

HOLY ISLAND / LINDISFARNE NATIONAL NATURE RESERVE

Translating Clock Time into Wildlife Time

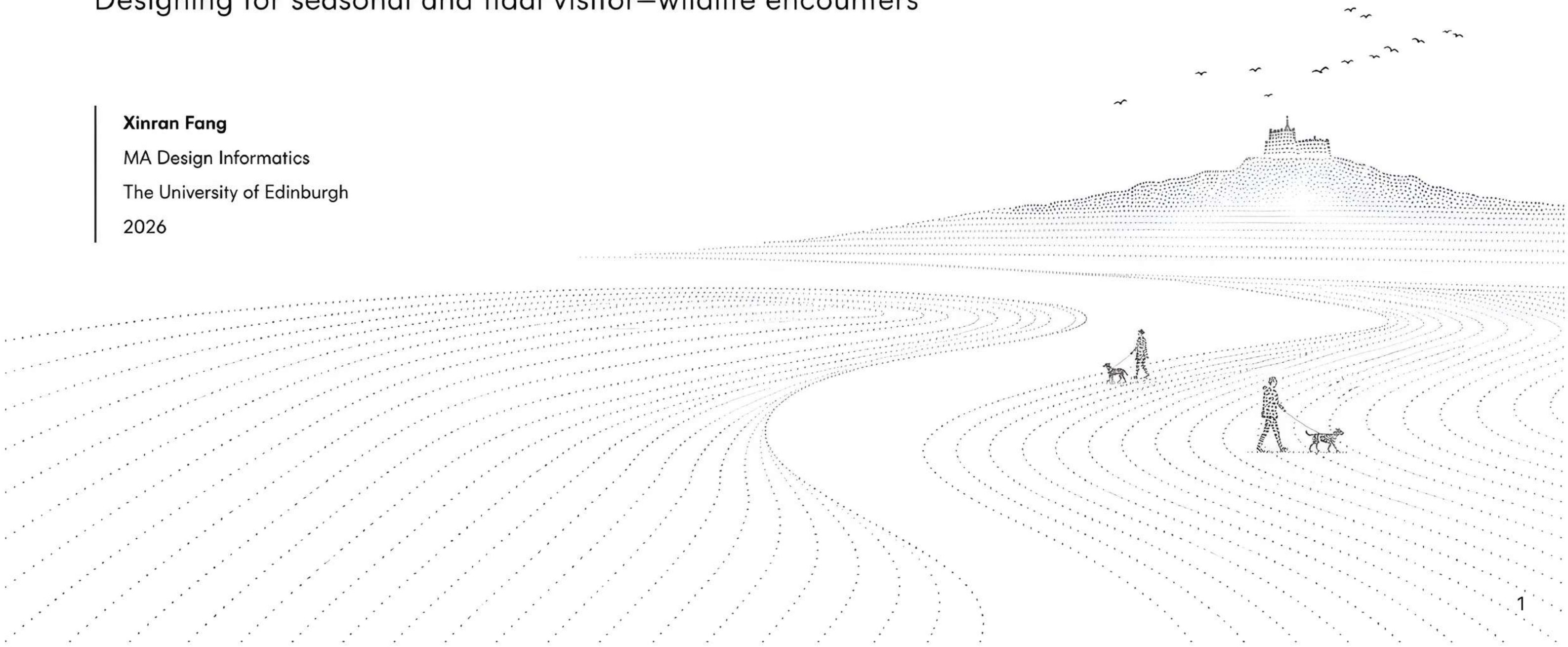
Designing for seasonal and tidal visitor—wildlife encounters

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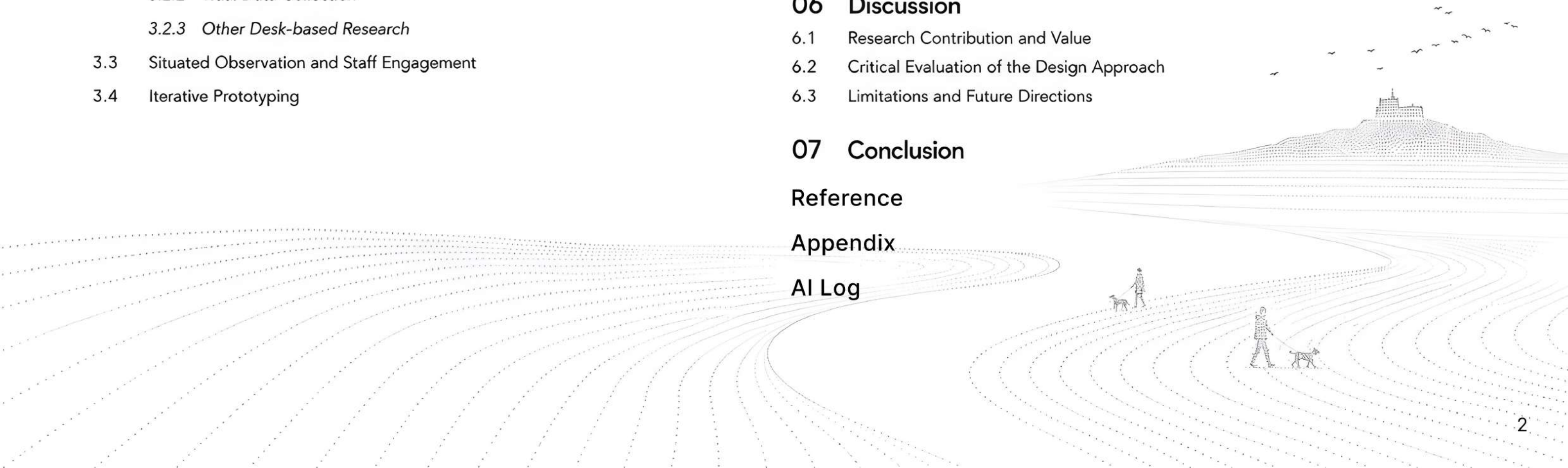
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CHAPTER

01

Introduction

Introduces the project context and asks how seasonal and tidal wildlife rhythms can be translated into situated visitor guidance on Holy Island.

1. Introduction

Holy Island is both a popular visitor destination and an important wildlife habitat. People visit the island for its history, religious heritage and coastal landscape, while the surrounding Lindisfarne National Nature Reserve supports birds and other wildlife throughout the year (Natural England, 2014; Wild, 2012). Visitors and wildlife therefore use the same environment for different purposes, making Holy Island a useful context for exploring how tourism and wildlife conservation coexist within a shared landscape.

Sharing the same landscape, however, does not necessarily mean that its ecological role is visible or understandable to visitors. Research has shown that visitor activity can affect wildlife, the effects vary according to the conditions of an encounter (Larson et al., 2016; Tablado & Jenni, 2017). On Holy Island, existing visitor management uses signs, paths, boundaries and access restrictions to guide visitor behaviour and protect sensitive areas (Natural England, 2014). These spatial measures are important for communicating what visitors are expected to do. However, they have a more limited effect to explain why a particular place may be ecologically important under particular conditions. The issue addressed by this project is therefore not simply a lack of conservation information, but how the ecological reasons behind visitor guidance can become more understandable.

This question becomes particularly important because the ecological meaning of the beach-mudflat environment is not fixed. Wildlife activity and habitat sensitivity change across seasonal and tidal conditions, meaning that the same beach or mudflat may have different ecological significance at different moments. Visitors, by contrast, commonly organise their journeys through dates, clock time and the causeway crossing timetable. Clock time is essential for planning access to Holy Island, but on its own it does not communicate what the same moment may mean ecologically. This creates a design opportunity not to replace human clock time with wildlife time, but to use familiar temporal references as an entry point into changing ecological rhythms.

The project responds to this opportunity by exploring how a visitor's selected clock time might be translated into an interpretation of seasonal and tidal ecological conditions. Rather than presenting season and tide as separate background information, the design connects them to what wildlife may be doing at a particular moment, why that condition matters and how a visitor might respond. The project therefore asks: How can seasonal and tidal wildlife rhythms be translated into situated visitor guidance within the beach-mudflat environment of Holy Island?

A Research through Design approach was used to investigate this question. Desk-based research first established an ecological and contextual evidence base, which was then situated and refined through site observation and engagement with the reserve manager. These findings informed the development of the prototypes, while subsequent design iterations, formative feedback and further research were used to check and revise emerging decisions. Research and design therefore developed iteratively throughout the project rather than as separate stages.

The project developed two connected prototypes: the Time Translator and a situated AR experience. The Time Translator is the core prototype for translating a visitor's selected clock time into seasonal and tidal ecological interpretation. The AR experience then extends this interpretation into the physical landscape by exploring how ecological relationships that are difficult to perceive directly might become more noticeable in situ. Together, the prototypes investigate a time-based approach to environmental interpretation that connects visitors' familiar temporal references with the changing rhythms of wildlife. They are intended as interpretive design propositions rather than precise ecological predictions, tracking systems or official visitor guidance.

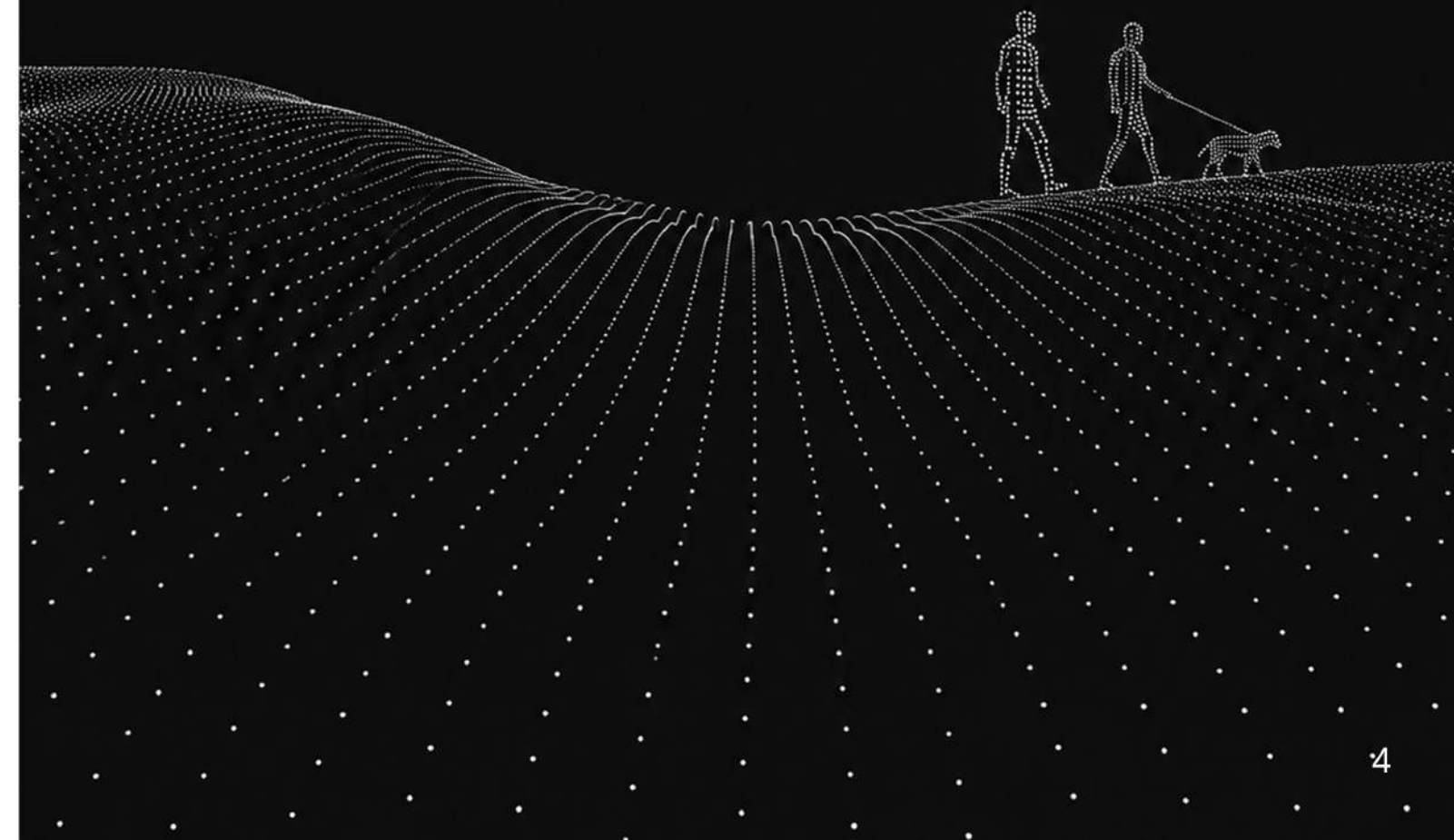
The dissertation develops this argument across six further chapters. Chapter 2 establishes the contextual and theoretical foundations of the project. Chapter 3 explains the Research through Design approach and research methods. Chapter 4 presents the main findings and develops them into a design framework, while Chapter 5 shows how this framework was translated and refined through the two prototypes. Chapter 6 critically discusses the contribution, limitations and future development of the project. Finally, Chapter 7 returns to the research question and brings together the main conclusions of the study.

CHAPTER

02

Context and Literature Review

Establishes the theoretical and contextual foundations for understanding visitor-wildlife encounters through clock time, ecological rhythms and more-than-human responsibility.



2. Context and Literature Review

2.1 Shared Landscape but Different Understandings

The Holy Island of Lindisfarne is a landscape shaped by the coexistence of tourism, heritage and nature conservation (Figure 2.1). Wild (2012, p. 126) notes that the island receives "in excess of half a million visitors per year" and estimates that tourism accounts for "between 70 and 80% of the island's economy". These figures show that tourism is central to both the island's economy and the way its landscape is used, making visitor-wildlife relations an important part of conservation on Holy Island. The island's historical and religious heritage also contributes to its role as a visitor destination, as it continues to attract visitors interested in both its "religious and secular history" (Wild, 2012, p. 126). At the same time, Holy Island forms part of Lindisfarne National Nature Reserve, managed to support birds, plants and landscape alongside the people who live and visit there (Natural England, 2014). Holy Island therefore cannot be understood as a single-purpose landscape. It is simultaneously a place of recreation and cultural interest, and an active ecological environment subject to conservation management.

Within this shared landscape, visitors and wildlife use the same environment in very different ways. Visitors engage with Holy Island through temporary visits to heritage attractions, walking and recreation, whereas the reserve provides wildlife with habitats for feeding, resting and breeding (Natural England, 2014). Spatial coexistence does not automatically lead to ecological understanding: Gruas et al. (2020, p. 8) suggest that recreationists often have limited awareness of the consequences of their activities for wildlife. Visitors may therefore share the same environment with wildlife without necessarily recognising how that environment is being used ecologically or how their own activities may affect it.

For this reason, Holy Island provides a suitable context for investigating how design might mediate the relationship between visitors and wildlife. The significance of the site lies not simply in the presence of both tourism and conservation, but in the fact that they operate within the same landscape while being understood through different forms of use. Visitors move through spaces that are simultaneously being used by wildlife, yet the ecological significance of those spaces may not always be apparent to them. This creates a situated design problem: how might visitor-facing design make the ecological use of a shared environment more perceptible, so that visitors can better understand the conditions they are entering and respond to them more appropriately?

2.2 Clock Time and Ecological Rhythms

Beyond the spatial differences in how visitors and wildlife use the landscape, temporal rhythms also change how their activities are organised. Human activity is commonly coordinated through standardised forms of time, including hours, dates, timetables and schedules. Lefebvre describes this as linear repetition, which consists of the recurrence of similar actions at "roughly similar intervals" (Lefebvre, 2013, p. 8). Such temporal organisation enables everyday practices to be planned and coordinated through a shared clock-based framework. On Holy Island, this clock-based time becomes especially visible because access is closely tied to scheduled safe-crossing times (Northumberland County Council, n.d.). Clock time therefore functions as a practical framework through which visitors organise their journeys to and from the island.

