abby Crosby (Cornwall Wildlife Trust), Richard Thompson (Plymouth University), Heather Buttivant (Looe Marine Conservation group), other LMCG members, Steve Pound (South West Water) other local figures such as local Coast Guard and kiosk manager.
- Review of scientific literature regarding ecological enhancement of coastal structures.
- Design ethnography techniques: observation, visual journal, photo and video recordings.
- Visit to the beach with Local VMCA chair.
- Visit to the beach with area manager from SWW.
- Talks with visitors to the beach.
- Internet search.
- Review of literature written on the beach and pipeline (CWT).

1.2. Results

General

- The beach enjoys a healthy, biodiverse ecology, known around Cornwall for its diverse rock pools
- The beach gets many visitors throughout the year but mainly in summer
- Local LMCG (Looe Marine Conservation Group) is keen to help support the project

Use of the structure by People

- Main activities on the beach connected to the outfall pipe are rock-pooling, kayaking and walking to Looe Island
- Kayaks are usually dragged to the end of the pipe to be launched
- People walk off the pipe at two main points: opposite Looe Island and at the end, to visit rock pools
- Many visitors just walk along the pipe and back without getting off it

Use of the structure by Nonhuman species

- Some limpets and periwinkles (very few top shells and a dog whelk) can be found on areas of the pipe with a rougher surface
- Some areas of the pipe have a rougher surface because a wooden rather than a metal mould was used to make them. Rougher sections have been colonized faster
- Some green algae growth on sections of the pipe in higher tidal area
- Seaweed growth on section of the pipe in lower tidal area. This is also where fewer people walk, as it is after the turn to Looe Island
- gastropod concentrations in shaded area under manhole
- Barnacles can be found on a section of the pipe that has been worn down heavily
- Keel worms can be found on the side wall of pipe at low tidal zone

General Ecological and geomorphological principles relevant to the site

- Surface complexity enhances biodiversity on artificial structures (Moschella et al 2005, Kostylev et al 2005)
- At a scale of <1cm Barnacles were more abundant (Coombes 2011)
- At a scale of <10cm general increase in diversity (Moschella et al. 2005)

- Creating rock pools (scale 10-100cm) increases diversity and the presence of species sensitive to desiccation (Moschella et al. 2005). This becomes even more important above mean tidal level
- "Rock pools can ... provide suitable habitats for recruitment and settlement of species such as limpets, winkles (littorinids) and crabs." (Moschella et al. 2005)
- Carbonate rocks increase surface complexity by weathering and bio-erosion (Moschella et al. 2005)
- Human activity is a major cause of disturbance to biocolonisation (Moschella et al. 2005, Thompson et al. 2002)
- Topographic features provide shelter from waves and refuge from predators (Moschella et al. 2005)
- "Promoting settlement of limpets can be a very useful, cost effective and environmentally sensitive tool for drastically reducing the abundance of nuisance green algae that generally flourish on disturbed habitats such as frequently-maintained man-made structures or slipways." (Moschella et al. 2005)

Suggestive possibilities

- It may be possible to increase the durability and longevity of a structure by means of biocolonisation (currently being tested by Coombes and Naylor)
- Promoting barnacle colonisation can make a surface safer to walk on for people

Other consideration

- It is important to promote interaction between people and the environment to address the metabolic rift

2. Questionnaire template

The next four pages contain the template of the questionnaire used for assessing the two design proposals for the outfall pipe at Hannafore.

Hannafore tests feedback form

You are invited to take part in a research project by giving feedback on design tests installed on the outfall pipe on Hannafore beach. The feedback is anonymous. Parts of it may be used in future publications, exhibitions or presentations including my own PhD thesis.

Please feel free to ask me if anything is unclear or you require more information.

Part 1: ***General questions***

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1. How old are you?

▢ Under 12 years old ▢ 12-17 years old ▢ 18-24 years old ▢ 25-34 years old

▢ 35-44 years old ▢ 45-54 years old ▢ 55-64 years old ▢ 65-74 years old

▢ 75 years or older

2. How far have you travelled to be here today?

▢ 0-5 miles ▢ 6-10 miles ▢ 11-20 miles ▢ +20 miles

3. Do you believe structures like the outfall pipe on this beach can have an ecological function (e.g. provide habitat and feeding grounds for marine life) **in addition to their use by people?**

▢ Yes ▢ No

4. If yes, what do you think this function may be?

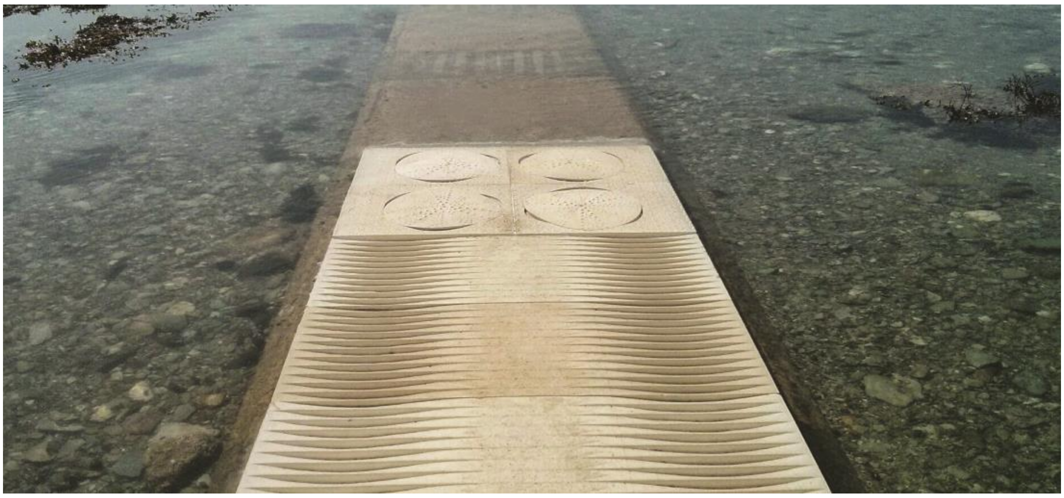
5. In your opinion, is there value in creating habitat for marine species (e.g. sea snails, barnacles, crabs, anemones…) **on the outfall pipe?**

▢ Yes ▢ No

6. If yes, what is the value?

Part 2: ***Feedback on the designs***

The test tiles recently placed on the outfall pipe were designed to enhance the habitat value of the structure while keeping it a safe walkway for humans.



