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Connecting to the Sea: A Place-Based Study of the Potential of Digital Engagement to Foster Marine Citizenship

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Abstract

The Sustainable Development Goals for creating sustainable, resilient cities and addressing human impacts upon coastal waters and marine environments create a mandate for coastal cities to empower local communities to value city seascapes. One key way to achieve this is through more inclusive pathways to connect to the sea using participatory methods. This research used a participatory co-design approach in Plymouth—the UK's first national marine park—to explore the potential for place-based digital engagement to connect people with the sea, especially for deprived neighbourhoods. We sought to answer the research question of whether place-based digital technologies can engage communities with marine spaces and make coastal areas more accessible. Using the collaborative community-led concept of a city marine park, we explored the requirements for digital technologies needed to create marine citizenship and address the challenge of building coastal resilience. We describe a participatory action research study that took place in an urban coastal community, run in collaboration with a local organisation, the Rockpool Project, over a period of six months. Through a baseline survey, we identified some of the barriers to accessing the sea and ways in which the sea was perceived as a space in the city. We also ran a series of co-design workshops using creative prototyping with local families to help define the requirements for a digital toolkit that could enable them to access the sea. The results found that by enabling access to temporal and biodiverse marine spaces such as rocky shores, place-based digital technologies can create new ways for communities to access and engage with the sea. Place-based digital technologies have the potential to create marine citizenship by building a connection between people and marine environments to care for the sea as a shared resource. We propose this can help establish a sense of place and contribute to marine stewardship in coastal communities.

1. Introduction

1.1. Research Context: Sustainable Development Goals (SDG's) and Coastal Cities

There are a number of urban planning challenges linked to marine and coastal environments, which are facing unprecedented change due to the dual impacts of human activity and climate change (Department for Environment Food & Rural Affairs [DEFRA], 2002, 2018). These are particularly true of more urban marine environments in cities or towns and include socio-economic and cultural change as well as sea and air pollution, climate change, and extreme weather (Emmins et al., 2023). These can result in reduced visits to the marine and coastal environment, inadequate planning of coastal developments, and the fragmentation of coastal communities (and corresponding loss of social capital; DEFRA, 2002, 2019). One of the ways that has been identified to address this is the designation of City Marine parks (Pittman et al., 2019) that have the potential for building a more inclusive marine citizenship (Fletcher & Potts, 2008; McKinley & Fletcher, 2012) in coastal cities and create socio-economic and environmental benefits. Pittman et al. (2019, p. 3) define a city seascape as "the marine and coastal space (above and below water) that most influences the city and is most influenced by the city." In order to engage with a city seascape and promote marine citizenship, projects need to build a sense of marine citizenship.

Despite the strategic importance of coastal cities to achieving Sustainable Development Goals (SDG's), Pittman et al. (2019, p. 3) highlight the fact that "surprisingly little attention has been directed at finding innovative ways to integrate the seascape into city-wide initiatives to achieve healthy, prosperous, and sustainable coastal cities." Much of the discussion around coastal towns and cities has been anecdotal, as is partly reflected in the fact that there is no official definition of a "coastal community" and as such there is little collated data on the subject, which has deterred efforts towards the governance of coastal spaces and contributed to the ineffective participation within blue space practices (Corfe, 2017; Leyshon, 2018). The UN SDG's for creating sustainable cities and communities provide an agenda for coastal cities to value their city seascapes, which aligns specifically with two interrelated indicators for the SDG11 sustainable cities and communities. The first is that urbanisation should be "inclusive and sustainable urbanisation and that capacity for participatory, integrated, and sustainable human settlement planning and management in all countries" (UN Habitat, 2019). The second is that there should be "universal access to safe, inclusive, and accessible, green and public spaces, particularly for women and children, older persons, and persons with disabilities" (UN Habitat, n.d.). Graells et al. (2021, p. 4) highlight that multidisciplinary research on defining and designing sustainability solutions associated with participatory approaches "are still scarce and represent a gap in the knowledge." Therefore, in addressing the SDG's there are the dual aspects of creating participation and inclusive access to address the specific challenges in SDG11 around coastal cities.