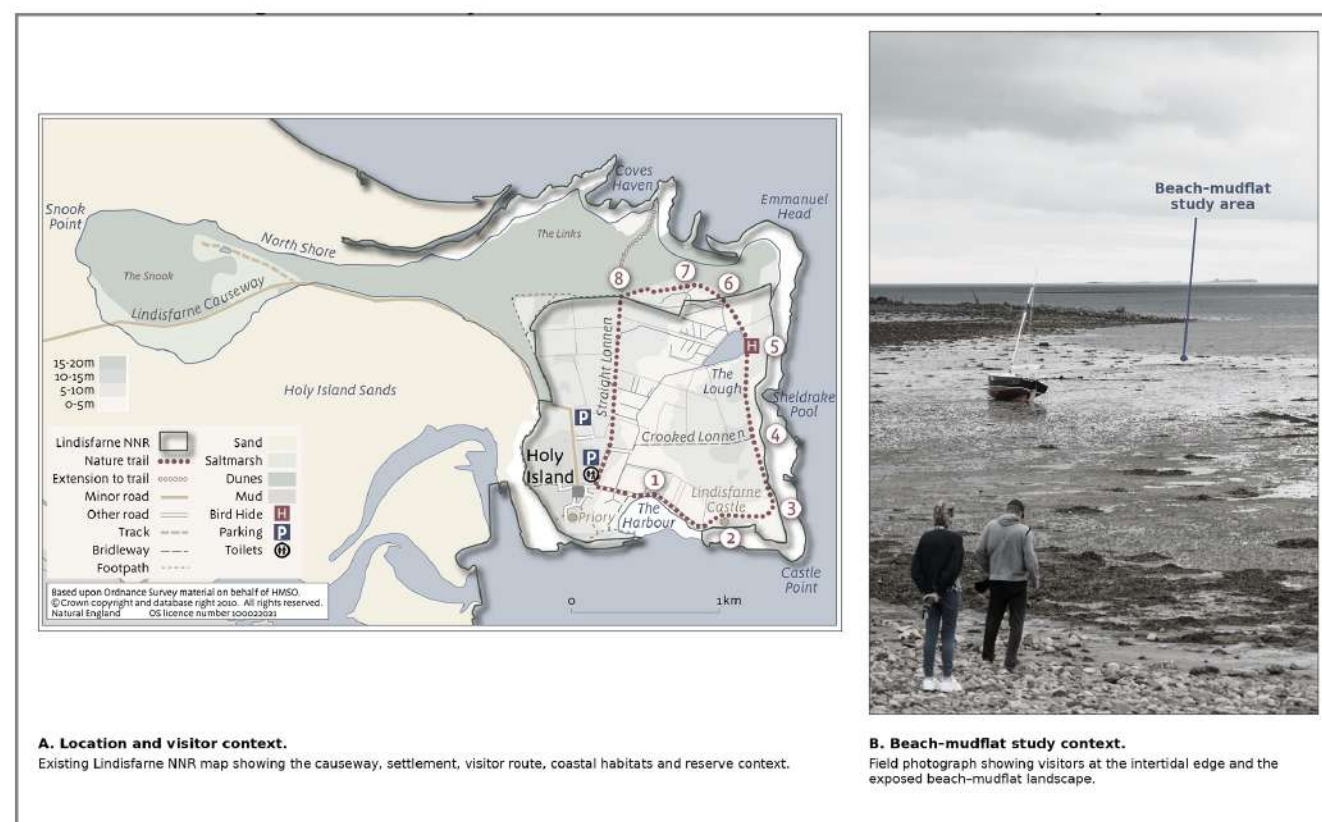


Figure 2.1 Holy Island as a shared visitor-wildlife landscape

By contrast, ecological activity, responds to changing environmental conditions. Lefebvre associates cyclical rhythms with "days, nights, seasons, the waves and the tides of the sea" (Lefebvre, 2013, p. 8). Unlike linear rhythms organised through standardised intervals, these cyclical rhythms emerge through recurring environmental phenomena and continually reshape habitat conditions. This distinction is particularly relevant to Holy Island, where wildlife use of the landscape changes through seasonal and environmental cycles (Figure 2.2). For example, migratory birds stop over during spring and autumn, while winter brings major concentrations of wildfowl and wading birds (Natural England, 2014). The ecological meaning of the landscape is therefore not fixed, but changes as different wildlife activities emerge across these recurring rhythms.

Clock time should therefore not be treated as the only temporal framework through which the landscape can be understood. Adam describes clock time as a form of time "abstracted from context and content" (Adam, 2006, p. 119), which helps explain why a scheduled time alone cannot show what is happening ecologically in a particular place. This distinction is analytical rather than absolute. Clock-based schedules and ecological rhythms coexist within the same landscape and may intersect through the activities of visitors, wildlife and environmental change. The design question is therefore not how one form of time might replace another, but how these different temporal references might be made more legible in relation to one another.

2.3 More-than-human Design and Visitor Responsibility

The need to become more attentive to other species' temporalities also raise a question for design: how can design respond to rhythms that are not organised around human priorities? More-than-human design provides one way to approach this question. It extends the scope of design beyond human users to include animals, plants, ecosystems and the relationships through which humans and non-humans coexist (Forlano, 2017). This perspective challenges the tendency to treat non-human life merely as environmental background or as a resource for human use, and therefore shifts the focus from designing only for humans towards designing within a wider network of ecological relationships.

This perspective is particularly relevant to visitor-wildlife relationships because visitors do not simply observe the environment; their presence and behaviour can also affect the other species that use it. In a global systematic review of 274 studies of non-consumptive recreation, Larson et al. (2016) found that over 93% of the reviewed articles documented at least one effect of recreation on animals, and that 59% of these effects were classified as negative. This finding shows that activities commonly understood as low impact may still affect animals or habitats. Moreover, these effects are not uniform across different encounters. Tablado and Jenni (2017, p. 217) identify three categories of factors that modulate wildlife responses to human disturbance: factors related to "the humans themselves", intrinsic characteristics of the animals concerned, and the "spatio-temporal context" of an encounter. This means that the ecological consequences of a similar visitor activity may differ as well.

Different Temporal Frameworks on Holy Island

Clock-based human organisation and ecological rhythms shaping the same landscape

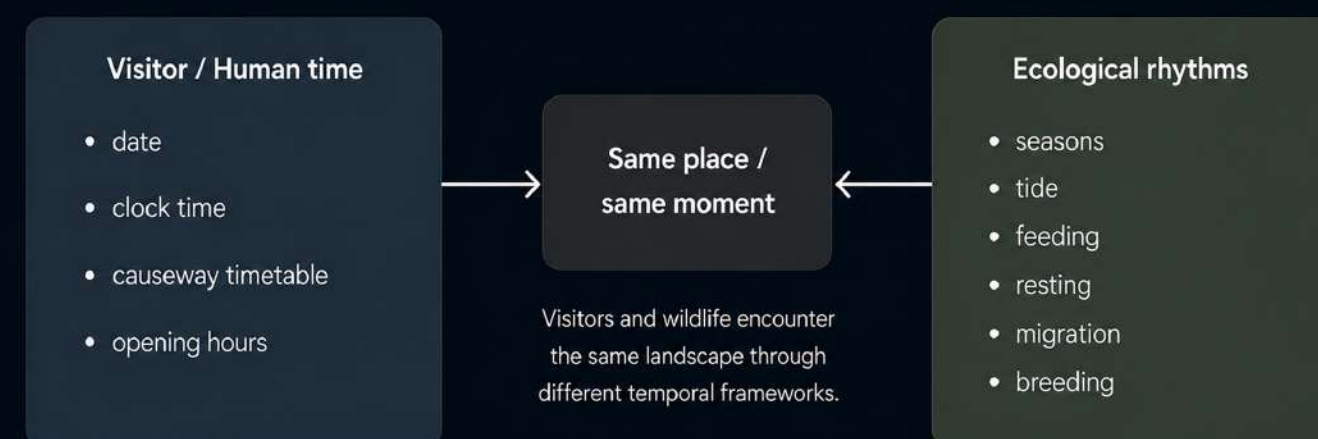


Figure 2.2 Different temporal frameworks on Holy Island

Recognising this connection also raises a question of responsibility. Within the visitor management context of this project, this shifts the design question towards how visitors might adjust their own behaviour in response to wildlife needs. Wildlife cannot be expected to reorganise feeding, resting or breeding activities around visitor schedules; Design facing to visitors can, however, influence how people move, time their activities and respond to ecological sensitivity. Marion and Reid (2007, p. 5) describe low impact education programs in protected areas seeking to maintain "high quality visitor experiences" while avoiding or minimising damage to the environment. This dual purpose indicates that visitor experience and environmental protection should not be treated as separate design objectives. Rather than simply making a landscape easier to access, design facing to visitors should help people recognise when, where and why their behaviour may need to change in response to wildlife needs. However, the challenge is that wildlife needs are often not directly visible to visitors. This raises the question of how ecological knowledge can be communicated within the visitor experience.

2.4 Environmental Interpretation and Situated Design

One role of environmental interpretation is to make ecological knowledge understandable to visitors. At a seal-watching site, Marschall, Granquist and Burns (2017) found that teleological signs explaining the purpose of protective behaviour were, in some situations, more effective than signs that simply stated what visitors should do. This suggests that visitor guidance can be more meaningful when behavioural instructions are connected to the ecological reasons behind them. Beyond providing more ecological information, the next challenge is to make that information meaningful in the situations where visitors encounter it. As discussed above, wildlife responses can vary according to species and spatio-temporal context (Tablado & Jenni, 2017), suggesting that general conservation guidance may not always reflect varying conditions. Situated interpretation offers one way of addressing this challenge. Dean (2021) found that national-park interpretation and place-based education use the distinctive attributes of a place to facilitate meaning-making. Applied to visitor-wildlife relationships, this suggests that ecological guidance should also connect general conservation principles to particular sites and circumstances.

Many wildlife activities and habitat functions may still remain difficult to perceive directly, creating a role for digital and augmented forms of interpretation. Augmented reality (AR) can embed digital information within the physical environment and provide "contextualized, just-in-time instruction" during environmental field experiences (Kamarainen et al., 2013). This makes AR potentially useful for connecting hidden ecological processes to the landscape. At the same time, AR representations might simplify ecological complexity. Research on environmental-model visualisation shows that visually appealing representations do not always lead to accurate understanding, especially when uncertainty is not clearly communicated (Bannister et al., 2021). This creates a design challenge: ecological information needs to be made visible without making it misleading. Yet this challenge also creates an opportunity to explore how changing wildlife rhythms can be translated into situated visitor guidance in a clear but careful way.

CHAPTER



Methodology

Explains how Research through Design connected ecological research, situated observation, expert engagement and iterative prototyping throughout the project.



3. Methodology

3.1 Research through Design

This project adopted a Research through Design approach, in which designing was used not only to investigate how ecological rhythms might be interpreted and communicated to visitors (Zimmerman et al., 2007). This was the most appropriate approach because the research question concerned a relationship that could not be examined through ecological data alone: how seasonal and tidal wildlife rhythms might be translated into situated visitor guidance.

The research process was therefore iterative rather than linear. Zimmerman, Forlizzi and Evenson describe Research through Design as a process involving grounding, ideation, iteration and reflection (Zimmerman et al., 2007). In this project, research findings informed the development of design concepts and prototypes, while prototypes exposed further questions that required reconsideration and refinement through feedback and further research. In this way, designing functioned as part of the inquiry itself, allowing the project to move repeatedly between understanding the problem, developing a possible response and critically revising that response. The following methods were therefore used as interconnected components of this process, each contributing to and informing the development of the project.

3.2 Desk-based research

Desk-based research was used to establish an ecological and contextual understanding of Holy Island before the design process moved into more situated investigation. This was necessary because the project concerned wildlife rhythms that unfold across seasonal and tidal timescales and could not be captured through a short period of field observation alone.

3.2.1 Seasonal Data Collection

The first stage focused on seasonal wildlife activity. The Lindisfarne NNR blog (Lindisfarne National Nature Reserve, n.d.) was used as the main source because its dated posts from 2012 to 2025 document bird arrivals, feeding, roosting, breeding and migration (Figure 3.1), allowing recurring seasonal changes in wildlife activity to be identified beyond individual observations. An AI-assisted scraping and extraction process was used to locate dated records relating to species presence and activities such as arrival, feeding, roosting, breeding and migration. Relevant extracted entries were checked against the original NNR posts before being included in the chronological dataset, after which the records were compared manually across dates and years to identify recurring patterns.



Figure 3.1 — Examples of dated NNR records used in seasonal data collection

The resulting records were arranged chronologically and grouped according to recurring changes in dominant wildlife activity. For design purposes, these patterns were synthesised into four broad interpretive phases: Winter Refuge, Spring Transition, Breeding-Nesting and Autumn Passage (Figure 3.2). Blur boundaries were assigned where the dominant pattern of reported activity appeared to change. Because wildlife arrival, departure and breeding activity develop gradually, adjacent phases were allowed to overlap rather than being separated by fixed calendar dates. As the blog was not a systematic ecological dataset and coverage varied between years, these phases were treated as broad interpretive periods rather than fixed ecological seasons. For use within the prototype, however, each calendar date needed to return a single seasonal state. Dates within transitional overlaps were therefore assigned to the dominant interpretive phase used by the interface. This was an operational simplification intended to maintain a clear visitor interaction rather than to suggest that ecological transitions occur at fixed calendar boundaries. The resulting phases, date ranges and interpretations were subsequently reviewed with the reserve manager for ecological plausibility and site relevance.

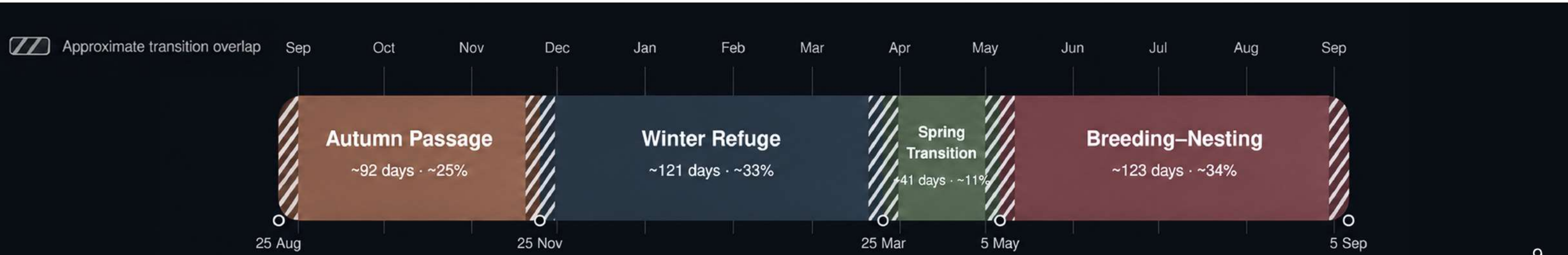


Figure 3.2. Annual timeline of the four seasonal interpretive phases and their approximate transition overlaps

3.2.2 Tidal Data Collection

While seasonal data provided an annual context for understanding wildlife activity, it could not explain how the same habitat might change over the course of a single day. To address this shorter timescale, the second stage examined tidal change. Holy Island experiences a repeating tidal cycle in which the causeway connecting it to the mainland is cut off twice each day during high tide (The Holy Island of Lindisfarne, n.d.). Treating the tide only as high or low would reduce it to two fixed conditions and overlook the transitions between them. The tidal cycle was therefore divided into four interpretive states: High Tide, Outgoing Tide, Low Tide and Incoming Tide. This made it possible to consider not only how much intertidal habitat was exposed, but also whether it was being uncovered or covered, as these processes may influence habitat availability and wildlife activity differently.

However, the available data did not provide these four ecological stages directly, so this data had to be converted into an approximate four-stage tidal classification (Figure 3.3). For each safe crossing window, the published opening time was defined as S and the closing time as E , giving a total safe duration of $D = E - S$. The window was then divided proportionally into three parts. The first 40% of the window was classified as Outgoing Tide, the middle 20% as Low Tide, and the final 40% as Incoming Tide:

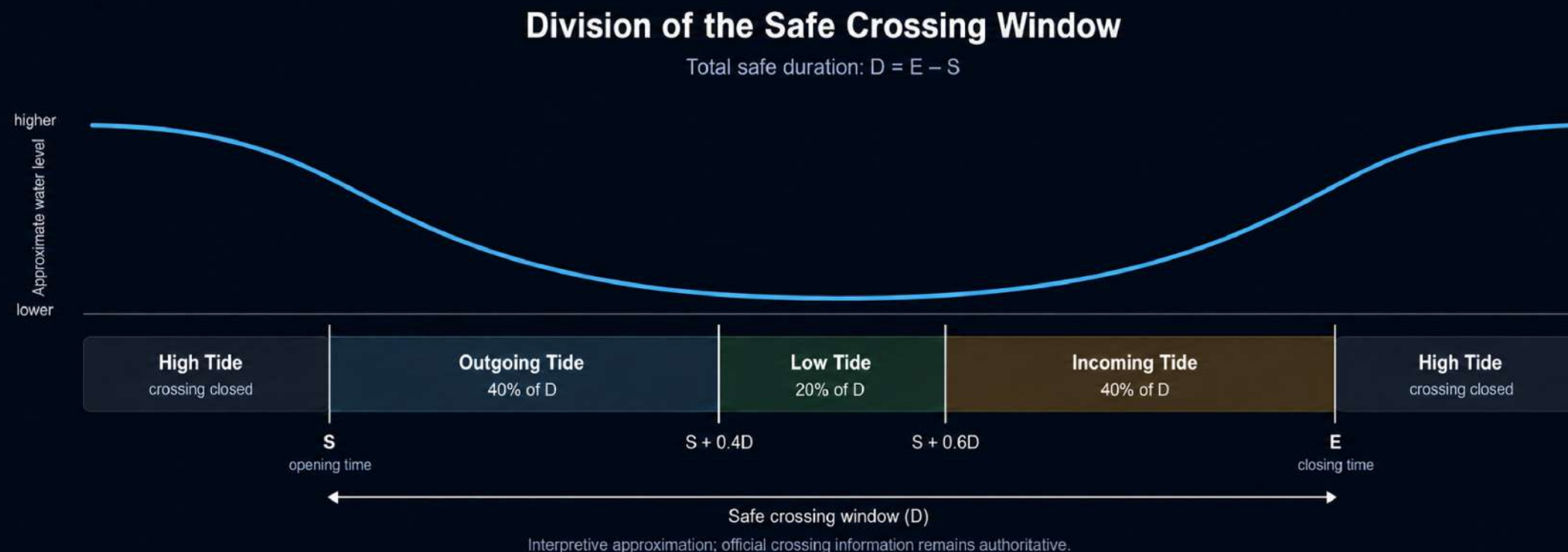
The period between the end of one safe window and the beginning of the next was classified as High Tide. This allowed any selected date and clock time to be matched with one of the four tidal states. Formula can be listed as follow:

$$\text{Outgoing Tide: } S \leq t < S + 0.4D$$

$$\text{Low Tide: } S + 0.4D \leq t < S + 0.6D$$

$$\text{Incoming Tide: } S + 0.6D \leq t \leq E$$

Figure 3.3 Translation of crossing windows into four approximate tidal states



The 40–20–40 division should be understood as a design heuristic rather than a scientific tidal model. It was used to create a workable distinction between a shorter period around low water and the longer transitional periods on either side, while retaining the direction of tidal change within the interface. The proportions were not derived from direct water-level measurements or astronomical tide calculations and therefore do not represent precise tidal boundaries. Similarly, the label “High Tide” is used in the prototype as an interpretive shorthand for the broader causeway-closed period rather than the exact astronomical high water point. The resulting four states were therefore used to support temporal interpretation within the design, not to provide real-time tidal prediction or safety guidance.