In order to answer the next questions please try to imagine each of the two designs covering the entire length of the walkway. The images below might help with this.

Design A “Urchin”

Design B “Wave”

7. Which of the designs do you think does a better job at creating habitat for marine species?

▢ Design A “Urchin” ▢ Design B “Wave” ▢ The original smooth walkway

7.1. Please explain your answer

8. Which of the surfaces feels more pleasant to walk on?

▢ Design A “Urchin” ▢ Design B “Wave” ▢ The original smooth walkway

9. Which feels safer to walk on? (e.g. less slippery)

▢ Design A “Urchin” ▢ Design B “Wave” ▢ The original smooth walkway

10. What do you like and dislike about each design, why?

Design A “Urchin”	Design B “Wave”

11. Overall, which of the surfaces do you like best? Please explain your answer

▢ Design A "Urchin" ▢ Design B "Wave" ▢ The original smooth walkway

12. Do you have anything you would like to add?

Thanks for your feedback!

Please contact me if you have any additional thoughts or questions

3. Table summarizing species counts on Hannafore site visits

Date of visit	Treatment	Total individual animals in family/genus in 10 quadrants of 25 cm x 25 cm									
		Periwinkles (Littorinidae)		**Top shells (Trochoidea)**		**Limpets (Patellidae)**		**Dog whelks (Nucella)**		**Common hermit crabs (Pagurus bernhardus)**	
		Tide out	**Tide out + 4h**	**Tide out**	**Tide out + 4h**	**Tide out**	**Tide out + 4h**	**Tide out**	**Tide out + 4h**	**Tide out**	**Tide out + 4h**
30.05.2014	A	2	2	0	0	0	0	0	0	0	0
	B	15	2	13	11	0	0	0	0	0	0
	C	33	2	2	1	1	1	0	0	0	0
19.06.2014	A	5	4	3	5	0	0	0	0	0	0
	B	51	48	10	11	0	0	2	0	0	0
	C	45	1	1	0	0	0	0	0	0	0
27.07.2014	A	9	7	0	1	0	0	0	0	0	0
	B	56	56	15	13	0	0	0	0	0	0
	C	60	3	1	0	0	0	0	0	0	0
03.09.2014	A	9	10	12	14	0	0	0	0	1	1
	B	76	71	36	38	0	0	0	0	0	0
	C	37	3	0	0	0	0	0	0	0	0
10.09.2014	A	16	15	11	12	0	0	0	0	0	0
	B	114	110	36	36	0	0	0	0	0	0
	C	31	2	0	0	0	0	0	0	0	0

Table 1: Animal counts on five site visits on A (Urchin), B (Wave) and C (flat concrete), taken first as the tide recedes from the test site and again four hours later. Apart from one hermit crab observed on the Urchin tile, all animals observed and counted during the test period were snails

4. Hannafore end of trial survey

4.1. Species found on the Wave tile

All these species were found in the side grooves, i.e. the area intended for colonization.

Algae

- **Fucus spa. Probably Fucus vesiculosus (bladderwrack):** Quite abundant, growing in the side grooves. Could potentially grow to also cover the centre. Having the grooves drain would disadvantage it and so would introducing limpets earlier on. Growth slows down in the winter. Summer growth may be kept low by high human traffic. Not enough time to establish if this species could compromise the use of the tile as a walkway.

- **Scytosiphon:** Present in side grooves, abundant though less than the Fucus. Same concerns as to Fucus

- **Ephemeral green algae:** Green algae, typical to high shore, present in side grooves, less abundant than above two.

- **Hildenbrandia spa. (Encrusting red algae)**: Colonising the surface of the side grooves, very abundant on vertical wall of the grooves apparently due to these being more shaded, providing forage to various sea snails. Does not seem to present a risk of spreading to walkable surface or to top of grooves (They are in contact with shoes when people are walking on the grooves). Presence significantly reduced in areas where limpets have established.

Grazing snails

- **Gibbula umbilicalis (flat or purple top shell):** Most common snail at end of trial. Found abundantly in the side grooves feeding on algae. Both juvenile and adult samples were found.

- **Phorcus lineatus (Toothed top shell):** Another member of the top shell (Trochidae) family, found quite abundantly in the side grooves feeding on algae. Both juvenile and adult samples were found.

- **Littorina littorea (Common periwinkle):** Found abundantly in the side grooves grazing on algae. Both juvenile and adult samples were found.

- **Littorina saxatilis (Rough periwinkle):** Another member of the winkle family found less abundantly in the side grooves grazing on algae. Both juvenile and adult samples were found.

- **Patella vulgata (Common limpet):** Although the tiles were designed with them in mind, limpets were the last snail species to establish on the tiles. 5 individuals were found at the end of the trial, 2 of medium-small size and 3 small. Although these were less abundant and last to arrive, the effects of their presence was clearly visible in the form of grazing marks in the red algae cover in the side grooves. Presence of Hildenbrandia was visibly lower around the areas where limpets have established.

PREDATOR SNAILS

- **Nucella lapillus (Dog Whelk):** Two individuals were found on the tile, in the grooved area (others were viewed on other sampling days preying on other snails).

4.2. SPECIES FOUND ON URCHIN TILE

ALGAE

On the Urchin tile, algae were visible only in the small exposed pools collecting by the entrance to the covered rock pool. Here only Fucus spa. and Hildenbrandia spa. were identified and in much smaller quantities than in the larger grooves of the Wave tile.

GRAZING SNAILS

Grazing snails were also found just in the small entrances to the pools and in smaller quantities than on the Wave tile. Species found were: Gibbula umbilicalis, Phorcus lineatus and Littorina Littorea**.** These were also found, in smaller quantities than on the Wave tile.