1.2. Overcoming Barriers to Accessing the Sea

In order to address the SDG's for coastal cities, there is a need to understand what barriers prevent access to coastal spaces. In this article, we focus on the challenges for communities and deprived coastal

neighbourhoods. Research has shown that higher levels of deprivation correlate with lower levels of feelings of connectedness with the natural environment (Graells et al., 2021; Gray et al., 2023; Shamsuddin et al., 2012; Toomey et al., 2020, 2023). Association with the sea and marine environments and concern about the impact of the climate crisis have also negatively impacted higher levels of deprivation (Graells et al., 2021). This means there is a need to improve participation and establish a deeper sense of place to engage the coastal communities in place, keeping these assets and delivering the social and environmental benefits they confer. Research has evidenced inequalities around access and well-being in coastal communities, particularly in the UK, and establishes a correlation between higher levels of deprivation in coastal communities and poor well-being outcomes (Barton et al., 2022; Haighton et al., 2019). Conversely, the positive well-being benefits from exposure to green and blue space do not appear to be experienced by communities in disadvantaged areas facing socio-economic challenges (Ashbullby et al., 2013; Pool et al., 2023) and this is further compounded by intersections of age, gender, and disability as well as the barriers to accessing these spaces. Consequently, there is a need for innovative approaches to empower communities' access to city seascapes (Fletcher & Potts, 2008; McKinley & Fletcher, 2010). One of these innovative approaches is digital technologies as, according to Kelly et al. (2022, p. 129), these "emerging technologies have huge potential for engaging and educating groups about the ocean and, in particular, for sharing and developing ocean knowledge." But what is clear is that these technologies need to be aligned to relevant issues and communities, as only then can they increase knowledge uptake and care for the environment, which can promote personal action.

Therefore, the research question we seek to address is: "Can digital technologies enable participation and access to urban coastal space that foster marine citizenship?" In order to address this question, we first outline a literature review that addresses issues of marine citizenship in coastal cities and the challenges of inclusion around barriers to accessing the sea. We propose an approach using digital technologies such as citizen science to create new ways to engage people with the sea and to encourage marine citizenship. We introduce a study involving a coastal city in the UK where we used participatory methods and co-design to explore the potential of digital technologies for overcoming barriers to access to the sea. We outline the results which found that people often lack the tools and experience of accessing the sea and that there is a need for new ways to engage people. We also define the term "digital marine citizenship," which seeks to outline the role of digital engagement in fostering engagement with the sea. In summary, we outline some of the requirements of digital tools that might be appropriate for overcoming barriers to access the sea and how these fit within a broader agenda around addressing SDG aims for coastal cities, participation, and inclusion.

2. Literature Review

2.1. Marine Citizenship and the Sea as a Public Space

In the context of the SDG's it is recognised that individual citizens should have an understanding of the environmental impact of their actions and a corresponding understanding of how to adapt their behaviour or participate in activities to reduce their impact. The pathway to achieving this can be understood as a form of citizenship, that is, a level of responsibility for the environment. According to Fletcher and Potts (2007, p. 514), this relies on the connection between individuals and their local environment as a key rationale for personal involvement in environmental issues through "invoking a sense of global ownership and responsibility that is actualised locally." Therefore, citizenship makes the connection between broader

environmental challenges and individual action at a local scale. In the context of the sea or ocean, as a specific environment, the term "ocean citizenship" describes this relationship between people's everyday lives and the health of the coastal and marine environment (Fletcher & Potts, 2007). Marine citizenship is also a term used to describe how people engage with the sea, take personal responsibility, and create change towards pro-marine conservation behaviours (Buchan et al., 2023; Fletcher & Potts, 2008; McKinley & Fletcher, 2010). According to McKinley (2010), marine citizenship relates to the human–ocean relationship in society such that people also have a right to participate in shaping their relationship with the ocean:

> Having understanding of the individual rights and responsibilities towards the marine environment, having an awareness and concern for the marine environment and the impacts of individual and collective behaviour, and having a desire to have a role in ensuring on-going sustainable management of the marine environment. (McKinley, 2010, p. 294)

The ongoing cultural shifts in the interpretation of the coast and the relationship with the seascapes over time have created challenges for the governance of these spaces and, consequently, for building marine citizenship in coastal communities. From their integration as a part of the working life of the city in the 1900s to their increasing role in societal and cultural activities, the perceptions and definitions of these spaces have been ever-changing and ambiguous (Leyshon, 2018). There have been efforts within environmental governance practices to bring the same cultural and landscape character and planning mechanisms into dialogue for seascapes to better inform the decisions for governing and managing these spaces (Gray et al., 2023; Leyshon, 2018). The significance of these seaside spaces varies substantially in the way they are conceptualised such that seascapes could be perceived as a boundary, or an interface offering different possibilities for these spaces and the way they are managed (Barton et al., 2022; Leyshon, 2018). The characterisation is necessary to localise our understanding and response to environmental change through greater attention to establishing a baseline for informing judgements and decisions concerning the management of change (Leyshon, 2018). For this research, we adopt Pittman et al.'s categorisation of a city seascape as a collaborative community-led city marine park, which is more linked to urban social policy initiatives such as increasing access to green and blue natural infrastructure for community health and well-being (Pittman et al., 2019, p. 3). Pittman et al. (2019) also emphasise the participatory role of the marine park as a place for collective local knowledge and to encourage people to be more responsible and to care for the city seascape. In this way it aims to be a catalyst for pro-environmental behaviour (Pittman et al., 2019, p. 6) through a feedback circle linking experience and understanding to greater value, care, and enjoyment.