3.2.3 Other Desk-based Research

The third stage examined existing visitor management. NNR visitor guidance and byelaws (LIFE WADER, n.d.; Natural England, 2014) were organised according to the behaviours they addressed, including keeping to paths, controlling dogs, maintaining distance from wildlife and avoiding disturbance. This provided a record of how the reserve currently translates conservation concerns into practical expectations for visitors.

Finally, supporting ecological literature and official reports were used to supplement or cross-check where the main sources were incomplete or required further explanation. This included uncertain seasonal periods, species-specific information and relationships between tidal change and habitat use. Together, these sources provided contextual evidence for the subsequent site-based investigation and design development, while remaining uncertainties in the desk-based material were examined through situated observation and engagement with reserve staff.

3.3 Situated Observation and Staff Engagement

Building on the desk-based research, the next stage aimed to place the initial evidence within the specific context of Holy Island and to address questions that published sources alone could not resolve. Site observation was used to examine how visitor routes, conservation guidance and the habitats were encountered in practice. However, observation could only show what was visible on site; it could not explain things behind reserve management decisions. Engagement with the reserve manager was therefore used alongside observation to provide specific site ecological and management knowledge and to check areas of uncertainty identified during desk-based research. The following sections describe these two methods in turn, beginning with site observation and then discussing the engagement with the reserve manager.

Site observation focused on the public-facing areas in which visitors encounter both the landscape and existing guidance, including public routes, signs, fences and visitor behaviours (Figure 3.4). Photographs and field notes were used to record how these elements were designed and how they related to the surrounding habitat. The observation remained non-interventionist: visitors and wildlife were not approached or disturbed. The purpose was to understand how the spatial and informational conditions identified through desk-based research appeared in the actual site context.

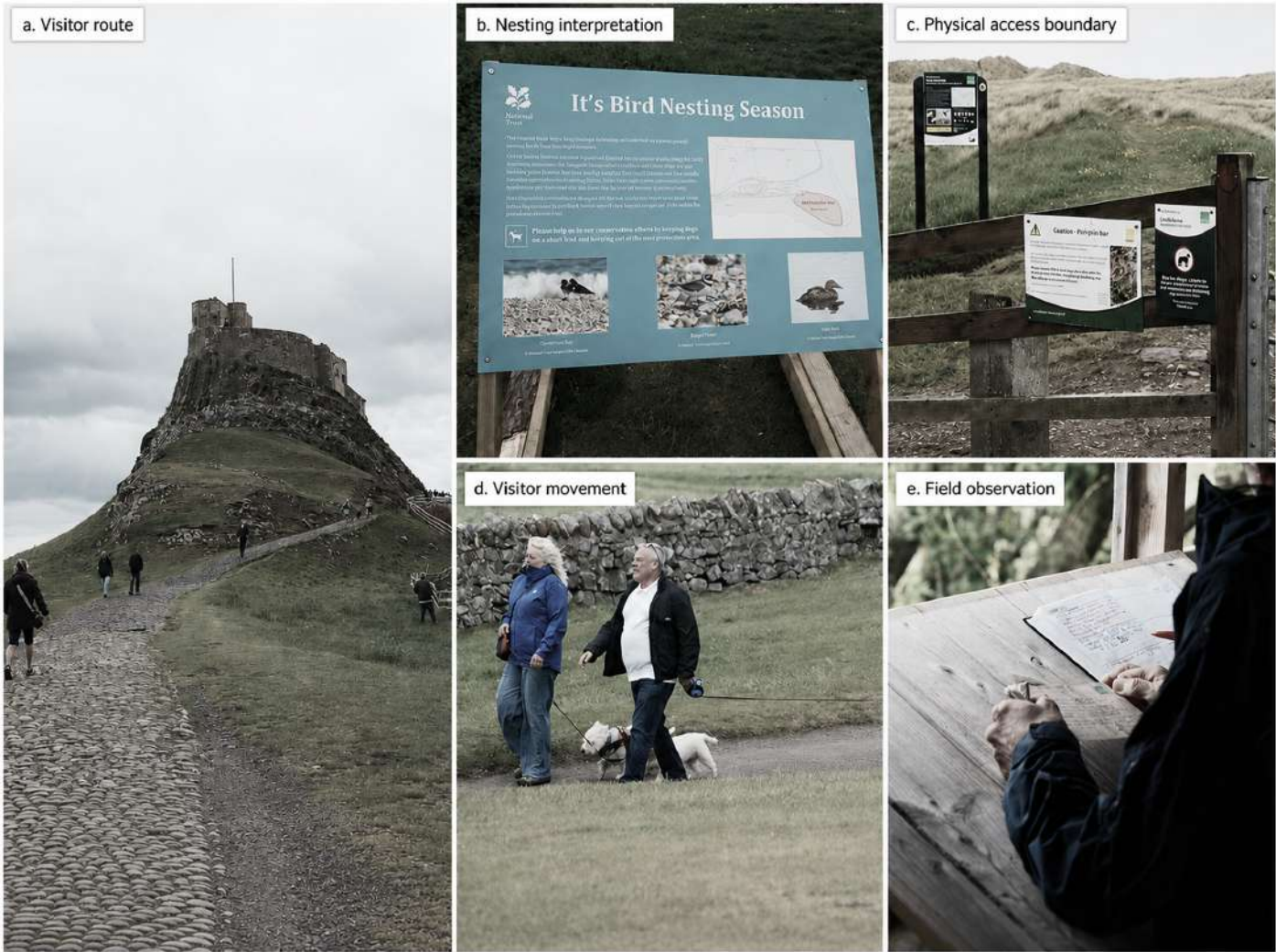


Figure 3.4 Site observation photographic record

The site observation was conducted on 6 June during a visit of approximately four hours. The observation covered main routes, the residential edge, beach and mudflat areas, signs and fences, historic sites, wildlife viewing locations and visible visitor behaviour, focusing on locations where visitors encountered the landscape or conservation guidance. As the observation represented a limited snapshot of one visit rather than repeated behavioural study, it was used to identify situated design conditions and possible issues for further investigation rather than to make claims about visitor behaviour.

Alongside site observation, engagement with the reserve manager took place at two stages of the project, providing a long-term and practical perspective that complemented the situated research. The first discussion took place on site on 18 June, before design development. While observation provided a snapshot of the site during the field visit, the reserve manager's ongoing involvement in wildlife conservation and visitor management (Figure 3.5) provided insight into how ecological conditions, visitor pressures and management responses change across seasons and situations. The discussion covered site sensitivity, habitat differences, common forms of visitor disturbance and existing management approaches, while also providing an opportunity to review and refine information previously collected through desk-based research.

A second engagement took place online on 8 July, in the design process, and focused on formative feedback on the developing prototypes. This helped refine ecological interpretation, habitat scope and the relationship between the proposed guidance and existing reserve practices. Feedback from both engagements was considered alongside site observations and published material to clarify factual details, refine the project scope and inform subsequent design decisions. These engagements functioned as formative expert consultation rather than formal interviews or evidence of visitor outcomes.



Figure 3.5. Two stages of reserve manager engagement

3.4 Iterative prototyping

Taken together, the desk-based research including situated observation and staff engagement formed the evidence base for the design process. At the same time, the prototypes themselves exposed areas where the existing evidence was unclear or difficult to represent, creating a repeated movement between research and design.

The project did not move directly from research into a fixed design stage. Initial desk-based research first established a preliminary understanding of wildlife rhythms and the context of Holy Island. This understanding was then examined through site observation, where it provided further evidence for the initial ideas. However, new evidence also raised new questions, prompting these ideas to be reconsidered and further developed. These emerging ideas were subsequently discussed with the reserve manager and staff. Their long-term experience of the reserve provided a further perspective, helping to refine the understanding from which the first prototypes were developed.

Once prototyping began, the process became more iterative. As a rough design prototype was developed, further desk-based research was used to support and check the information. Refining the prototype also revealed new problems, such as how ecological relationships should be simplified and communicated, which led to reflection and further design changes. The revised prototypes were then discussed with the reserve manager and supervisor for formative feedback. When this feedback raised ecological or site-specific questions, the project returned to the research material for further checking before the prototype was revised again. The same process was repeated through later iterations. The overall process is summarised in Figure 3.6, while the specific design iterations and resulting changes are discussed in Chapter 5.

Methodological relationships in the Research through Design process

How desk-based research, situated investigation and iterative prototyping informed one another

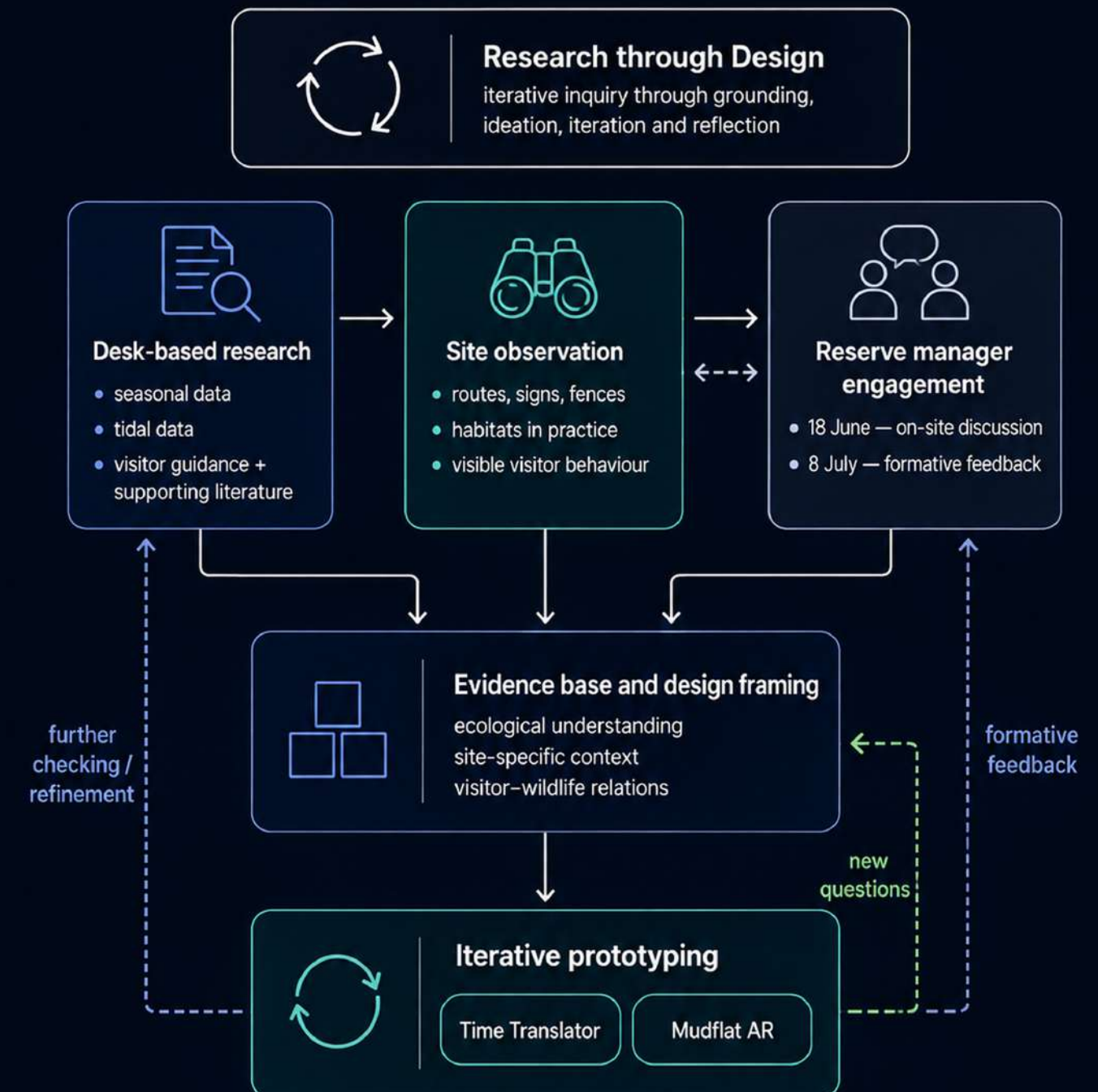


Figure 3.6 Iterative Research through Design Process

CHAPTER

04

Research Findings and Design Framing

Identifies how changing seasonal and tidal conditions reshape habitat meaning, translating these findings into visitor responsibility and design requirements.



4. Research Findings and Design Framing

4.1 From Spatial Guidance to Temporal Interpretation

As discussed in Section 2.1, visitors and wildlife may share the same landscape while using and understanding it differently. The ecological role of a habitat is not always visible to visitors, even when wildlife is active. On Holy Island, this creates a challenge for visitor management because people may be asked to change their behaviour without fully understanding the ecological reasons behind that request. This section explains how site observation and further ecological research led the project from spatial guidance towards temporal interpretation.

Physical boundary management remains necessary. At Lindisfarne, fences, access restrictions, managed paths, viewing areas, warning signs and byelaws are used to reduce pressure on sensitive habitats and species. These measures make otherwise invisible ecological boundaries more legible by showing visitors where they should walk, where access is restricted and which areas require greater care. This is particularly important where nests, chicks or feeding activity cannot be easily detected within the landscape.

Site observation nevertheless suggested a possible gap between the presence of information and the attention it receives. Some visitors passed fences or signs without visibly slowing down or stopping to read them. This observation cannot establish whether the signs were unnoticed, understood or remembered, nor can it demonstrate their overall effectiveness. It does, however, indicate that the presence of information alone does not guarantee visible engagement within the visitor experience. In some cases, detailed species descriptions and general conservation messages also made the behavioural instruction less visually prominent. Visitors may therefore see that a boundary or warning exists without fully understanding why it has been introduced.

The limitation is not only whether visitors notice, but also what these management approaches are able to explain. Spatial guidance such as fences can indicate where visitors should or should not go, but it does not necessarily make the ecological reasons behind these boundaries apparent. Behavioural guidance such as signs can explain why care is required and what visitors are expected to do, but it may still present ecological sensitivity as relatively fixed rather than showing how it changes across seasonal and tidal conditions. More importantly, the issue was not only how ecological sensitivity was communicated, but that the sensitivity itself was not fixed. Further ecological research showed that the significance of the same habitat could change over time as wildlife activity and habitat availability shifted.

More importantly, the issue was not only how ecological sensitivity was communicated, but that the sensitivity itself was not fixed. The same location could serve different ecological functions under changing tidal conditions (Townshend & O’connor, 1993). Within a tidal cycle, an intertidal area may be submerged, gradually exposed, used by birds for feeding and then covered again. Across the year, the same landscape may support overwintering waterbirds, spring arrivals, breeding birds or autumn migrants. The ecological meaning of the habitat is therefore not fixed, as wildlife use and habitat availability change with seasonal and tidal conditions.

This shows why the temporal dimension cannot be separated from the spatial issue. Spatial guidance can explain where care is required, while temporal interpretation can help explain why that location matters at a particular moment. Temporal interpretation is therefore intended to complement rather than replace existing spatial management by making its changing ecological reasons more understandable. Having identified this temporal dimension, the following section examines how seasonal and tidal rhythms shape changing ecological conditions within the beach-mudflat environment. It considers how these two rhythms intersect and how they affect what wildlife may be doing at a particular place and moment.

4.2 Intersecting Seasonal and Tidal Rhythms

Following the shift from spatial guidance to temporal interpretation, this section introduces the two ecological rhythms used in the framework. Section 4.2.1 considers seasonal rhythms as a broader context for migration, wintering and breeding across the year. Section 4.2.2 then considers tidal rhythms as shorter changes in the availability of the beach-mudflat habitat. Examining them separately establishes the role of each rhythm before Section 4.2.3 brings them together in the seasonal-tidal matrix.



Figure 4.1 Spatial guidance encountered on site

4.2.1 Seasonal Time

The four interpretive phases developed in Section 3.2.1 provide the broader temporal context for understanding how wildlife use of the landscape changes across the year. Their significance for this project lies in how these changing activities also alter the conditions under which visitors encounter the same habitat.

During Winter Refuge, concentrations of wintering waterbirds depend on the reserve for feeding and resting, making disturbance particularly relevant where visitor activity overlaps with these areas. Spring Transition represents a period of change, as some wintering populations depart while migratory and breeding activity begins to increase, meaning that the ecological use of the landscape is also shifting. During the breeding and nesting process, nests, eggs and chicks can increase the sensitivity of coastal and upper shore habitats, while their limited visibility may make this sensitivity difficult for visitors to recognise. Autumn Passage introduces another period of movement, as migratory birds pass through the reserve and wintering populations begin to return, again changing which wildlife activities may be present within the landscape.