UNDER THE COVER

The covered rock pool was monitored to some extent throughout the period of the trial using an endoscope, but this did not allow the proper identification of the species within the pool. In order to properly observe the covered pool, the lids were taken off at the end of the trial. Upon opening the lid, it became evident that the pool had been filled with an oxidised sediment which did not make for good habitat conditions. The sediment must have filled in during the last month of the trial as on the previous visit the endoscope could still move freely within the pool. This was probably due to the increasing storminess of the sea as winter approached. Nevertheless, some live species were found within the pool which were not present on the Wave tiles. These were two species of worms on the back of the cover: Pomatoceros spa. (Keel worm) and Spirorbis spirorbis (polychaete worms) and one crab: Carcinus maenas (Shore crab)**.** None of these were likely to continue surviving in the clogged pool.

APPENDIX 2: ADDITIONAL PRACTICE

This section is a review of the additional practice carried out during the PhD period that has contributed to the development of the Principles of Multispecies Design, but in ways that were less significant than the Hannafore project. The additional practice explored elements of Multispecies Design that were not fully explored within the Hannafore project. Specifically, the relationship between science and design within Multispecies Design projects.

1. SCIENCE-DESIGN COLLABORATION

The project at Hannafore enjoyed, in many senses, a high level of creative freedom. The location and design brief were chosen and set with the explicit aim of exploring the possibilities of designing for ecological enhancement outside a set scientific framework. This approach allowed me to explore speculative scenarios, taking into consideration multiple sociocultural, ecological and technical aspects of the design rather than focusing just on empirically demonstrable outcomes. While I received invaluable guidance and support from the scientific partners during the project, this way of working may not be representative of most science-design collaborations.

In other cases, the ecological goals for a project would be set by the scientific partner, or, in the case of operational projects, the engineer consulting on a coastal engineering project (Naylor et al. 2012), and the designer (or science-designer collaborative team) would be charged with developing solutions that fit these goals. Such is the case, for example, with ECOncrete, a company specialised in creating ecological concrete solutions for both terrestrial and marine environments. The company employs a part- time designer whose job is to develop design solutions that fit the requirements specified by the biologists and act as a link between them and the manufacturers (Sella et al., 2013).

The project described hereafter is intended as a case study for reflection on aspects of science-design collaboration, where the science goal is to design tiles to test specific research questions, and to help build a sufficient evidence-base to enable the manufacture and widespread engineering application of these techniques. It reveals, to some extent, that there is room, even in light of a tighter scientific brief, for creative interpretation, as well as room to explore conceptual ideas as long as they do not interfere with the scientific study.

The project was developed in collaboration with Dr. Larissa Naylor, to be part of a multi-location, five-year study into the biogeomorphological effects of barnacle colonisation. Her team has recently found that ecology (seaweeds and barnacles) appear to be helping protect coastal assets from deterioration (Coombes et al., 2013) and that it is possible to enhance concrete to recruit more barnacles (Coombes et al., 2015). This research project would be a continuation of these studies into bioprotection (Coombes et al., 2013).

Since the specific sites for the study were not set while we were developing the design proposals[17], the project was not developed as a site-specific proposal and the inputs to the design gravitated, in turn, more towards the scientific literature, in place of the Multispecies Design Ethnography methods explored in the Hannafore project.

The project saw the development of two tiles for the context of the scientific project. The size of the tiles was specified in the scientific brief presented to me by Dr. Naylor, to 12cm x 12cm, with the possibility of varying the depths. The function of the tiles was to encourage rapid uniform barnacle colonisation. Below is a description of the two tiles followed by a comparative discussion.

2. Grooves

The first tile is an attempt to reproduce experiments carried out by Dr. Coombes during his PhD, using 3D manufacturing technology that would allow for greater repeatability and standardisation. Coombes (2011) demonstrated that concrete tiles containing small grooves (<1mm) encouraged more barnacle colonisation than tiles made of flat concrete. To create the grooves, Coombes used a brush to texture the concrete while it was still wet. This created small ridges of varying size along the concrete (see Fig A2.1 below).

[17] Two initial sites for deployment of the tiles are intended for winter-spring of 2016 in Scotland and The Isle of Wight

Fig A2.1 Coombes' brushed concrete tile at the beginning of the trial (left) and two years later (right).

For the first tile, I had been asked by Dr. Naylor to create a mould for a concrete tile that would feature similar grooves in a symmetrical and uniform pattern, that could be reproduced using digital manufacturing technologies. This would allow for future testing of this manufactured version of the designs made by Coombes et al. 2015, and enable these to be tested, and if successful, used to encourage engineers to adopt these simple designs in future engineering projects.

A resin-board tile was created using a CNC milling machine at Makernow FabLab at Falmouth University (Fig A2.2 below). The grooves where created with a slope on one side (Fig A2.3) to allow a comparison of different orientations and exposures to the sun. Consequentially, a silicon mould was created from the model.

Fig A2.2 Resin-board model of the grooved tile

Fig A2.3 Detail of the slopes on the grooves tile model

3. ENCRUSTATION

The second tile, named Encrustation[18], is a second iteration of the same brief from the grooves tile, assuming more creative freedom of interpretation. Designed, again, to promote barnacle colonisation using small grooves, this tile adds a visual element to the design, recalling a barnacle colony (Fig A2.4 and A2.5).

Fig A2.4 Resin-board model of the Encrustation tile

The Encrustation tile features both vertical and horizontal grooves and topographic fluctuations that create the typical barnacle shapes. The alternating direction of the grooves has the scientific goal of enabling some grooves to be washed in the direction of waves and others to be perpendicular to this, to enhance the likelihood of settlement by cyprid barnacles. The tiles are designed to create a continuous pattern when placed side by side (Fig A2.6).

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[18] Encrustation is the collective noun used for barnacle colonies.

A resin board model was created using a CNC milling machine (Fig A2.4 above). In this case, rather than modelling the grooves into the 3D design of the pattern, they were achieved by widening the tool pass of the milling machine and running a 2mm semi-spherical tool first in the Y axis for the vertical grooves and again in the X axis to create the horizontal ones. For this, the CAD file was split into the shell of the barnacles (featuring the vertical grooves) and the openings (featuring the horizontal grooves).

Recalling the shape of barnacles for the tiles is a way of subtly hinting at their function as tiles intended for barnacle colonisation, as well as a play on an ecological phenomenon that is not fully understood by scientists: Barnacles are known to colonise areas previously colonised by other barnacles, and although different hypotheses have been proposed over the years[19], why this happens is still being unravelled by scientists. This notion, of operating on the margins of what is known and achievable by science, was something we were interested in exploring with this second tile.

Fig A2.5 Detail of model for Encrustation tile

[19] Hypotheses range from chemical explanations based on chemical trails left by adult barnacles that are then picked up by barnacle cyprids (Larman et al., 1982) to the hypothesis that cyprids use their sense of vision to locate adult barnacle settlements (Matsumura and Qian, 2014).

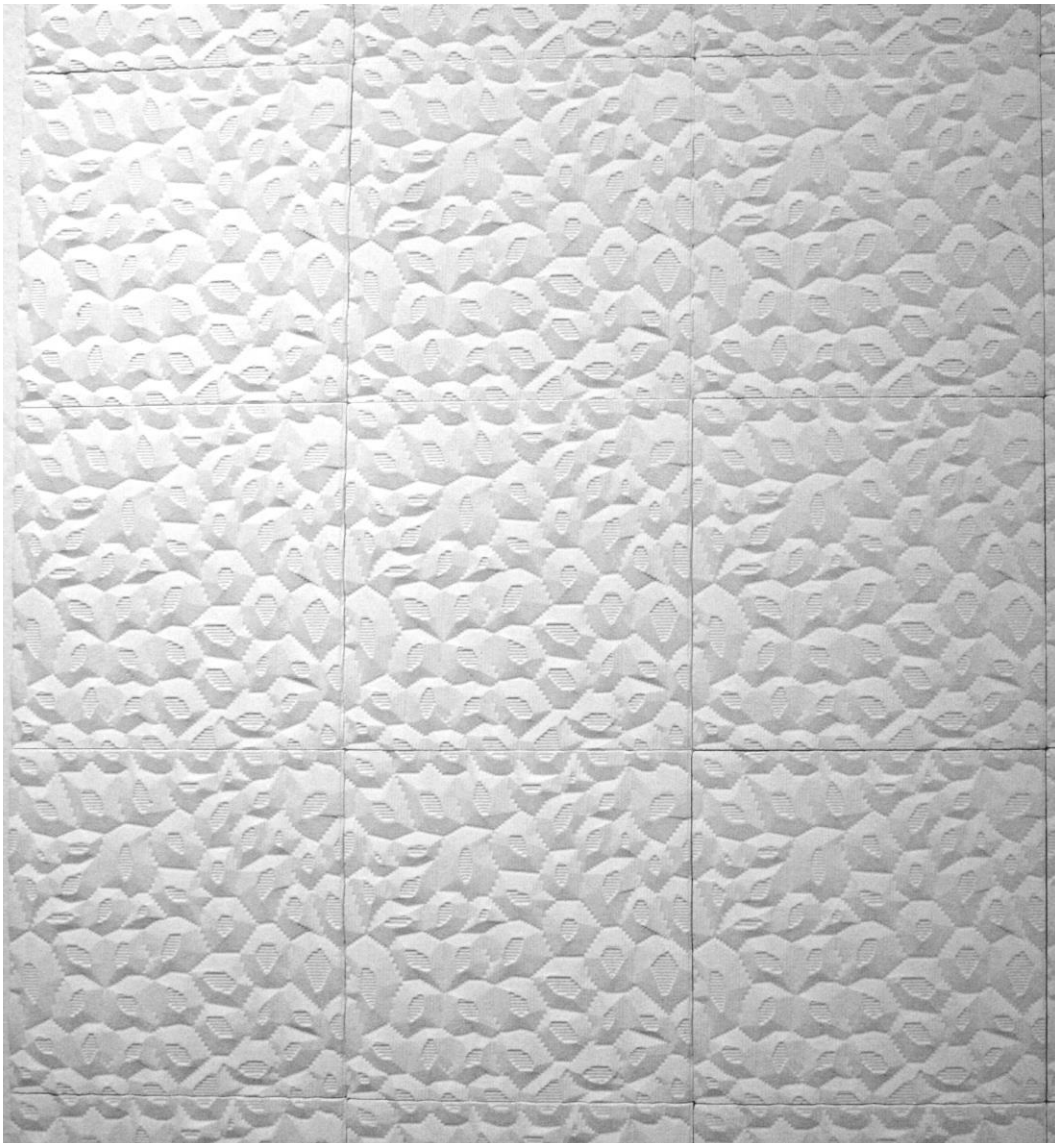

Fig A2.6 Plaster casts of the Encrustation tiles
placed side by side

4. Discussion

In many respects, the groove tile is more promising. It more accurately mimics the grooves of the brushed concrete and, as such, would be a *safer bet* for engineers and for use within the new research project as it builds on previous results from manual manipulation of concrete to create texture (Coombes et al. 2015). At the same time, this is also the source of some of its limitations. The new research project sets out to study how barnacles affect the surfaces they colonise and how to achieve the most rapid barnacle colonisation. Thus, achieving barnacle colonisation is a means to an end and it would make sense to go for the *safer* tile. This approach however holds the risk of affixing barnacle colonisation to a specific form while this may not necessarily be needed[20], a form that, while being functional, says little about the function of the tiles and does little to connect the ecological with the sociocultural (as the Encrustation tile aspires to do).

While in a scientific study the tendency may be to build on what has already been shown to work, in a culture of design there is often more emphasis on novelty. This approach has its own limitations in that it is more speculative and often less grounded. However, it may also lead to more radical innovation. In the case of this project, it was manifested in the numerous prototypes I proposed to Dr. Naylor before the final Encrustation tile was chosen, most of which had been rejected for a variety of reasons related to the goal of colonising barnacles.

At the meeting point of these two approaches, expressed in science-design collaborations, something interesting happened: Although none of the prototypes I proposed had been previously tested, upon looking at them Naylor and Coombes could say if they thought barnacles would colonise them or not. This returns to the notion that scientists often know more than what is official scientific knowledge and collaborating with designers may help bring forward this tacit knowledge.