The four phases therefore provide a broader seasonal context for understanding changes in wildlife activity across the year. Seasonal time alone, however, cannot explain the current availability of the beach-mudflat habitat, because this changes repeatedly with the tide. The seasonal phases must therefore be considered alongside the tidal states.

4.2.2 Tidal Time

Tidal rhythms provide another temporal dimensions used in this project. Visitors commonly encounter the tide through the causeway timetable, which tells them when access to Holy Island is possible and safe. Within the beach-mudflat environment, however, tidal movement also changes the amount of habitat available to wildlife. As the water advances and retreats, feeding areas are covered or exposed, while birds may move between feeding, resting and roosting locations.

As described in Section 3.2.2, the tidal cycle was translated into four approximate interpretive states: High Tide, Outgoing Tide, Low Tide and Incoming Tide. At High Tide, much of the intertidal habitat is covered, reducing access to feeding areas and potentially concentrating birds in more limited resting or roosting locations. During the Outgoing Tide, the mudflat gradually reopens and feeding opportunities begin to return, while Low Tide represents the period of greatest exposed feeding surface. During the Incoming Tide, this surface gradually contracts again as the water advances. These four states provide a simplified way of comparing how habitat availability changes across the tidal cycle. However, the ecological meaning of a tidal state also depends on the time of year, because the species present and their activities change across migration, wintering and breeding periods. Tidal time therefore needs to be considered alongside the seasonal phases.

4.2.3 The Seasonal-Tidal Intersection

The preceding subsections show that neither seasonal nor tidal time can explain ecological conditions on its own. Seasonal time provides the broader context of wildlife presence and activity across the year, while tidal time describes shorter changes in habitat availability, including whether feeding areas are exposed, contracting, covered or reopening. A more situated interpretation therefore emerges when these two rhythms are considered together.

The relationship can be expressed as:

Seasonal interpretive phase × approximate tidal state → interpreted ecological context

This relationship connects broader seasonal activity with shorter changes in habitat availability to interpret what may be happening under a particular combination.

Combining the four seasonal stages with the four tidal states produced a matrix of sixteen interpretive combinations, showing at different stages the possible activity of wildlife and visitors as well as design opportunity (Figure 4.2). The matrix should be understood as an interpretive synthesis of recurring seasonal activity and approximate tidal habitat conditions, rather than as a predictive ecological model. Individual combinations indicate plausible ecological contexts that can support visitor interpretation, not deterministic descriptions of wildlife behaviour. In this sense, the matrix organises the changing relationship between time, habitat and wildlife into an interpretable structure and provides the basis for translating ecological conditions into situated visitor guidance.

Figure 4.2 Seasonal-tidal interpretation matrix showing sixteen interpretive combinations

Scenario	Typical visitor activity	Wildlife temporality	Possible visitor response	Early design opportunity
 Mudflat	Walking, photography, dogs running	Low tide exposes mudflats as important bird feeding areas	Keep distance; avoid active feeding areas; keep dogs on lead	Tide-linked feeding alert
 Nesting	Walking off-path, exploring, taking shortcuts	During the breeding season, nests, eggs, and chicks may be vulnerable and difficult to see	Stay on paths; avoid nesting areas; slow down	Invisible nest warning
 Birdwatching	Birdwatching, wildlife photography	Birds require uninterrupted feeding or resting periods	Observe quietly; maintain distance; use designated viewing points	Distance-sensitive viewing guidance

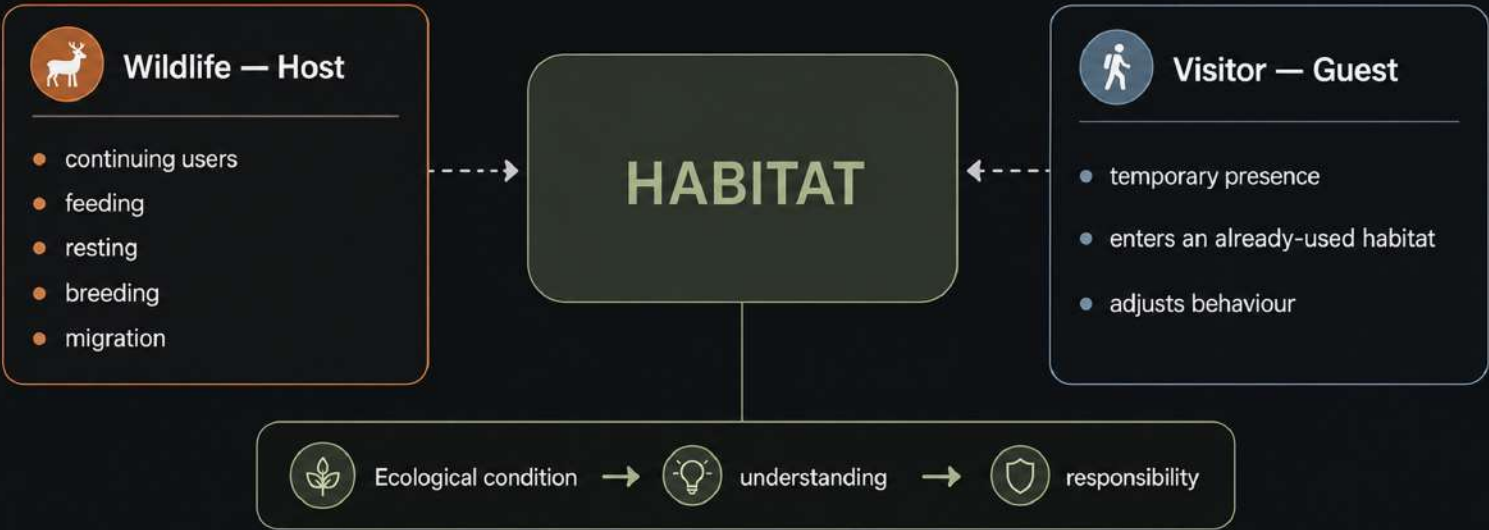
4.3 Translating Ecological Conditions into Visitor Responsibility

The seasonal-tidal framework provides a way of understanding how ecological conditions may change at a particular place and moment, but ecological interpretation alone does not explain how visitors should respond. To connect these changing conditions with visitor behaviour, the project adopted a Host-Guest framing. Rather than treating wildlife as occasional occupants of a landscape primarily organised around human use, this framing recognises wildlife as continuing users of the habitat and visitors as temporary entrants.

Within this framing, wildlife can be understood as the host because feeding, resting, migration and breeding already take place within the landscape before and during a visitor's presence. The visitor, as a guest, therefore, encounters a habitat that is already in use. Responsibility is not limited to whether a visitor is permitted to enter a particular space but also involves responding appropriately to the ecological activities and sensitivities present at that time.

This framing revealed an important requirement for the subsequent design: behavioural guidance should not be presented as a detached instruction but should be connected to an explanation of the ecological condition that makes the action relevant. In this way, visitor responsibility can emerge from understanding why a habitat matters at a particular moment, rather than from rules alone. This requirement informed the development of the visitor-facing interpretation explored in Chapter 5.

Figure 4.3 Host & Guest Framing



4.4 Design Requirements Emerging from the Findings

The findings above identified several requirements for translating ecological rhythms into interpretation facing to visitors. First, the changing ecological meaning of the beach-mudflat environment could not be communicated through spatial information alone. Visitors commonly organise their visit through dates, clock time and access schedules, while wildlife activity is shaped by overlapping seasonal and tidal rhythms. A design response therefore needed to create a connection between these familiar human temporal references and the changing ecological conditions of the habitat.

Second, ecological information is needed to support understanding rather than remain detached from visitor action. The Host & Guest framing suggested that guidance can become more meaningful when a particular behaviour is connected to the ecological condition that makes it appropriate. The design therefore needed to connect ecological activity, its significance and visitor responsibility through a clear explanatory sequence, rather than presenting behavioural instructions in isolation.

Finally, some of the ecological relationships identified through the research remain difficult to perceive directly within the landscape. Food resources may be hidden beneath the sediment, nests and young birds may blend into their surroundings, and the ecological function of an apparently open area may change without an obvious physical boundary. A further design requirement was therefore to make such relationships more perceptible without suggesting that they could be observed directly or continuously.

Together, these requirements established the basis for the design development that followed: connecting visitor time with ecological rhythms, linking ecological explanation to visitor responsibility, and making otherwise ecological relationships which are difficult to perceive more legible. Chapter 5 examines how these requirements were translated and refined through the development of the project's prototypes.

CHAPTER

05

Design Development

Translates the research framework into the Time Translator and mudflat AR experience through progressive narrowing, structuring and iterative refinement.



Figure 4.4 Design Requirements



5. Design Development

5.1 From a Broad Temporal Question to a Situated Design Direction

The project initially emerged from the theoretical concern established in Chapter 2: that human clock-based organisation can make other temporal rhythms less perceptible. Early design exploration therefore considered how non-human temporalities might be made more noticeable. At this stage, however, the direction remained abstract and lacked a situated context through which the relationship could be explored in practice.

Holy Island was subsequently used to situate this initially abstract temporal question within the specific visitor-wildlife context established in Chapter 2. The scope then gradually shifted towards examining how different stakeholders experienced and responded to the same environmental rhythms. Early stakeholder mapping (Figure 5.1) examined the relationships between visitors, residents, reserve management and wildlife, whose activities are shaped by different needs, priorities and temporal rhythms. The tide emerged as a shared environmental condition connecting these groups, although its significance differed for each. For visitors, it structures access and travel schedules; for residents, it affects everyday mobility; and for wildlife, it influences the availability of intertidal feeding and resting habitat. Within these relationships, reserve management occupies a mediating position, translating between ecological rhythms and human schedules through information, access control and conservation measures.

The project was then narrowed from this wider stakeholder network to the relationship between visitors and wildlife. The relationship between visitors and wildlife was retained as the primary design focus because it aligned most directly with the emerging question of how changing ecological conditions could inform visitor guidance. Reserve management remained important as a mediating and knowledge providing stakeholder, while residents moved outside the immediate scope of the developed prototype.

Formative feedback from the reserve manager then led the design scenarios to be reorganised around habitat types, because different habitats respond differently to seasonal and tidal conditions. Comparing the scenarios also showed that each habitat would require its own ecological research, purpose and interaction, so the developed prototype was narrowed to the beach-mudflat environment.

After narrowing the scope, the ecological and visitor guidance material relating to the beach-mudflat was reorganized. I began to arrange them as an interpretive storytelling sequence, providing an initial structure for turning the research findings into a visitor facing experience. These findings led to two connected design directions. The Time Translator was developed as the core response to the research question, connecting visitors' familiar clock time with changing seasonal and tidal conditions. The mudflat AR experience was then developed as a situated extension of this temporal interpretation, exploring how ecological relationships associated with the selected condition might otherwise remain difficult to notice. The following sections explain how these two directions were developed and refined.

Figure 5.1 Stakeholder relationships and the different meanings of tidal time on Holy Island

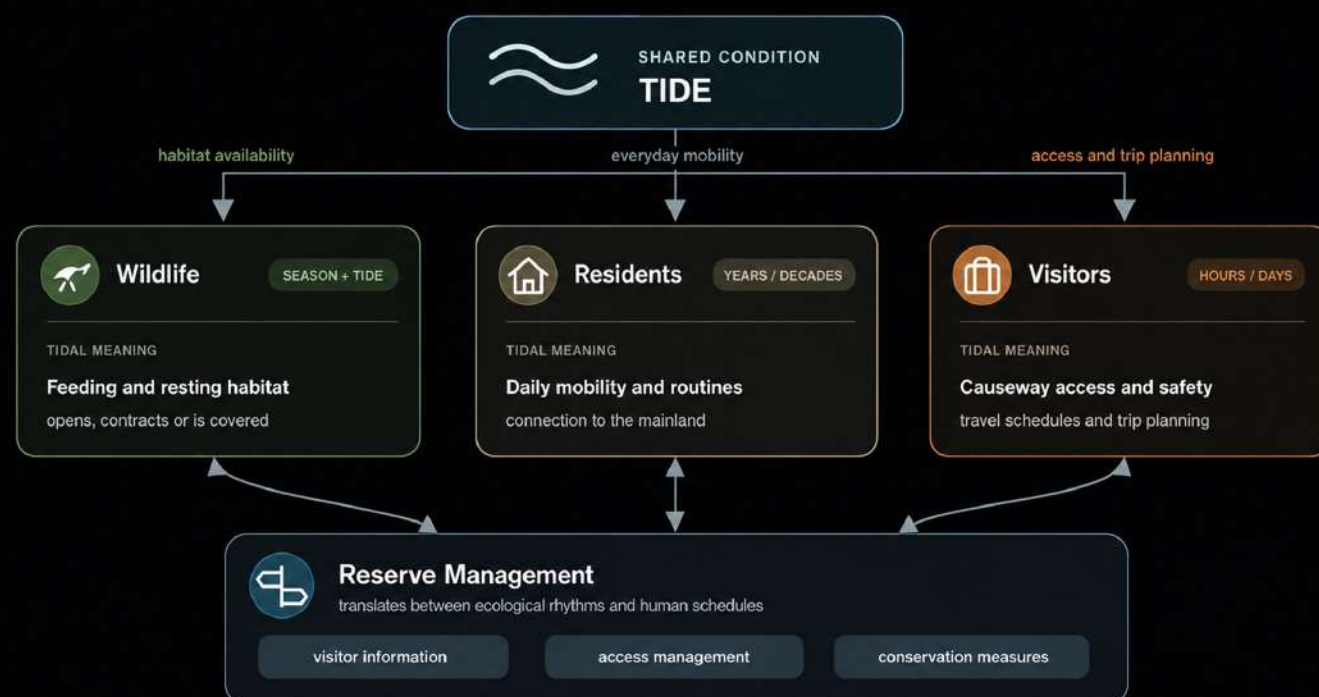


Figure 5.2 — Narrowing the design focus

From broad temporal concern to habitat-focused design direction



Design Development → Chapter 5

5.2 Operationalising the Temporal Framework

Building on the temporal requirements identified in Chapter 4, the next design task was to convert seasonal and tidal rhythms into a structure that could operate through a brief visitor interaction. The ecological evidence contained multiple overlapping species activities and temporal patterns, while visitors would interact with the prototype through a much simpler input: a selected date and clock time. The design therefore needed to reduce this complexity into a small number of interpretable states without removing the distinction between the broader annual rhythm and shorter-term tidal change.

For the seasonal layer, the four interpretive phases established through the research, Winter Refuge, Spring Transition, Breeding-Nesting and Autumn Passage, were retained as the states used by the prototype. Rather than reproducing conventional meteorological seasons, these labels were organised around dominant wildlife activities, allowing a selected calendar date to begin communicating ecological meaning rather than functioning only as a position within the year. The seasonal layer therefore translated familiar calendar time into a broader wildlife-centred context.

A second tidal layer was required to connect the visitor's selected clock time with short-term tidal change. Using the classification established in Section 3.2.2, the published causeway timetable provided the temporal reference through which a selected time could be associated with High Tide, Outgoing Tide, Low Tide or Incoming Tide. The timetable was not reproduced as access guidance; instead, its clock-based structure provided a bridge between the time visitors already use to organise their journey and the tidal rhythm relevant to the beach-mudflat habitat. Retaining four states rather than a simple high or low distinction also preserved the direction of tidal change while keeping the information concise enough for the interface.

Once both temporal layers could be derived from the same visitor input, they were combined into a seasonal-tidal structure. The purpose of this matrix was not to ask visitors to interpret sixteen combinations directly, but to provide an underlying content structure through which the same selected date and time could produce a more situated ecological interpretation. Seasonal state supplied the broader annual context, while tidal state situated that context within shorter-term habitat change. In this way, the matrix operationalised the temporal relationship identified in Chapter 4 as a system that could support visitor facing interpretation.

At this stage, however, the matrix remained an internal design structure rather than a usable visitor interface. Its sixteen combinations contained the necessary temporal logic but still needed to be translated into information that could be presented clearly and connected to visitor action. The next stage therefore focused on how this underlying structure could be presented through the Time Translator.

Figure 5.3 Translation of Seasonal Ecological Evidence into Design States

Seasonal State	Dominant Ecological Context	Role in the Design
Winter Refuge	Feeding, resting, energy maintenance	Frames seasonal context around reliance on feeding and resting habitat
Spring Transition	Arrival, departure, territorial change	Communicates transition, overlap, and changing wildlife presence
Breeding-Nesting	Nests, eggs, chicks, breeding activity	Introduces less visible ecological vulnerability
Autumn Passage	Migration and returning populations	Highlights movement and changing species presence

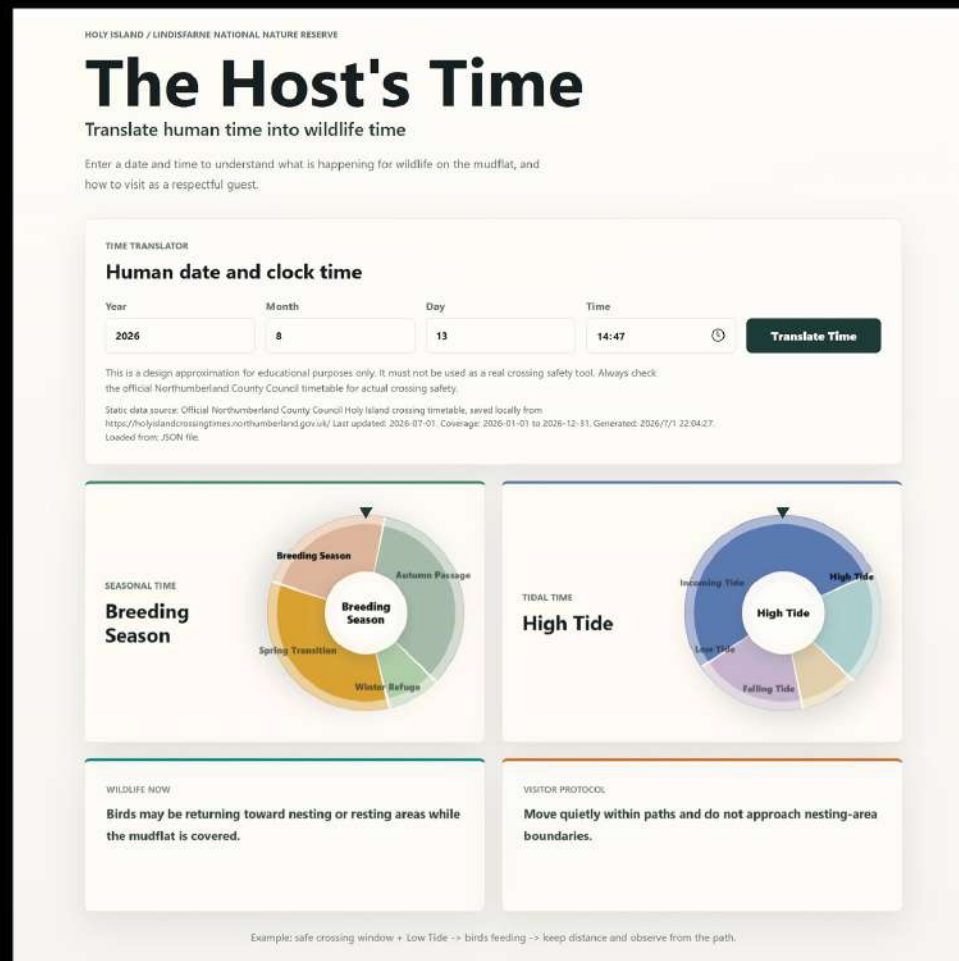
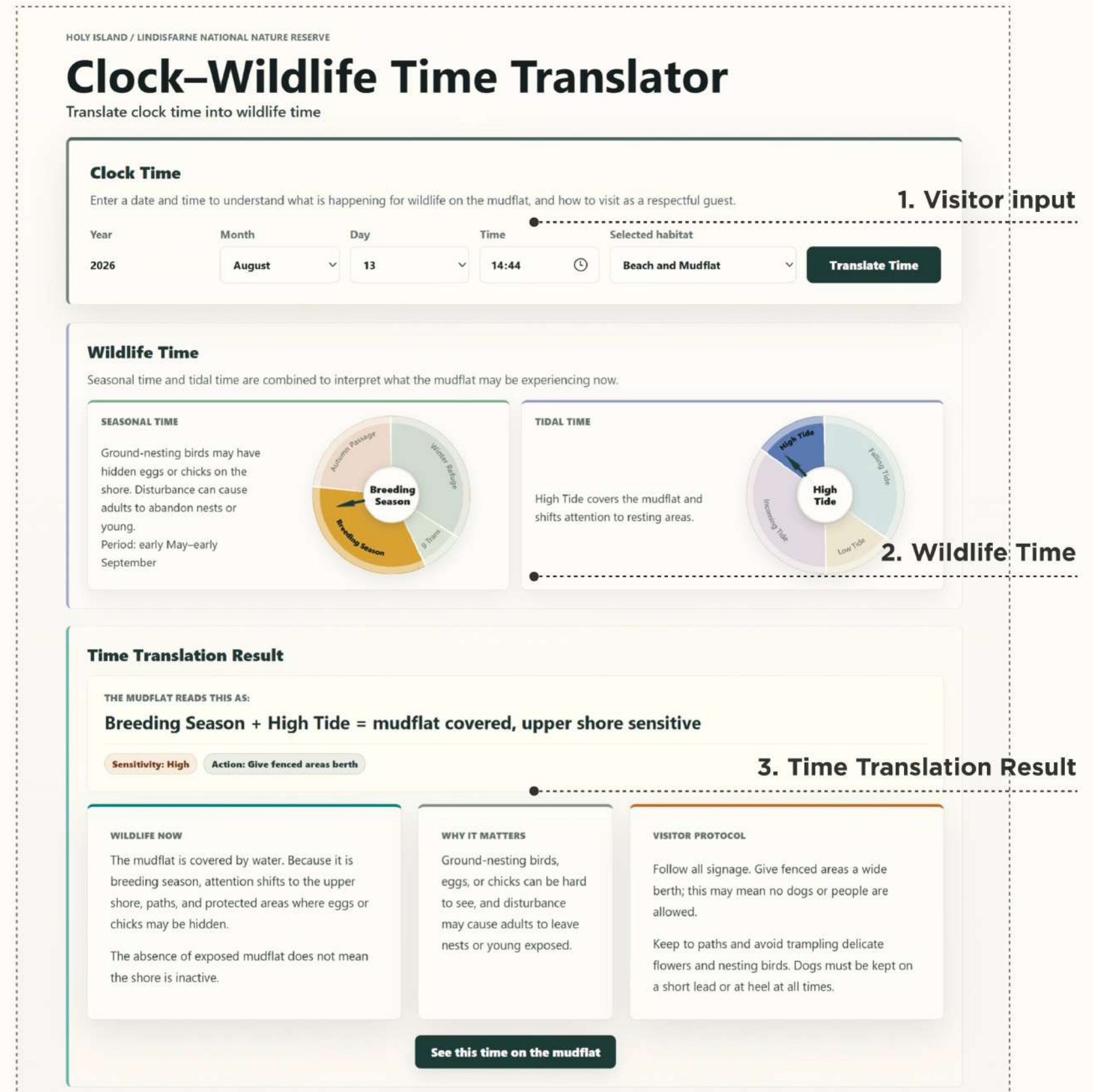


Figure 5.4 Version 1—Early Prototype

5.3 Developing and Iterating the Time Translator

With the seasonal-tidal matrix established as the underlying content structure, the next design challenge was to present this logic clearly within a brief visitor interaction. Rather than asking visitors to interpret the matrix directly, the Time Translator used a selected date and clock time to identify the corresponding seasonal and tidal states before presenting the resulting ecological interpretation. In this way, the complexity of the matrix remained behind the interface, while the visitor interacted only with a familiar temporal input and a concise output.

Figure 5.5 Revised Version—Final Web



Key Revisions

1. From a basic date-and-time input to a clear translation of seasonal and tidal states.
2. From displaying ecological information directly to a structured sequence: Wildlife Now → Why It Matters → Guest Protocol.
3. From general conservation advice to contextual guidance grounded in current visitor guidance and byelaws.
4. From a static information website to an interactive AR experience with onboarding, layer controls, species information and distance warnings.

During design review, early interface iterations (Figure5.4) revealed that simplifying access to the matrix did not necessarily make its intended meaning clear. The first versions displayed the seasonal and tidal states alongside ecological information, but the relationship between these elements was not explicit at the interface level, information pile up together. The different temporal states were also difficult to distinguish immediately. More importantly, the output moved too quickly from describing possible wildlife activity to recommending visitor behaviour. Although the recommendation might be appropriate, the ecological reason for that recommendation remained unclear. This exposed a gap between showing a condition and explaining why a response might matter.

The interface was therefore reorganised around a explanatory sequence includes three stages: Wildlife Now, Why It Matters and Guest Protocol. Wildlife Now introduced the wildlife activity or habitat use associated with the selected temporal condition. Why It Matters was added as an explicit bridge between ecological information and behavioural guidance, explaining how disturbance could affect that activity or why the habitat might be sensitive at that moment. Guest Protocol then translated this explanation into a concise visitor response. A separate sensitivity indicator provided a quick visual cue, while the sequence carried the fuller reasoning from ecological condition to consequence and finally to action. The indicator was used as a qualitative design cue rather than as a validated ecological risk score.

During later refinement, the reserve manager suggested grounding the Guest Protocol in existing NNR byelaws and visitor guidance (Natural England, 2026). The behavioural outputs were therefore developed by drawing on established reserve expectations, including guidance relating to dogs, visitor distance and the avoidance of wildlife disturbance, rather than being generated solely from the project's ecological interpretation. The prototype consequently used design to contextualise existing behavioural guidance within changing ecological conditions, rather than to propose a new system of conservation rules. A full mapping of the sixteen seasonal-tidal combinations, their ecological interpretations, sensitivity cues and corresponding Guest Protocol sources is provided in Appendix A.

Following the interpretive approach established by the matrix, the wording of the ecological outputs remained cautious, using terms “may”, “likely” and “can” where appropriate. At the same time, ecological interpretation was kept separate from official causeway and safety information. These decisions were implemented at the interface level to clarify how the Time Translator should be read, rather than to add further complexity to the interaction. The resulting prototype therefore functioned as a layered explanatory interface: visitor clock time provided the entry point, the temporal framework supplied the ecological context, and the final sequence connected that context to visitor responsibility.

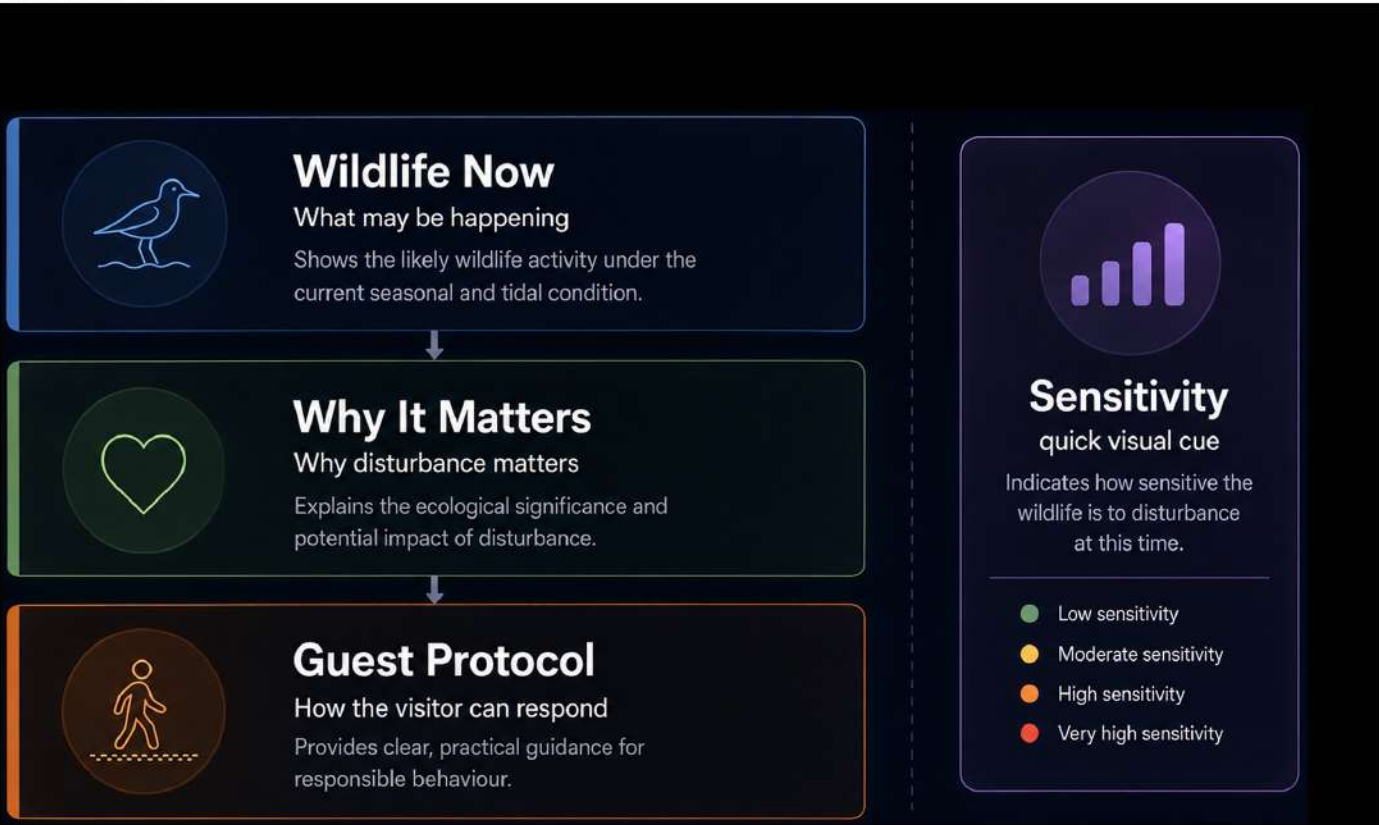


Figure 5.6 Explanatory Structure of the Time Translator

5.4 Developing the Mudflat AR Experience

The Time Translator was designed to communicate when and why the beach-mudflat might become ecologically sensitive, but this interpretation remained primarily screen-based. This revealed a second design challenge: how could ecological relationships that were difficult to perceive directly be made more noticeable in situ? The AR experience was developed to address this gap by extending temporal interpretation into the physical setting of the habitat.

The beach-mudflat environment was retained as the focus because it brought together the temporal and perceptual issues identified through the research. Its ecological function changes across seasonal and tidal conditions, while many relevant features remain difficult to detect visually. Food resources may lie beneath the sediment, nests and young birds can blend into the surrounding environment, and apparently open areas may support different forms of wildlife activity at different times. These findings were translated into three visual layers, Food Underneath, Chicks and Eggs, and Guest Boundaries, each focusing attention on a different form of ecological invisibility. These overlays represented possible ecological relationships associated with the selected seasonal-tidal context; they did not indicate the real-time location of wildlife, food resources or habitat boundaries. Feedback from the reserve manager also led the prototype to define this habitat scope more explicitly rather than implying that the same representation applied across the whole reserve.

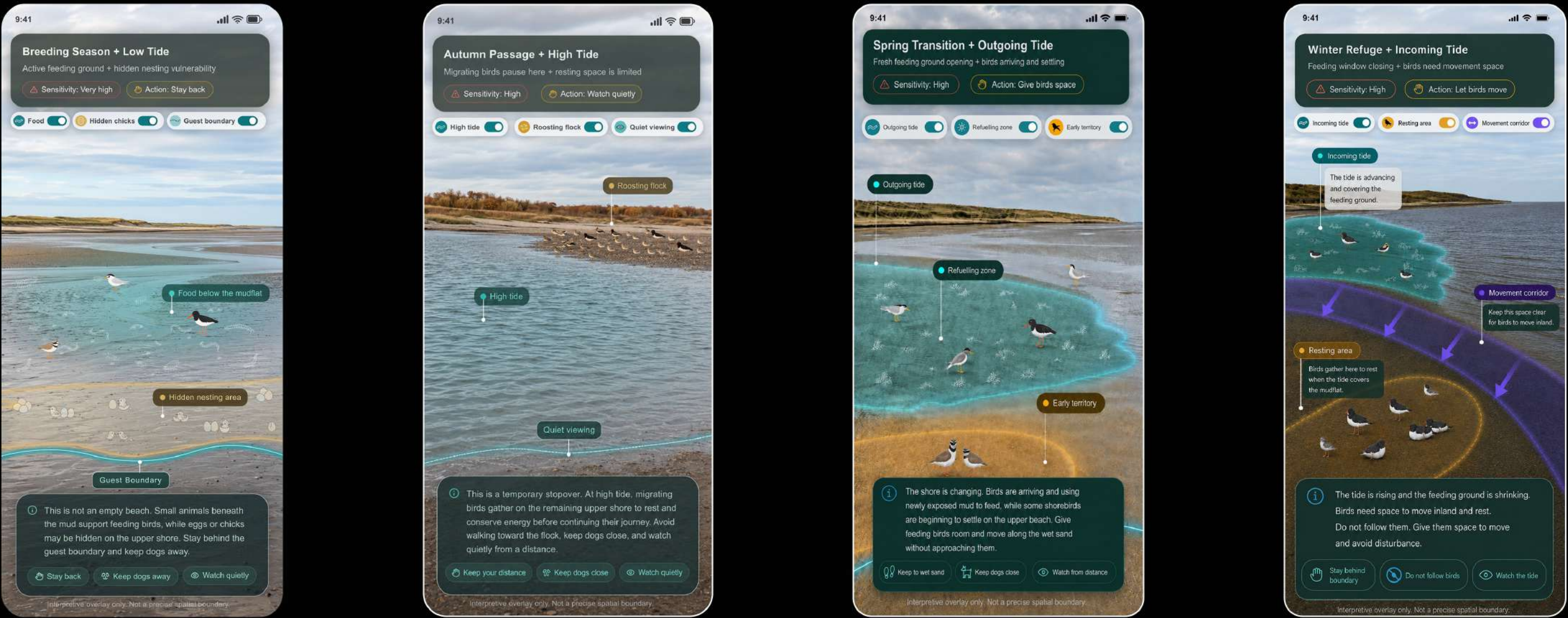


Figure 5.7 AR experience design prototype of representative states under different seasonal and tidal conditions: (a) Spring Transition + Outgoing Tide; (b) Winter Refuge + Incoming Tide (c) Breeding Season + Low Tide; and (d) Autumn Passage + High Tide.