Looking at the Encrustation tiles, both Coombes and Naylor said they believed they would be colonised. They also speculated on what parts of the tiles would be the first to be colonised (the low ridges connecting the barnacles). The tile breaks the rigidity of form of the straight grooves and creates a link to the world of humans by visually hinting at the function of the tiles. In addition, by insinuating on the phenomenon of barnacles colonising areas previously colonised by other barnacles, it highlights one of the beauties of science: that until something has been proven, all other options are kept open. Is it possible that barnacles would recognise the pattern and colonise the tile in response?

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[20] Coombes and Naylor, for example, demonstrated barnacle colonisation also on exposed aggregate and air bubbles

APPENDIX 3: WORKSHOPS

1. INTRODUCTION

As part of this research project, four workshops were held with art and design students on the subject of designing with, and for, wild animals. The workshops all took place in the period after deploying the Hannafore tests and while I was developing the Principles of Multispecies Design. They served as a way of reviewing and fine-tuning those principles (as they were being developed) by observing how they are perceived and applied in the work of other artists and designers.

Two of the workshops were held with Master's students in Design at Lund University in Sweden, one with Master's students in Art and Environment at Falmouth University and one with Sustainable Product Design undergraduates at Falmouth University. In total, over 60 students participated in the workshops, divided into work groups of 3-4 students per group.

The main assignment for the groups in the workshops was to develop a design proposal for addressing the needs of one wild animal species and its relationship to humans and human habitats. The focus was on the process of design, and how it changes when the clients are nonhuman. The groups were asked to propose a research strategy for studying their animal clients, identify a specific need and propose a concept for addressing it.

My aims for the workshops were:

1. To explore how the notion of Multispecies Design is perceived by future designers and artists.
2. To observe how the students interpret and put into practice the theoretical inputs presented to them in their design process.
3. To highlight opportunities and difficulties in the practice of Multispecies Design.

The workshop consisted of the following steps[21]:

STEP 1: INTRODUCTION: ANIMALS AS CLIENTS OF DESIGN (THEORETICAL INPUT CA. 1 HOUR)

In this introductory section, I presented to the students some of the motivations behind the call for redesigning human habitats to support greater biodiversity, as well as the need to view wild animals as clients of design.

STEP 2: CHOOSING AN ANIMAL CLIENT AND PROPOSING A STRATEGY FOR RESEARCHING IT (CA. 30 MIN)

Each group was asked to choose an animal that they believed could benefit from their skills as designers. The students were also asked identify a specific need of the animal they chose and come up with a research strategy for studying their animal. Animals chosen by the students were: Lynx, Spider, Orca, Fox, Alligator, Bee, Owl, Rat, Seagull, Elephant and Badger.

STEP 3: EXAMPLES OF DESIGN FOR WILD ANIMALS (CA. 15 MIN)

Next, the students and I discussed a few examples of art and design projects involving wild animals, including some of my own work.

STEP 4: CONCEPT GENERATION (2-6 HOURS)

At this stage, the students were asked to sketch out a concept for addressing the need they had previously identified. The students were asked to prepare a visual presentation of their concept to present to the class, including sketches/models illustrating its function and interfaces with humans and animals.

STEP 5 PRESENTATIONS AND DISCUSSION (CA. 1 HOUR)

In the final stage, the students presented their work to the class. Each group had five-ten minutes to present their project, followed by a discussion and questions from myself and the other students.

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[21] The time dedicated for each section varied slightly between workshops according to the time available. Three of the workshops were of one day and the last one at Lund was spread over two days.

Directly after the workshops, the students were asked to complete an online feedback form, the results of which are in section 3 of this appendix.

2. Reflection on the workshops and student feedback

The workshops were met with enthusiasm and engagement by the students and for every animal chosen, different needs and design opportunities were identified. The students recognised the need for a separate set of design tools for designing for wild animals and integrated well the notion of animals as clients, as well as human/animal interactions as designed experiences, into their design concepts.

The workshops also highlighted some aspects of designing for wild animals I had underestimated, primarily the tendency to try to control areas of the animal's life through the design proposal. This was evident in projects that treated animal clients more as pets than as wild species living amongst humans. This led to the inclusion of the sections on domestication, maintaining boundaries and avoiding dependency in the Principles of Multispecies Design (see section 5.3.6).

In their feedback on the workshops, students reported the workshop had given them practical tools for researching and designing for wild animals. The use of role playing and somatic practices were deemed especially useful as a way of gaining nonhuman perspectives in the design process. Many students also stated they were motivated to become involved in the field of designing for wild animals and addressing biodiversity loss through design.

One of the participants in the Arts & Environments workshop (that was designed as a workshop open to participants also outside the study course), was a behavioural ecologist from Exeter University. Her comments have been helpful in articulating how science design collaboration is viewed from a scientific viewpoint and in articulating the role of designers and artists in conservation projects. In her view, this role is to find creative solutions to implementing conservation goals in a way that is acceptable and appreciated by the general public (see feedback of participant 4, page 191-192). This has helped stress the importance of placing MD at the intersection between ecological and human studies and the role of the designer in linking the two.

3. Workshop feedback

Following are the student's responses to the workshop feedback forms from three of the workshops (the last workshop at Lund University did not include a feedback form).