The AR experience was designed as a continuation of the Time Translator rather than as a separate interaction (Figure 5.8). After selecting a date and clock time, the corresponding seasonal-tidal condition was carried into the AR experience as contextual information. This allowed the visual layers to be interpreted in relation to the same temporal condition rather than appearing as generic ecological content. Within the camera view, visitors could activate the three layers individually or in combination. Individual layers isolated a particular relationship, while combined views showed how hidden food resources, vulnerable wildlife and visitor-sensitive space could overlap within the same habitat. The Guest Boundaries layer was conceived as an interpretive visualisation of visitor-sensitive space rather than as an official or ecologically precise boundary. Its purpose was to draw attention to the need for spatial sensitive distance, not to prescribe an exact measurable distance.

Several smaller interactions were also used to connect the visualisation back to ecological interpretation. Wildlife illustrations changed according to the selected seasonal condition, and species information could be accessed without leaving the main AR view. Contextual visitor guidance was retained alongside the visual layers so that the overlays were not presented as visual effects alone but remained connected to the Host-Guest framing established earlier in the project. The complete interaction flow, species states and representative protocol outputs are documented in Appendix B and Appendix C.

Iteration also helped clarify the limits of the AR interaction. An earlier version used a movable footprint to represent visitor proximity, but supervisory feedback identified a risk that this could imply real-time tracking or reliable measurement of distance from wildlife and habitat boundaries. The footprint was therefore removed, shifting the interaction away from simulated spatial measurement and towards observation and interpretation. This change clarified the role of AR within the project: rather than identifying exact wildlife locations, measuring food resources or prescribing precise spatial boundaries, it was used to make otherwise ecological relationships that difficult to perceive more legible within the visitor's surroundings.

Together, the two prototypes addressed related but different forms of ecological invisibility. The Time Translator translated a visitor's familiar clock time into changing seasonal and tidal context, while the AR experience extended that interpretation into the landscape by drawing attention to ecological relationships that might otherwise remain unnoticed. The two experiences therefore worked as complementary parts of the same interpretive process: the Time Translator addressed when and why ecological meaning changes, while AR explored what may be difficult to perceive within that changing condition.

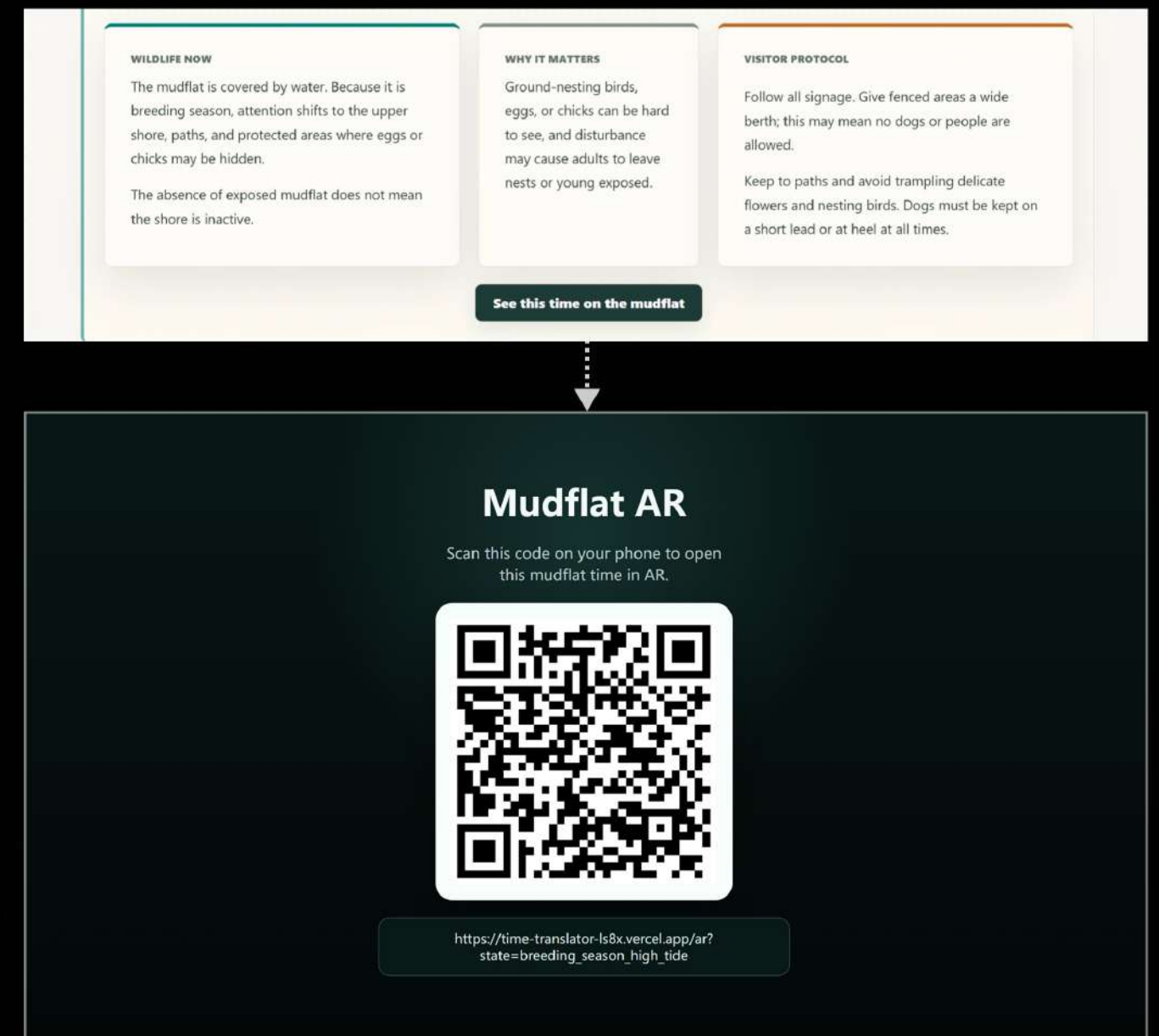
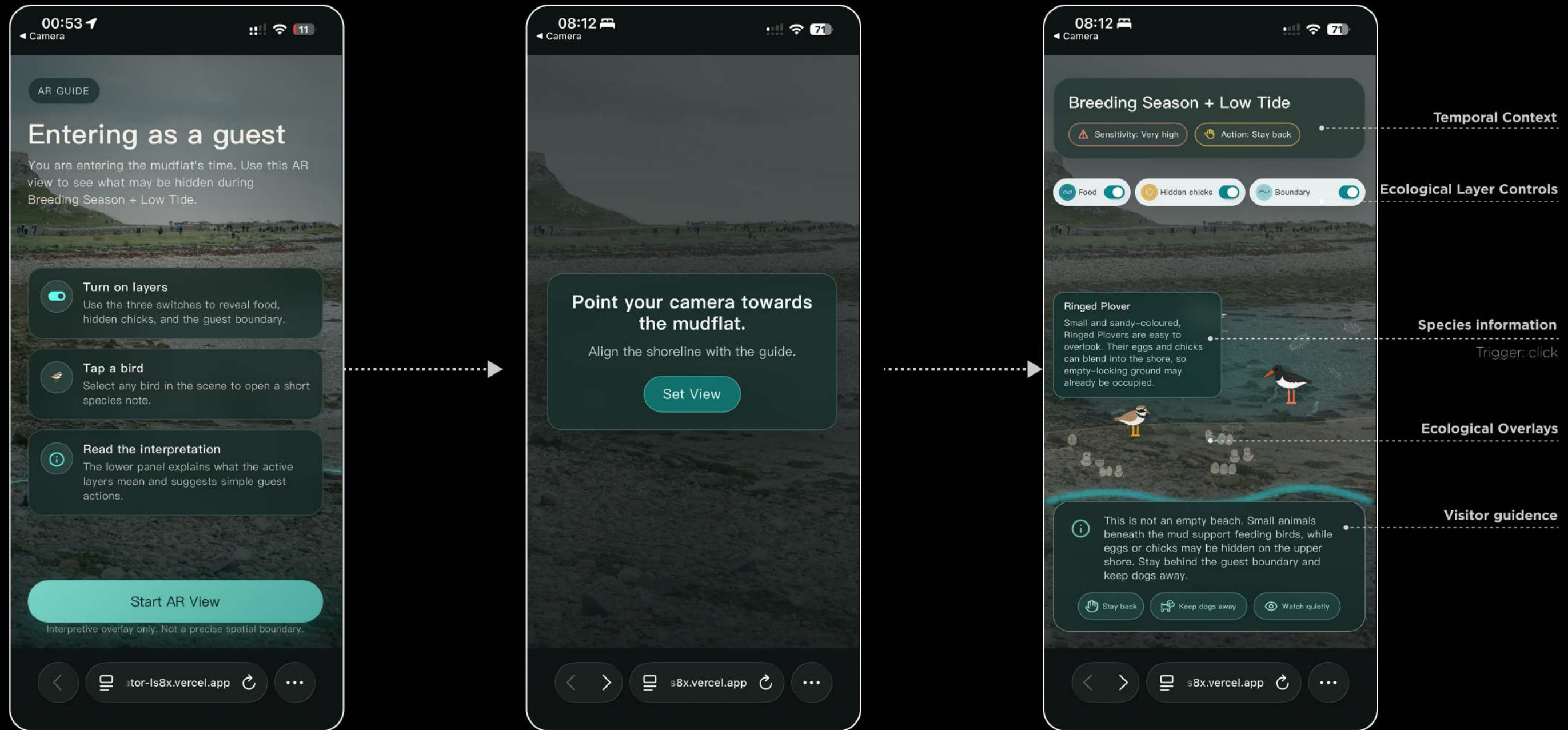


Figure 5.8 How to start the journey of AR experience, click the button and scan the QR code to enter immersive interface

AR Interaction Flow



1. AR Introduction — Introduces the guest framing and explains how to interact with the AR layers.

2. View Alignment — Guides visitors to align the camera with the mudflat before ecological information is displayed.

3. Ecological AR View — Reveals current wildlife activity, hidden habitat features, and appropriate visitor responses.

CHAPTER



Discussion

Brings together the project's findings to show how familiar human time can become an entry point into changing ecological rhythms and visitor responsibility.



6. Discussion

6.1 Research Contribution and Value

This project contributes a time-based approach to environmental interpretation by exploring how visitors' familiar clock time can become an entry point for understanding changing ecological rhythms. The research began with the distinction between standardised clock-based organisation and ecological rhythms shaped by seasonal and environmental change. However, the design process showed that these temporal perspectives do not need to be treated as opposing systems. On Holy Island, clock time remains practically necessary because visitors rely on crossing times, transport schedules and opening hours to organise their journeys. The design opportunity therefore lies not in replacing clock time, but in extending what a selected moment can mean. By connecting a visitor's date and clock time with seasonal and tidal conditions, the project explores how an existing human temporal reference can be used to make another temporal perspective more legible at a conceptual level.

A second contribution lies in proposing how visitor guidance might shift from instruction alone towards ecological explanation. Existing environmental interpretation research suggests that behavioural guidance can become more meaningful when visitors are given the ecological reason behind a requested action rather than only being told what to do. Building on this principle, the project treats visitor responsibility as a response to a habitat that is already being used by wildlife. The Host-Guest framing supports this shift by positioning visitors as temporary entrants whose behaviour should respond to feeding, resting, migration or breeding activities already taking place within the landscape. The resulting design approach therefore does more than translate ecological time into information; it connects ecological condition, ecological significance and visitor responsibility. In this sense, the value of the project lies partly in reframing guidance from a detached rule into a situated explanation of why a particular response may matter at a particular moment.

The project also identifies two related forms of ecological invisibility that require different forms of interpretation. The first is temporal invisibility: visitors can see a beach or mudflat without necessarily recognising how its ecological meaning changes across seasonal and tidal conditions. The Time Translator responds to this as the core prototype, connecting a familiar clock-based input with a changing ecological context. The second is perceptual invisibility: ecological relationships such as food beneath the sediment, camouflaged nesting activity or changing habitat use may remain difficult to perceive even when visitors are physically present. The AR experience explores this second issue as a situated extension of the Time Translator, showing how selected relationships associated with a temporal condition might become more noticeable within the landscape itself. The value of the prototypes therefore lies less in any individual interface feature than in their connected roles: one translates changing temporal conditions, while the other explores how ecological relationships associated with those conditions might become more perceptible.

Taken together, these contributions suggest that more-than-human design does not necessarily require removing human systems of organisation but can instead work by creating interfaces between different ways of inhabiting and interpreting the same environment. In this project, clock time remains the visitor's practical point of entry, while seasonal and tidal rhythms broaden the meaning attached to that time; ecological explanation then connects this interpretation to the visitor's position within an already active habitat. The contribution is therefore primarily conceptual and design-oriented: it proposes and operationalises a situated approach for translating ecological rhythms into visitor interpretation. The following section critically evaluates what this approach enables, as well as the trade-offs introduced through its simplification and representation.

6.2 Critical Evaluation of the Design Approach

The design approach offered a practical way of translating complex ecological rhythms into a form that could be accessed through a brief visitor interaction. Using date and clock time as the point of entry reduced the amount of ecological information that visitors needed to interpret directly, while the seasonal-tidal structure preserved a distinction between broader annual patterns and short-term habitat change. This abstraction reduced the amount of information presented at one time and was intended to improve legibility, but whether visitors actually understand it more easily remains untested. Reducing multiple species, overlapping activities and gradual transitions into a limited number of states made the framework easier to communicate, while simultaneously removing some species-specific and transitional detail. The value of the abstraction therefore lies not in reproducing ecological complexity, but in selecting enough temporal information to support situated interpretation without overwhelming the visitor.

The relationship between the Time Translator and AR introduced another productive tension between abstraction and situated experience. The Time Translator provides a coherent conceptual structure for exploring different dates and times, although its effectiveness for visitors has not yet been evaluated. Its ecological interpretation also remains mediated through a screen. The AR experience responds to this limitation by placing selected ecological relationships back into the landscape, particularly those that may otherwise remain difficult to notice, such as food beneath the sediment or vulnerable wildlife blending into its surroundings. However, increasing perceptual immediacy also increases the risk that a representation may appear more spatially precise than the underlying evidence supports. The removal of the movable footprint illustrates this tension: although the feature could have made visitor proximity more tangible, it also risked implying real-time tracking and accurate distance measurement. Removing it reduced this sense of precision and refocused the AR experience on interpretation rather than measurement.

The Host & Guest framing introduced a further trade-off. As an interpretive metaphor, it helps position visitors as temporary entrants into a habitat already being used by wildlife, which supports the project's emphasis on responsibility. However, it also simplifies complex multi-species relationships into two broad roles and may risk anthropomorphising wildlife if treated too literally. The framing should therefore be understood as a visitor-facing device rather than a literal ecological description. Taking together, the prototypes are strongest when understood as complementary rather than independent solutions: the Time Translator provides a structured way of interpreting when and why ecological conditions may change, while AR explores what may remain difficult to perceive within those conditions. The resulting prototypes demonstrate the potential of the approach rather than its effectiveness with visitors, which remains an empirical question.

6.3 Limitations and Future Directions

Several limitations should be acknowledged when considering the contribution of this study. The following discussion focuses on three areas that particularly affect how the prototypes can be interpreted and how the research might be developed further.

First, and most importantly, the prototypes were not formally evaluated with visitors. Feedback from the reserve manager and project supervisor was formative and contributed to the development and refinement of the design, but it should not be interpreted as evidence of visitor outcomes. The study therefore cannot claim that the prototypes improve visitors' understanding of wildlife, change their behaviour, or reduce ecological disturbance. Future work should involve on-site visitor testing to examine whether the seasonal and tidal conditions are understood as intended, whether *Why It Matters* successfully connects ecological information with behavioural guidance, and whether the Guest Protocol is clear and actionable. The AR experience should also be tested for possible misunderstandings, particularly whether visitors interpret visual overlays as representations of possible ecological relationships rather than as real-time wildlife locations. Longer-term research could then investigate whether improved ecological understanding influences visitor behaviour in environmentally sensitive areas.

Second, there are limits to how closely the temporal and spatial representations correspond to changing environmental conditions. The four seasonal phases are interpretive abstractions derived from uneven longitudinal NNR records rather than formally defined ecological seasons. Although they were reviewed and refined through reserve-manager consultation, they simplify gradual transitions and variation between species and years. The tidal states introduce further approximation because they are derived from causeway safe crossing windows rather than direct measurements of water level or an astronomical tide model. They therefore provide an approximate temporal interpretation rather than a real-time representation of habitat conditions. In spatial terms, the AR experience relies on predefined visual layers and does not detect the visitor's immediate surroundings or align digital objects with observed ecological features in the landscape. Future development could improve this correspondence by incorporating more direct tidal or environmental data into the Time Translator and by exploring location or scene AR that adapts its content to the visitor's physical surroundings.

Third, the current design is limited in its habitat scope. Although the interface includes options for several habitats, only the beach-mudflat environment has been developed into a detailed experience. The other habitat options should therefore be understood as indications of how the framework might expand rather than as completed or validated designs. As highlighted through formative feedback, different habitats involve different ecological rhythms, sensitivities and visitor relationships, so the existing interaction cannot simply be transferred unchanged to another setting. Future development should therefore begin with habitat-specific ecological research and visitor needs before determining what information, interaction and form of interpretation would be appropriate. In this way, the framework could eventually support a collection of distinct and responsive experiences rather than applying the same design structure generically across the reserve.