3.1. Lund workshop 1 feedback summary

Student	Before the workshop, have you ever considered design may have a role in addressing biodiversity erosion or human/animal relationships?	Please elaborate if you wish	After completing the workshop, do you now believe design may have a role in addressing biodiversity erosion or human/animal relationships?	Please elaborate if you wish	Has the workshop given you any practical or conceptual tools for designing for wild animals? Do you believe you may use these tools in the future?	Was there anything in the workshop that didn't make sense or felt irrelevant for you?	Interesting	What is the most interesting thing you have learnt?	Fun	What was fun or not fun about the workshop?	Comprehensible		Motivating	Anything else to add?
1	Yes	One super interesting project about design for animals was done at Konstfack in 2010: http://www.andreij.com/Care-for-Cows	Yes	I have great confindence in the problem solving power of design. It seems it can be applied to most problems.	Yes, first of all a mindset. But also some useful research methods e.g. role playing, eco femenism	Everything was super interesting! Though some academic lingo was a bit difficult to understand if english is not your native language. All in all a very good presentation!	5	How useful design can be for tackling these sort of problems	5	You could easyly follow every step. It was fun that it was short work sessions so you dont go to deep and get stuck.	4	Some of the lingo was a bit hard to follow.	5	I heve been thinking before of design for animals as a possible career and this workshop/lecture only reinforced that feeling :)
2	Yes	Before the workshop I sort of imagined that design that adresses biodiversity was something done mostly by non-designers, for example by biologists. Or "products" in very large scale made by architects and city planners.	Yes	After the workshop I feel very much inspired and motivated, since I realized that I, as a industrial designer, have a oppurtunity to do something in this area.	Role playing and dancing was pretty new tools for me and I feel interested in trying them out in the future. The thought experiments by Von Uexkull was also new and interesting.	-	5	Co-creation with animals and all the examples of what have been done in this area	5	Overall a fun and relaxed workshop.	4	Sometimes the presentation went to quick, for example in the beginning. Since some of the information presented was completly new it takes a while to take it in. At the same time I think you did a very good job explaning the more complex parts in a easy manner.	5	I feel super insipired and would really like to make a larger project in this area as soon as I can.
3	Yes		Yes		Yes, it has. I did not know that much about this subject and I found it really interesting; The way we approached it was a great tool that surely I will use in the future.	No, there wasn't.	5	Now I know that to change and help the environment we can just think about easy solutions that already exists in nature: to recreate the natural balance	5	to make a project in few hours just following all the tasks step by step.	5		5	

								that humans destroyed						
4	Yes		Yes		To constantly thinking about the factors physical and cultural context when working with animals. Like as you do when you work with people. All are equal, and all are different. It was something I have not reflected so much about when it comes to animals.	Nope!	4	That you must understand that you are dealing with multiple worlds when working with animals. Animals, humans and the plants world.	4	Interesting to look at examples and try to find your own solutions.	4	Yes!	4	Maybe not focus on this topic, but to be aware of this when developing products that will be exposed to the wild nature.
5	No	I guess I had only thought of it in a way of designing tools and accessories for pets, but didn't realize the possiblities to create a real, meaningful impact and work for creating a better relations between us humans and other spieces.	Yes		It has helped me to get a better overall-view of the designprocess and rely more heavily on research than assumptions. Designing while keeping other speicies in mind is to me the next level of design and architecture thus I believe it really can create more awareness about environmental- and animals problems amongst people. And society will have to acknowledge these problems and deal with them in a more serious way.	No	5	That there's lots of improvements that can be made for other species that in the end also will benefit us humans.	5	The different approach to design compared to regular design projects focused on human target groups. I wouldn't say that it was "not fun", but in the begining I put lots of energy and thoughts into motivating which animals we wanted to help, the reason why etc, but the pace between the steps fellt to fast sometimes, (Thoughts like: "Why don't we have more time?"). At the end of the day I thought of it more as you wanting to teach us more of the process than actually generating an amazing solution which would explain the fast pace. If this was your intention I don't know.	5		5	As long as I can find a way to pay the bills I'd love to do more animal related projects and try to spread the word amongst others.
6	No		Yes		The workshop has emphasized the importance of practice based research to me as well as it made me reflect upon and see	I can´t think of anything particular right now. However, I found it nice that it was very snappy and	4	The most interesting to me was the fact that the field "Design for animals" is not that established	4	It was fun to work in groups and to also to keep it casual and not so serious presentations.	5		4	

					design from another perspective. Practiced based research I want to use a lot more in my further studies as I find it very helpful in elaborating a design project.	short exercises. It could be helpful though to maybe have a full day workshop rather than half... It seems a bit short maybe.		yet. There is an opportunity and designers should work on that.						

3.2. FALMOUTH DESIGN WORKSHOP FEEDBACK SUMMARY

Student	Before the workshop, have you ever considered design may have a role in addressing biodiversity erosion or human/animal relationships?	Please elaborate if you wish	Before the workshop, have you considered design may have a role in addressing biodiversity erosion or human/animal relationships?	After completing the workshop, do you believe design has a role in addressing these issues?	Has the workshop given you any practical or conceptual tools for designing for wild animals? Do you believe you might use these tools in the future?	Was there anything in the workshop that didn't make sense or felt irrelevant?	Interesting	What was interesting or not interesting about it?	Fun	What was fun or not fun about the workshop?	Comprehensible	Which elements were hard to follow or understand?	Motivating	Anything else to add?	Do you feel confident in your ability to design for wild animals?
1			Yes	test	test	test	4	testing	5	test	5	test	5	test	
2			Not really	Yes. Everyone can do something to help biodiversity. It's just helping them to help the wildlife	Yes. Definitely designing for the eco system in the future	No	4	Interesting. Never thought about designing for biodiversity before	4	Different client	4		5		More help and information
3			Not really, but the workshop is very inspiring and interesting, it has made me think about designing for non human species a lot, and may be something that I look into in the future.	Yes, through good, considered, sustainable, design many of the problems can be solved.	The theory behind designing and for non human species defiantly and the methods of research.	No.	5	The different aspects that wouldn't necessarily be thought about first hand like the external and social factors associated with designing for non human species really interested me and the great potential for suitability within the topic.	4	Quick designing was very good, perhaps a little more guidance with the research would have been appreciated.	5	Generally none, everything seas well structured and explained and the attitude was very friendly and encouraging for questions to be asked.	4	Not that I can think of...	To an extent as an introduction it was extremely successful ang gfave a lot of the theory behind the designing, however I would always be interested in learning more...
4			Yes. Design for animal is an area which really interests me.	Of course it does. Biodiveristy, the preservation of animals ext, it all has problems. And how do you fix a problem? Design.	I do not know what this means.	It was all very clear.	4	I like animals and I feel that when you're interested in something, you work much better and can go into more depth, so I enjoyed hearing of the current concepts that will be tried out on a walkway at Loo. Good use of chocolate to demonstrate biodiversity.	4	All of it was interesting.	5	Well instructed, good layout on a3 sheets.	5		Yes, there is a lot of research done about many animals so any problem you can find out in seconds and go ahead and continue the design process

5			I have considered design for animals only in from a human perspective, only looking at the benefit for humans.	Yes, design that encompasses the human and animal world together.	I was especially interested in the ways of exploring the animal as a client, such as ethnographic research and thought experiments.	No.	5	This was a topic I had not previously thought to explore, especially designing to benefit humans and animals simultaneously. It was all very interesting :)	5	It was fun to think as an animal whilst designing.	5		5		Yes, I feel as if I can easily access secondary research that would allow me to design effectively, even though I am not an ecologist.
6			No	Yes it is important to protect habitats and Eco systems.	It has helped me understand how to cater for the needs of an animal that may not be able to communicate these needs	No	5		4	Could move at a faster pace. But was interesting and informative	5		4		
7			I had considered it but never really thought about it much.	I think we can design for animals, it is harder because we cannot communicate much with them, but we should consider them more in our design projects, because design can help solve problems.	I will consider designing for wild animals in the future, I learnt a lot about the animal we chose just by doing some research.	I did find it harder to design for animals, as there is a lot to think about when designing (is that concept right, ethical etc?)...	4	It was interesting as it was an unusual type of client we had to design for.	3	It was hard to find in a short amount of time, a concept which would work and make the animal's life better...	5		3		I don't feel that confident in designing for animals, but maybe if I had more knowledge about them, or found different ways of doing research, I could find it easier to design for animals.
8			Not really no, I had thought about bringing various wildlife specs into human design but not designing specifically for ecology!	absolutely, however it entirely depends on the specie and actually getting down to the main problem that surrounds it. From doing a project with others it became difficult to not make the design intended for humans rather than seeing the animal as the client.	I will definitely use them but ones that apply to circumstances I can study and research myself. For example my group chose crocodiles and this was very difficult, I would rather use an animal that exists in the wild in the UK and is much easier to intergrade with day to day human life.	No, it was all relevant!	4	Being taught about an entire new field and involving new clients that we aren't taught about but should be on our course!	4	The fresh approach to design was fun but needed to be more active, the idea of acting seemed like it is the most effective means of understanding the needs of animals. I particularly liked the idea of how different animals view the same environment such as a town centre, how a fly may only be able to see blocks of shape and shade.	5	None	5	Not too sure, I'll have to get back to on that, but I am going to do my next project on this sort of theme!	Yes, but mainly for ones accessible for primary research, I would steer clear of animals in foreign countries on the whole, I also would rather do these sort of things in smaller groups
9			Yes, but only as a secondary impact. Not as a primary design focus.	Yes, because of the nature of design we as designers are able to engage in a wide variety of aspects such as social, environmental, scientific, philosophical and creative. Designers are able to use all of these	Yes, it has raised an awareness of the usefulness of empathy when designing for a non-communicative client. And how research can be traditionally factual but a large part is emotional.	I was not clear on why ecological diversity decreases when it is preserved with walls, preventing anything going in or out.	5	The different outlook on design as not human centred but for environment/ecology as well. It is very important as we exist in this environment and so some attention must be paid to it.	4	Chance to play about with concepts and explore different way of thinking. Was laid back and enjoyable.	4	Outline direct impact on humans of the design or focus to fully engage people. Knock on impacts ect.	4	Try explain how by doing one small thing such as improving ecology of beach life, rock pools ect may impact on a larger scale. This will help people fully engage with it	Yes, a reliable source of information about wild animals and feeling confident in understanding all the knock on impacts of altering an environment and its effect on

				things to approach a problem and are not as limited by their profession as a scientist may be.										as well. Thanks for the workshop i found it very useful, best wishes	the wildlife and food chain ect.
10			Before the worksho I was addressing animal and human relationships through design. The issue is I had always found it hard to apply it. We are also distracted by global warning and climate change; only ever looking at the direct consequences towards wildlife. ie, polar bears drowning due to the melting of the ice. I'm also aware of the consequences of over fishing and over consumption but it still does not address our relationship to the erosion of biodiversity.	After the workshop I found I had a better understanding of how we can design to address and enhance the relationship between animals and humans. There are many ways such as adapting and creating small changes that allows the relationship to be balanced.	The workshop has provide me with tools such as putting myself in the place of the animal. See what it sees, feel what it feels. It is a useful tool when assessing any client base. I has also taught me to think ahead, get the ideas flowing then stat to incorporate the practicalities and details. Try not to limit yourself.	No, it was a very coherent presentation.	4		3		5		4		
11			yes, such as integration between animal and humans, making people appriciate wild animals more instead of having pets and zoos.	yes, it has helped me see that design can really help wildlife flourish all around us and educate us about the animals, it also gives the animals a chance to adapt to human environments.	seeing good examples of the work really helped inspire imagination for certain ideas, also it is interesting but really challenging to design for an animal as a client in a day, almost hard to wrap your head around as we are used to designing in a one way sense, so it is good to get an idea of how to design but i feel like i could of had much more time to do it.	no	4	i feel like i mabye didnt enjoy it as much in a team because we where designing for an animal that didnt leave much to the imagination, so mabye suggest some animals instead of letting the team decide	2	the bad choice of animal, maybe suggest animals in future.	4	none really	4	good presentation, i enjoyed seeing personal work, but the project needed a bit more of a brief, as freedom leaves you not knowing which direction to go.	i feel with the right amount of research an observation you could really come up with a good idea, if there was briefs with set information by a client you could really grab hold of an idea without having to go too far in to the science
12			Not really I design product that more on human interaction and not on animal diversity	Yes design for animal diversity will really help on nature we live on how to bring a more sustainable ways if living	Yes it will give me new ways in how to address issues on different area in design for example a tool to understand more on user centred design	No the workshop help a lot on what can be design for	5	The interesting thing about the workshop is how to break down the animal in many ways and how to incorporate in our designs	5	Fun part was chose and design a concept that will help people would cooperate together than fear the animal	4	I found any element to be hard to understand in the workshop	4	I think you can add information about how we react to animals like china killing sharks for there fins and	I feel confident to design for animals because there more problem in wildlife due humans effects on the environment