Taken together, these limitations position the project as an exploratory design contribution rather than a validated visitor intervention. Future work should therefore prioritize visitor evaluation, closer correspondence with changing environmental conditions, and habitat-specific development.

CHAPTER

07

Conclusion

Brings together the project's findings to show how familiar human time can become an entry point into changing ecological rhythms and visitor responsibility.



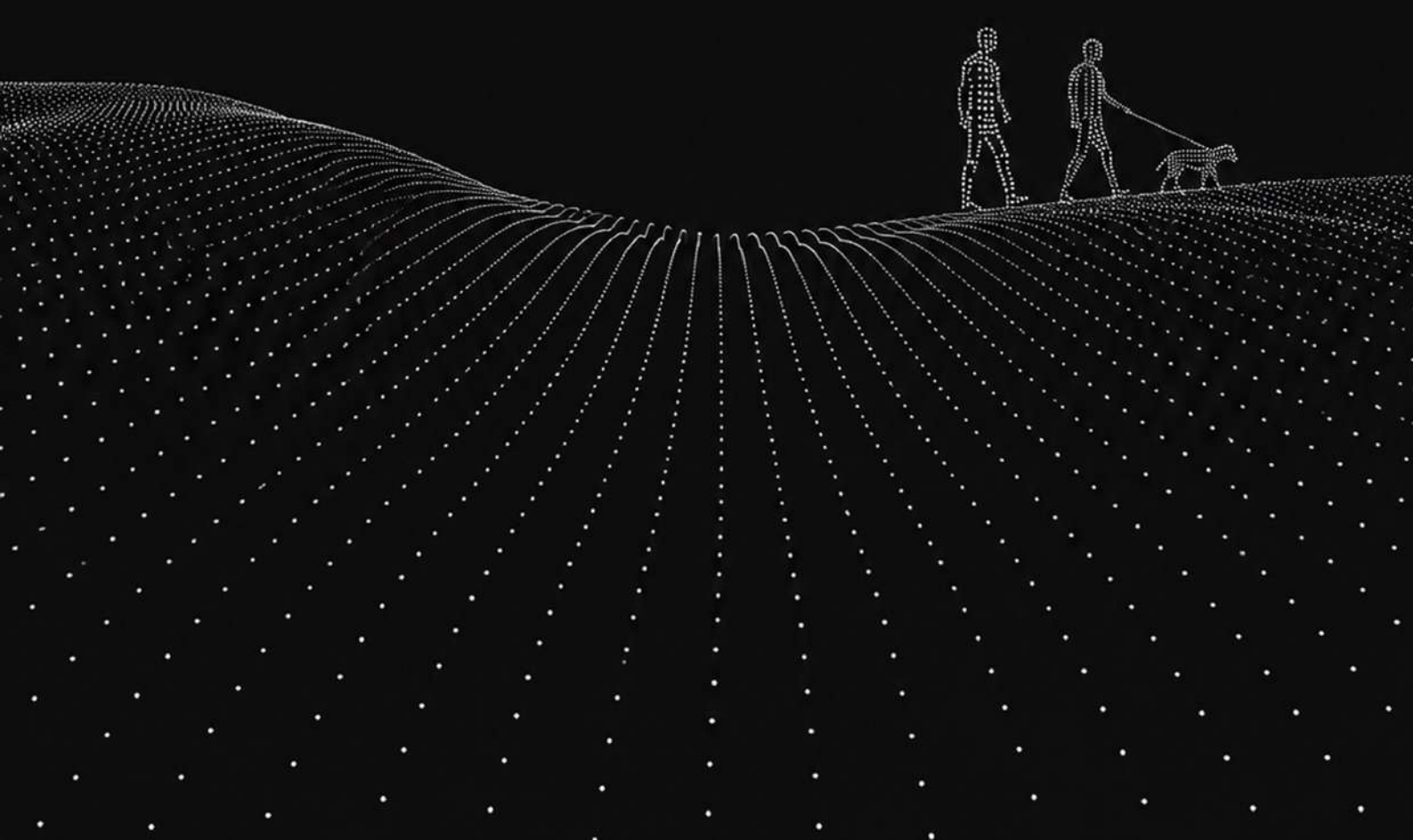
This project asked how seasonal and tidal wildlife rhythms could be translated into situated visitor guidance within the beach-mudflat environment of Holy Island. It suggests that such translation can begin with visitors' familiar clock time, using these everyday temporal references as an entry point into the changing seasonal and tidal conditions of the habitat. Rather than presenting ecological information as separate background knowledge, this approach connects visitor time with wildlife rhythm.

A key finding of the research is that understanding visitor-wildlife encounters requires attention to both spatial and temporal conditions. Existing spatial measures remain important for indicating where greater care is required, but the ecological meaning of a beach or mudflat is not fixed. The same location may support feeding, resting, migration or breeding under different seasonal and tidal conditions. Temporal interpretation can therefore complement spatial guidance by helping explain why a particular place may require different forms of attention at different moments. Crucially, this does not require replacing clock time with wildlife time. Clock time remains necessary for organising travel, access and everyday activity on Holy Island; the design opportunity lies instead in extending what that time can mean by connecting it with ecological rhythms.

The seasonal-tidal framework, Time Translator and AR experience explored this translation through two connected forms of interpretation. The Time Translator addressed the core temporal question by connecting a selected moment with changing ecological conditions, while the AR experience extended this interpretation by exploring how ecological relationships that are difficult to perceive directly might become more noticeable within the landscape. Their contribution therefore lies less in any individual interface feature than in the combined approach of connecting human temporal reference, ecological interpretation and visitor responsibility. The Host-Guest framing further supports this relationship by positioning visitors as temporary entrants into a habitat that is already being used by wildlife.

As an exploratory Research through Design project. Further research would be required to evaluate them with visitors, improve their correspondence with environmental conditions and develop habitat-specific applications. More broadly, however, the project suggests that more-than-human design does not necessarily require abandoning familiar human systems such as clock time. Instead, design can use these systems as points of translation, allowing a place to be understood not only through when people can enter or use it, but also through what that same moment may mean for the other lives already inhabiting it.

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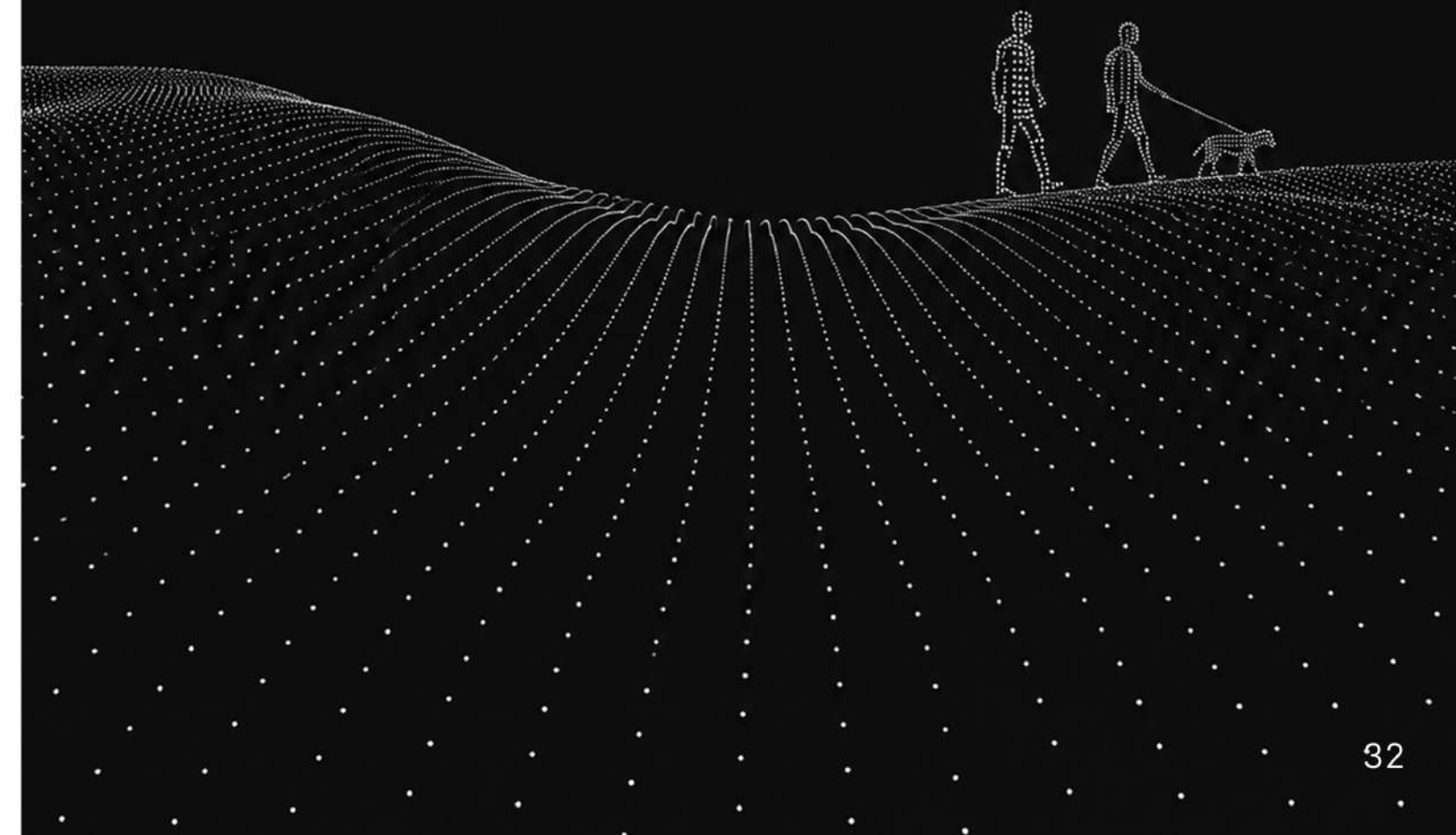
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Appendix



Appendix A

Full Seasonal–Tidal Interpretation Matrix

This matrix combines four interpretive seasonal phases with four approximate tidal states. The dissertation term Outgoing Tide corresponds to Falling Tide in the working prototype files. Breeding–Nesting corresponds to the interface label Breeding Season. These mappings standardise the academic terminology without implying that the prototype implements live ecological detection.

Seasonal phase	Tidal state	Ecological interpretation	Wildlife Now	Why It Matters	Sensitivity cue	Guest Protocol	Confidence / qualification and Appendix F category
Winter Refuge	High Tide	Winter Refuge + High Tide = mudflat covered, birds concentrated elsewhere	The mudflat is covered by water. Wintering birds may be resting or gathering on higher shore, saltmarsh, or roosting areas rather than feeding on the exposed mudflat. The feeding ground is temporarily unavailable.	When feeding space is covered, birds may depend more on quiet resting areas until the mudflat returns.	Resting refuge (very-high): The mudflat is covered, so birds may be resting or gathering away from the feeding ground.	Give 100m space: Follow all signage. Give all wildlife space to feed and rest; the guidance suggests at least 100m. When birds raise their heads, make a distress call, or fly off, move away and view from a distance. Dogs must be kept on a short lead or at heel at all times.	Confidence: medium. Interpretive synthesis; not a real-time ecological prediction. Source categories: F1, F3, F4, F6.
Winter Refuge	Outgoing Tide	Winter Refuge + Outgoing Tide = feeding ground reopening	The tide is falling and the mudflat is beginning to open. Wintering birds may start moving towards newly exposed feeding areas. This is a transition from waiting to feeding.	Birds may be preparing to use the mudflat after a period without access to feeding ground.	Feeding ground opening (very-high): The tide is falling and newly exposed mudflat may soon be used for feeding.	Keep to paths: Keep to paths and follow all signage. Give all wildlife space to feed and rest; the guidance suggests at least 100m. Dogs must be kept on a short lead or at heel at all times. Never let dogs chase birds or seals.	Confidence: high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F1, F3, F5, F6.
Winter Refuge	Low Tide	Winter Refuge + Low Tide = active winter feeding window	The mudflat is exposed. For wintering waders and waterbirds, this may be an important feeding window. The open mudflat is not empty space; it is a temporary feeding ground.	This feeding time is limited by the tide. Disturbance can reduce the time birds have to feed before the sea returns.	Active feeding window (very-high): The mudflat is exposed and may be used by wintering birds for limited feeding time.	Give 100m space: Give all wildlife space to feed and rest; the guidance suggests at least 100m. If birds fly off, you are already too close. Use binoculars or camera zoom and avoid flash photography. Dogs must be kept on a short lead or at heel at all times.	Confidence: high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F3, F4, F6, F7.
Winter Refuge	Incoming Tide	Winter Refuge + Incoming Tide = feeding space shrinking	The tide is returning and the exposed mudflat is shrinking. Birds may be finishing feeding and moving towards safer resting areas. The shoreline is changing quickly.	Birds may need to move without being pushed or chased by people or dogs.	Feeding space shrinking (very-high): The tide is returning and birds may need to move from feeding areas to resting areas.	Move away on alarm: Keep to paths. When birds raise their heads, make a distress call, or fly off, move away and view from a distance. Dogs must be kept on a short lead or at heel at all times. Never let dogs chase birds or seals.	Confidence: medium-high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F4, F5, F6.
Spring Transition	High Tide	Spring Transition + High Tide = covered mudflat, birds between phases	The mudflat is covered. During spring transition, birds may be moving between winter refuge, migration, and early breeding behaviours. Some birds may be resting away from the mudflat while waiting for feeding space to return.	This is a period of change, and birds may need quiet time to rest, recover, or prepare for the next stage of the season.	Seasonal transition (medium): The mudflat is covered while birds may be resting, moving through, or shifting between seasonal behaviours.	Check local signage: Know where you are and what rules are in place; seasonal access restrictions can vary, so check local signage. Keep to paths. Give fenced areas a wide berth. Dogs must be kept on a short lead or at heel at all times.	Confidence: medium-low. Interpretive synthesis; not a real-time ecological prediction. Source categories: F1, F2, F5, F6.

Seasonal phase	Tidal state	Ecological interpretation	Wildlife Now	Why It Matters	Sensitivity cue	Guest Protocol	Confidence / qualification and Appendix F category
Spring Transition	Incoming Tide	Spring Transition + Incoming Tide = feeding window closing during transition	The tide is coming in and feeding space is narrowing. Birds may be leaving the mudflat and moving towards safer areas. During seasonal transition, these movements may be part of a wider shift in behaviour.	Birds may be more easily disturbed when they are forced to move by the tide and by people at the same time.	Movement pressure (medium): The incoming tide may push birds away from the mudflat while visitor presence can add extra pressure.	Move away on alarm: Keep to paths and follow all signage. When birds raise their heads or make a distress call, move away and view from a distance. Dogs must be kept on a short lead or at heel at all times.	Confidence: medium. Interpretive synthesis; not a real-time ecological prediction. Source categories: F1, F4, F5, F6.
Breeding–Nesting	High Tide	Breeding–Nesting + High Tide = mudflat covered, upper shore sensitive	The mudflat is covered by water. Because it is breeding season, attention shifts to the upper shore, paths, and protected areas where eggs or chicks may be hidden. The absence of exposed mudflat does not mean the shore is inactive.	Ground-nesting birds, eggs, or chicks can be hard to see, and disturbance may cause adults to leave nests or young exposed.	Nesting-sensitive shore (high): The mudflat is covered, but the upper shore may contain hidden eggs or chicks.	Give fenced areas berth: Follow all signage. Give fenced areas a wide berth; this may mean no dogs or people are allowed. Keep to paths and avoid trampling delicate flowers and nesting birds. Dogs must be kept on a short lead or at heel at all times.	Confidence: high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F1, F2, F5, F6.
Spring Transition	Outgoing Tide	Spring Transition + Outgoing Tide = feeding space returning during seasonal movement	The mudflat is beginning to open as the tide falls. Birds may start using the exposed ground for feeding while also moving through a seasonal transition. The mudflat may become active gradually rather than all at once.	Birds using the mudflat during transition may need uninterrupted feeding or recovery time.	Feeding access returning (medium): The falling tide is reopening feeding space during a period of seasonal movement.	Give fenced areas berth: Follow all signage and keep to paths. Give fenced areas a wide berth; birds also nest, feed and roost outside these areas. Give all wildlife at least 100m space to feed and rest.	Confidence: medium. Interpretive synthesis; not a real-time ecological prediction. Source categories: F1, F2, F3, F5.
Spring Transition	Low Tide	Spring Transition + Low Tide = exposed feeding ground during seasonal change	The mudflat is exposed and may be used for feeding. During spring transition, birds may be refuelling, moving through, or beginning to shift towards breeding behaviour. The same open ground may support several overlapping needs.	Disturbance can interrupt feeding at a time when birds may be recovering energy or preparing for seasonal movement.	Exposed feeding ground (medium-high): The mudflat is exposed and may support feeding or refuelling during seasonal transition.	Give 100m space: Give all wildlife space to feed and rest; the guidance suggests at least 100m. If birds fly off, you are already too close. Keep to paths, use binoculars or camera zoom, and keep dogs on a short lead or at heel.	Confidence: medium. Interpretive synthesis; not a real-time ecological prediction. Source categories: F3, F4, F5, F6, F7.
Breeding–Nesting	Outgoing Tide	Breeding–Nesting + Outgoing Tide = feeding space opening, nesting shore remains sensitive	The tide is falling and the mudflat is beginning to open for feeding. At the same time, breeding season means the upper shore may still hold hidden eggs or chicks. Birds may need space both to feed and to raise young.	Visitors can disturb feeding birds on the exposed mudflat and also disturb hidden nesting life on the upper shore.	Feeding + nesting sensitivity (very-high): The mudflat is opening for feeding while the upper shore may remain sensitive for nesting.	Check seasonal restrictions: Know where you are and what rules are in place; seasonal access restrictions can vary. Give fenced areas a wide berth. In spring and summer, disturbance can result in birds abandoning eggs or chicks and disrupt feeding and resting activity.	Confidence: medium-high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F1, F2.
Breeding–Nesting	Low Tide	Breeding–Nesting + Low Tide = active feeding ground + hidden nesting vulnerability	For the mudflat, this is feeding time. Low tide has exposed the mudflat as a feeding ground. Because it is breeding season, the upper shore may also hold hidden eggs or chicks. This is not an empty beach; it is a space already being used.	Birds may have limited time to feed before the tide returns, while eggs or chicks on the upper shore may be vulnerable to careless steps or dogs.	Active feeding + hidden nests (very-high): Low tide exposes feeding ground while breeding season may make nearby upper shore areas vulnerable.	Give 100m space: Give fenced areas a wide berth and remember birds also nest, feed and roost outside these areas. Give all wildlife at least 100m space to feed and rest. Use binoculars or camera zoom and avoid flash photography.	Confidence: high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F2, F3, F7.