														try encourage products that can prevent this ways of treating our animals	
13			Yes, I have reserchiert about algae and your luminance, I wanted to find out if it is possible to develop a natural lamp with the power of light algae	no, not really	The tools were already known to me and I know more methods that will help me better. Like KA method, waterfall method and other	No.	2	There were large groups on a project. Either de projects must be distributed or small groups are made	3		3	I´m a erasmus student, and I have some problems to understand English	4		I realize that I have a lot of research and the experts have to ask in order to clarify some question, not everything is in books, you have to watch by yourself also
14			I always knew that design can be used as a medium to address various issues. But I realised through your workshop that what I am familiar with is the conventional way that design is used within a human/animal relationship: more about "protecting" humans and "creating a distance" from other animals, rather than understanding the animal and closing the gap.	Yes, of course. After your workshop my initial viewpoint changed and now I am sure that designers can definitely learn to include biodiversity in their everyday design processes. Humans getting closer to [wild] animals: it's a brave new world waiting to be explored! Not only human-centred design but also human/animal-centred design! Great stuff!	Yes. First of all, through the examples you provided, you gave me a fresh "pair of eyes" for looking at the overall design process. Now I have a new designer's mindset that will try to pursuit the inclusion of animals in my designs - accommodating animals rather that isolating them from humans. As you mentioned, "getting together with some grace".	Nothing felt irrelevant - as a conceptual approach, it is still challenging to put it into real practice, but this is something that I am really looking forward to doing as a future designer!	5	The example of seeing the world through the eyes of an insect, as well as dance improvisation as a technique for knowing the animal.	5	Designs students getting together to try this new mindset of design thinking.	4	How can we be sure that the way we think we see the animal is as accurate as possible? Challenging!	5	Thank you for a very special workshop!	I am not sure, because this is something I haven't done before, but now I have a starting point.

3.3. Art & Environment Workshop Feedback Summary

Participant	Before the workshop, have you considered design may have a role in addressing biodiversity erosion or human/animal relationships?	After completing the workshop, do you believe design has a role in addressing these issues?	Has the workshop given you any tools or new ways of thinking about working with wild animals in your practice? Do you believe you might use these in the future?	Was there anything in the workshop that didn't make sense or felt irrelevant?	Interesting	What was interesting or not interesting about it?	Fun	What was fun or not fun about the workshop?	Comprehensible	Which elements were hard to follow or understand?	Motivating	Do you feel confident in your ability to design for wild animals?	Anything else to add?	Do you believe creative practices have a role in biodiversity conservation?

1			The works shop was fantastic, it has helped me to think about animal in a different way as collaborators, but also that I may be able to benefit both humans and animals with my work	No, it was all great	5	I think the whole presentation and workshop was interesting, but particularly your approach to working with both humans and animals	5	Spending time with informed creative people, listing to ideas develop etc.	5	None it was all very clear.	5			Definitely. I feel that most creative people are trained to consider problems in a very broad manner, when I teach creative practice it is about thinking around anything in an imaginative way.
2			Yes. Although I work for 2 year old children I found it similar to working with animals. They don't speak for themselves & need the researchers/designers to tune into them	No.	4	The quotes & overview if the field at the beginning.	4	Balance between presentation & working with others with Daniel supporting work.	4	Just the first bit hadn't realised we had 5 minutes just to decide in an animal...went into solutions etc.	1			Yes by coming up with innovative solutions not easily found in ither practises
3			Not so much about wild animals, but ways to think creatively about relationships between animals and human in general. I found the approach and exercise very good and would use it in future work.	NO	4	the perspective change as in creating something FOR the animal was very good There wasn't anything, that was not interesting.	5	It was played for me and Claire to create something for our spiders!!!! It became quite real!!!	5	none	5		I think we need to address our relationship with animals and seeing them as equal partners on this planet instead of food and clothing resources. In industrialized countries human are too far removed from animals. Good luck with your Work and it was great to have meet you!!!!!!	Yes, I do believe that creative practice can pick up Responsibilities, as a part of a paradigm shift from "Art for Art Sake" to ways of social interaction and inclusiveness. My own practice is concerned with the unsustainability of the garment industry in particular where wool is concerned and I aim to raise awareness in the British Rare Breed Sheep and local sheep production.
4			Yes, though, as someone who predominantly attended as a scientist rather than an artist/designer, my interest and focus may have been a bit different from everyone else's. I appreciate having a chance to hear about how designers and artists think, and to think about how their forms of creativity differ from those normally observed in scientists. Conversely, I thought it was exciting to hear how much of the language, and many of the ideas, have some overlap with those of scientists; I think this indicates a real possibility to have meaningful collaborations.	No. However, I did think that the best proposals and discussions centred on ideas that were founded on accurate scientific knowledge. For example, there was one group who discussed elephants, but didn't really know anything about the biology of elephants or the nature of human-elephant conflicts. I thought the best discussions were those that involved animals and mini-projects that were well informed. Maybe in the future it would be better if all participants brought laptops so they could do some quick	5	I enjoyed seeing examples of projects that had been inspired by, or were intended for use by, wildlife; I particularly liked hearing about Daniel's own research. It was interesting to talk to artists and designers and hear about the vast array of things they do, and to get an idea of how they think their own tools and materials and visions can be integrated with science.	5	It was fun to explore all the potential creative solutions to a particular problem, without worrying about the constraints of budgets or scale or anything like that--to just sit down and come up with some exciting ideas that would be fun to play with in the real world.	5		5		Each year, I do a lecture for science journalism students about the "behind-the-scenes" world of academia and professional science. I wonder if it would be worth having a section like that in your book? Everyone at the workshop acknowledged that it is really important to do some research in order to get a basic understanding of the focal animal, and that some of this research might involve professional scientists. For many people, interacting with those people, and approaching that world, can be	Yes, absolutely. People will never agree to conservation policies if the policies, and the resulting management practices, will result in any sort of inconvenience--whether this means areas that are off-limits, or activities that cannot be performed in a certain way, or inability to use certain materials, etc. It will be necessary to find creative solutions to these problems, making conservation more palatable and easier to accomplish.

				research on their focal animals in order to incorporate accurate natural history considerations.									intimidating or mystifying, so it's useful to know a bit more about how it is structured and what those people are like (e.g., what their jobs consist of, whether they are open to being approached by strangers, how best to contact them, etc.). It might also be useful to think about how people conduct fundamental research and what sorts of permits are required to gain access to particular species and places--after all, it's no good trying to initiate a design/art project for an organism or habitat that you ultimately won't be allowed anywhere near! This kind of knowledge might help make people feel more secure about approaching potential collaborators...	