Seasonal phase	Tidal state	Ecological interpretation	Wildlife Now	Why It Matters	Sensitivity cue	Guest Protocol	Confidence / qualification and Appendix F category
Breeding–Nesting	Incoming Tide	Breeding–Nesting + Incoming Tide = feeding ground closing, shore still vulnerable	The tide is returning and the mudflat feeding space is shrinking. Birds may move away from the mudflat while the upper shore remains sensitive because of breeding activity. Both movement and nesting space matter now.	Visitors may accidentally push birds towards sensitive shore areas or disturb birds trying to move away from the incoming tide.	Movement + nesting sensitivity (high): The feeding window is closing while breeding-sensitive shore areas may still be vulnerable.	Move away on alarm: When birds raise their heads or make a distress call, move away and view from a distance. Keep to paths, give fenced areas a wide berth, and never let dogs chase birds or seals.	Confidence: medium-high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F2, F4, F5, F6.
Autumn Passage	High Tide	Autumn Passage + High Tide = mudflat covered, passage birds resting	The mudflat is covered. During autumn passage, birds may be moving through the reserve and using higher areas to rest while feeding ground is unavailable. Resting can be as important as feeding.	Migrating or passage birds may need quiet refuge to conserve energy between feeding opportunities.	Passage resting refuge (medium): The mudflat is covered and passage birds may be resting until feeding space returns.	Give 100m space: Give all wildlife space to feed and rest; the guidance suggests at least 100m. If birds fly off, you are already too close. Dogs must be kept on a short lead or at heel at all times. Use binoculars or camera zoom.	Confidence: medium. Interpretive synthesis; not a real-time ecological prediction. Source categories: F3, F4, F6, F7.
Autumn Passage	Outgoing Tide	Autumn Passage + Outgoing Tide = feeding ground reopening for passage birds	The tide is falling and the mudflat is reopening. Birds on autumn passage may begin using newly exposed areas to feed and regain energy. The mudflat is becoming a refuelling space.	Passage birds may depend on repeated, low-disturbance feeding opportunities during migration.	Refuelling ground opening (medium-high): The falling tide is reopening mudflat that may be used by passage birds to regain energy.	Keep to paths: Follow all signage and keep to paths. Give all wildlife at least 100m space to feed and rest. Dogs must be kept on a short lead or at heel, and must never chase birds or seals.	Confidence: medium-high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F1, F3, F5, F6.
Autumn Passage	Low Tide	Autumn Passage + Low Tide = exposed refuelling ground	The mudflat is exposed. During autumn passage, this may be a refuelling window for birds moving through the reserve. The open mudflat may look available to visitors, but it may already be occupied by feeding birds.	Disturbance can interrupt feeding and reduce the value of the mudflat as a stopping or refuelling place.	Active refuelling window (high): The exposed mudflat may serve as an important feeding and refuelling space for passage birds.	Give 100m space: Give all wildlife space to feed and rest; the guidance suggests at least 100m. If birds fly off, you are already too close. Use binoculars or camera zoom and avoid flash photography.	Confidence: medium-high. Interpretive synthesis; not a real-time ecological prediction. Source categories: F3, F4, F7.
Autumn Passage	Incoming Tide	Autumn Passage + Incoming Tide = refuelling window closing	The tide is coming in and the exposed mudflat is shrinking. Birds may be finishing feeding and moving to rest. For passage birds, this may mark the end of a short refuelling window.	Birds need to leave the feeding ground without extra pressure from people or dogs.	Refuelling window closing (medium-high): The incoming tide is reducing exposed mudflat and birds may be moving towards rest.	Move away on alarm: When birds raise their heads, make a distress call, or fly off, move away and view from a distance. Keep to paths. Dogs must be kept on a short lead or at heel at all times.	Confidence: medium. Interpretive synthesis; not a real-time ecological prediction. Source categories: F4, F5, F6.

Appendix B

Complete AR Layer Combination Matrix

The prototype uses three optional interpretive layers: Food Underneath, Chicks and Eggs, and Guest Boundaries. The eight possible on/off combinations are documented below. The overlays communicate ecological relationships and visitor responsibilities; they are neither real-time detections nor surveyed, legally exact spatial boundaries.

Food Underneath	Chicks and Eggs	Guest Boundaries	Ecological relationship displayed	Interpretive purpose	Limitation
Off	Off	Off	Camera view only.	Provides an unannotated baseline for comparison.	Absence of overlays must not be read as absence of wildlife or restrictions.
On	Off	Off	Subsurface prey and feeding-resource cues.	Reframes exposed mudflat as a temporary feeding ground.	Illustrative distribution, not sampled prey density or live detection.
Off	On	Off	Camouflaged eggs and chicks on the upper shore.	Makes low-visibility breeding vulnerability legible.	Representative placement; not a nest-location map.
Off	Off	On	A visible buffer or access cue.	Connects visitor position with respectful distance and managed space.	Not a surveyed boundary; current signs and fencing take precedence.
On	On	Off	Feeding resources plus hidden breeding life.	Shows simultaneous ecological uses across mudflat and upper shore.	Combines representative layers and does not establish co-location at the viewed point.
On	Off	On	Feeding-resource cues plus visitor boundary.	Links the feeding window to an actionable spatial response.	Approximate interpretation, not a safety or access determination.
Off	On	On	Hidden eggs/chicks plus visitor boundary.	Links breeding sensitivity to careful movement and distance.	Does not identify actual nests or replace fenced areas.
On	On	On	All three ecological and behavioural relationships.	Provides the fullest explanation of food, vulnerability and visitor responsibility.	High information load; all layers remain illustrative and context-dependent.

Appendix C

Mapping of Existing Visitor Guidance and Byelaws to the Guest Protocol

This appendix distinguishes statutory byelaws from advisory visitor guidance. The current byelaws page states that the Lindisfarne National Nature Reserve byelaws were passed in 1999 and remain in force. Proposed revisions shown on that page are not treated here as current rules. The suggested 100 m distance is visitor guidance, not a statutory distance.

ID	Source	Legal / advisory status	Behaviour category	Design wording	Prototype use
F1	Byelaws, clause (a)	Statutory	Disturbance / injury	Do not disturb or injure wildlife; move away if your presence changes behaviour.	Core warning and protocol language.
F2	Byelaws, clause (b)	Statutory	Eggs, nests and shelter	Do not take, damage or destroy eggs, nests or places used for shelter.	Chicks and Eggs layer; breeding-sensitive warnings.
F3	Guide for Visitors: Give Wildlife Space	Advisory	Suggested distance	Give wildlife space to feed and rest; the guidance suggests at least 100 m.	Distance cue; explicitly presented as guidance, not law.
F4	Guide for Visitors: Give Wildlife Space	Advisory	Behavioural alarm cues	If birds raise their heads, make an alarm or distress call, or fly off, move away.	Visitor-distance response and warning state.
F5	Guide for Visitors; Codes of Conduct	Advisory / local management	Paths, signs and fenced areas	Keep to paths, follow signs and give fenced protection areas a wide berth.	Guest Boundaries layer and local-rule cue.
F6	Byelaws, clause (g); Guide for Visitors	Statutory duty plus advisory explanation	Dogs	Keep dogs under the control required by the byelaws; visitor guidance specifies a short lead or at heel and no chasing.	Dog-related protocol output.
F7	Guide for Visitors; Codes of Conduct	Advisory	Photography and observation	Use binoculars or camera zoom, avoid flash and do not approach for a closer image.	Photography protocol output.
F8	Codes of Conduct	Advisory	Birdwatching / photography conduct	Prioritise avoiding disturbance and respond to signs of alarm.	General qualification across interpretive states.

Appendix D

Reserve Manager Engagement Probe

This appendix presents the probe used during the onsite engagement with the Reserve Manager on 18 June 2026. The probe combined seasonal sequencing, concern matching, spatial mapping and timeline activities to structure discussion around wildlife rhythms, visitor activity and reserve management across the year. It was used as a formative research tool to elicit site-specific knowledge and clarify relationships that were not fully visible through desk research or site observation alone; it was not intended as a formal interview instrument or quantitative evaluation.

1. Put these scenarios in sequence from the one you think need to pay attention least to the most

←

Less in need of attention

Most in need of attention

→

2. Scenario Prioritisation: Which description fit the scenario most?

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3. Visitor Action: What happens when visitors interact with wildlife?

--	--	--	--

(a) Scenario prioritisation



?

?

Most often occurs

Most often occurs

The most severe consequences

The most severe consequences

Hardest to solve

Hardest to solve

Walking	walking dogs	chasing birds	stops feeding	becomes alert	flies away
staying too long	dogs off lead		abandon chicks	change location	does not return
photography	approaching		leave nest		
leaving path	making noise				

(b) Behaviour–consequence matching



(c) Spatial mapping

Wildlife Rhythms

Jan

Feb

Mar

Apr

Jun

Jul

Aug

Sept

Oct

Nov

Dec

Please mark the times of year when important wildlife activities take place, such as:

- migration
- feeding
- breeding
- nesting
- chick rearing
- resting

You can draw lines, shade periods, or add short notes, using any forms you like. Please focus especially on periods when wildlife is more vulnerable to visitor disturbance.

(d) Wildlife rhythms across the year

Reserve Actions

Jan

Feb

Mar

Apr

Jun

Jul

Aug

Sept

Oct

Nov

Dec

Please mark the times of year when the reserve takes particular actions to protect wildlife or manage visitors, such as:

- temporary fencing
- access restrictions
- dog controls
- increased warden presence
- wildlife monitoring
- guided walks or public activities

You can draw lines, shade periods, or add short notes, using any forms you like. Please include both actions that restrict visitor behaviour and activities that invite visitors to observe, understand, or participate.

(e) Reserve management actions across the year

Visitor Rhythms

Jan

Feb

Mar

Apr

Jun

Jul

Aug

Sept

Oct

Nov

Dec

Please mark the times of year when different types of visitor activity are most noticeable, such as:

- high visitor numbers
- dog walking
- beach use
- walking off paths
- birdwatching and photography
- organised visits or events

You can draw lines, shade periods, or add short notes, using any forms you like. Please also indicate when visitor activity is most likely to overlap with sensitive wildlife periods.

(f) Visitor rhythms across the year

AI LOG



AI Log

ID	Project stage	AI tool	Purpose / Input	How AI was used	Researcher control / compliance boundary
A1	Research - topic exploration	ChatGPT	Early questions around human-centred time, non-human rhythms, tourism, wildlife and Holy Island.	Used to brainstorm relationships between themes and help organise possible research questions and areas for further investigation.	Final research question and scope were selected by the researcher through literature review, contextual research and fieldwork. AI suggestions were exploratory, not evidence.
A2	Research - source navigation	ChatGPT	Concepts and terminology relating to ecological time, wildlife disturbance, visitor guidance and Holy Island.	Used to suggest search terms, relevant concepts and possible source directions for later checking.	Academic claims and references were checked against original publications or official sources. AI summaries were not treated as authoritative evidence.
A3	Research - ecological record organisation	ChatGPT / AI-assisted processing	Public Lindsfarne NNR records and notes on seasonal wildlife activity.	Used to support initial extraction, grouping and organisation of recurring observations such as feeding, breeding, migration and wintering.	Original records remained the evidence source. The researcher reviewed the extracted material and determined the final seasonal categories used in the design.
A4	Research - tidal information organisation	ChatGPT	Existing crossing-time / tidal information and intended Time Translator interaction.	Used to help structure continuous tidal change into a small number of visitor-facing states for prototyping.	The researcher made the final simplification and treated the four tidal states as a design approximation rather than a scientific tidal model.
A5	Design - early concept development	ChatGPT	Research findings, stakeholder relationships, observations and early concept notes.	Used for brainstorming, comparison of design directions and critique of alternative framings.	The researcher selected, rejected and revised concepts. AI did not determine the project focus or final design direction.
A6	Design - scenario / habitat comparison	ChatGPT	Early scenarios including mudflat feeding, nesting and wildlife viewing.	Used to compare overlap, differences and possible ways of narrowing the design scope.	The researcher decided to focus on the beach-mudflat context and determined which ecological relationships were relevant to communicate.
A7	Design - information architecture	ChatGPT	Seasonal and tidal states, visitor-facing content, ecological matrix and interface iterations.	Used to test alternative information structures and identify communication gaps between ecological condition, significance and visitor response.	The final structure - Wildlife Now, Why It Matters, Sensitivity and Guest Protocol - was selected and refined by the researcher.
A8	Design - visual prototyping	ChatGPT image generation	Researcher-produced UI screenshots, sketches, diagrams and detailed visual instructions.	Used to create or refine presentation mock-ups, diagrams, layout studies and visualisations of design concepts.	Generated visuals were reviewed and corrected for typography, proportions, labels and consistency. They were used as design-development / communication material, not research evidence.
A9	Design - AR visualisation	ChatGPT image generation	Existing AR direction and ecological content for seasonal states.	Used to explore how otherwise difficult-to-see ecological relationships could be represented through layers, labels and interface states.	The researcher determined the ecological content, interaction purpose and final visual selection. The AR prototype does not claim real-time wildlife detection.
A10	Programming - Time Translator	OpenAI Codex / ChatGPT	Researcher-defined interface structure, interaction logic, content and visual specifications.	Used for coding assistance, implementation support and troubleshooting during development of the web prototype.	The researcher specified the intended behaviour, tested generated code and modified it as needed. AI served as technical assistance rather than autonomous development.
A11	Programming - AR prototype / debugging	OpenAI Codex / ChatGPT	Researcher-defined AR concept, error messages, screenshots and implementation problems.	Used to suggest code changes, explain errors and support debugging / technical experimentation.	Commands and code changes were executed and checked by the researcher against the intended design behaviour.
A12	Programming - Git / version control support	ChatGPT	Git / GitHub error messages and questions about recovering or switching versions.	Used to explain commands and provide troubleshooting steps for version management.	The researcher carried out the commands and verified the resulting project state.
A13	Reflection - design iteration	ChatGPT	Early and revised interfaces, diagrams and researcher descriptions of design problems.	Used as a critique tool to compare iterations and help articulate issues such as unclear temporal states, information density and weak transitions between ecology and behaviour.	The researcher decided which critiques were valid and which changes to implement. Reflection remained grounded in the documented design process.
A14	Reflection - dissertation structure	ChatGPT	Draft chapter structures, existing paragraphs and descriptions of the research process.	Used to test logical progression, identify repetition and suggest clearer transitions between theory, findings, design development and discussion.	The researcher retained control over argument, evidence and chapter structure and rejected suggestions that did not accurately represent the project.
A15	Writing - language editing	ChatGPT	Researcher-written drafts, notes, arguments, references and intended meanings.	Used to improve clarity, academic English, sentence structure and paragraph transitions, and to suggest alternative formulations based on researcher-supplied content.	All wording was reviewed and revised by the researcher. Factual claims and references were checked; AI-generated text was not accepted uncritically.
A16	Writing - captions / headings / reference formatting	ChatGPT	Figures, interface screenshots, appendix material and existing bibliographic information.	Used to shorten captions, develop headings, prepare concise figure descriptions and check reference ordering / APA-style presentation.	Final terminology and bibliographic details were checked by the researcher against the actual project materials and source information.

Critical Reflection on AI Use

AI was used primarily as an iterative support tool rather than as an authority. During research, it helped organise contextual material, while ecological interpretation remained grounded in original sources and site-specific knowledge. In design development, AI supported rapid comparison of information structures and visual alternatives, but outputs often required manual correction to maintain accuracy and consistency. Coding assistance was used for implementation and troubleshooting, with generated code tested and revised by the researcher. In writing, AI helped improve clarity and identify gaps in argumentation, but suggestions were checked against the literature, observations, reserve manager engagement and documented design process. Final interpretations, design decisions and evaluation remained the responsibility of the researcher.