2.2. Digital Technologies for Enabling Marine Citizenship

Kelly et al. (2022) outline one of the drivers of ocean literacy as "technological developments," with one of the ways it achieves this being by providing engaging and emotional experiences. Digital technologies offer a promising approach to addressing some of the challenges of engaging people in place (Cigliano et al., 2015; Fuentes et al., 2023; Willis & Gupta, 2023). They can help create new connections with place and foster nature connectedness, as well as give tools to empower communities to actively participate in shaping their physical environments (Willis & Gupta, 2023). Applications of technologies like augmented reality or projection have demonstrated how digital intervention can create new ways to engage with public spaces (Chisik et al., 2022; Nijholt, 2016). Technologies such as mobile applications, immersive experiences,

augmented reality and virtual reality, and interactive maps for wayfinding can not only create new ways to engage with the sea and the marine environment but also provide tools and resources for individuals to become active stewards of marine environments and play a significant role in fostering conservation efforts (Chisik et al., 2022; Nijholt, 2016). Further, leveraging the new modes of participation created by these tools can democratise the decision-making processes by enabling more efficient, inclusive, and participatory engagement with a wider set of stakeholders in collaborative decision-making, enabling them to influence the design and development of public spaces.

The use of digital technologies for citizen science can be particularly valuable in coastal and marine contexts. By fostering marine stewardship, influencing policy and management, and building community capacity for addressing environmental concerns, it can create a broader impact on marine conservation (Cigliano et al., 2015; Conrad & Hilchey, 2010; Jordan et al., 2019; Kelly et al., 2020). As such, digital technologies can not only foster effective engagement with the marine environment but also foster effective participation in the long-term sustainability of placemaking initiatives by embedding them within the community's social fabric. Previous studies have demonstrated this in the context of citizen science projects playing a valuable role in fostering community engagement with environmental issues and natural spaces (Kelly et al., 2019; Nursey-Bray, 2017; Willis & Gupta, 2023). However, globally, marine and coastal citizen science is quite underrepresented, with a bias for simple mass participation programs (Cigliano et al., 2015; Conrad & Hilchey, 2010; Martin et al., 2016; Sandhal & Tøttrup, 2020). There is an opportunity to diversify and expand marine and coastal citizen science to be more place-based and linked to marine citizenship.

3. Methods

3.1. Research Methodology and Study Design

The project adopted a participatory action research framework (Greenwood, 2007; Ivankova & Wingo, 2018) using a co-design approach. The method involved direct collaboration with the stakeholders affected by the study, and we worked with The Rockpool Project (TRP). TRP is a Community Interest Company (CIC) working to engage local residents in discovering, connecting, and protecting their local wildlife across Plymouth's coastlines. TRP CIC have been working with this community towards the creation of the first UK National Marine Park (NMP) along with Plymouth City Council. TRP is a community-driven marine conservation initiative dedicated to exploring and protecting the incredible biodiversity of the UK's rocky shores. They engage people of all ages through hands-on rockpooling activities, citizen science, and educational outreach, fostering a deep connection with local marine environments.

Ethical approval was obtained prior to commencing fieldwork through the Faculty Ethics and Integrity Committee (Ref 4098) at the University of Plymouth, which included processes for parental consent for child participants.

3.2. Setting

The study took place in Plymouth, UK, a coastal city in southwest UK known as an "ocean city," located on one of the world's largest natural harbours. The waterfront includes a road and walkway, with a lido, harbour, marina, and two public beaches. Plymouth established one of the UK's first NMPs (Plymouth Sound

National Marine Park, n.d.). The NMP in Plymouth seeks to address broader challenges around the sea and the city and aims to "forge a new relationship between the city and the sea, encouraging people to become 'marine citizens'" (Plymouth Sound National Marine Park, n.d.). The centre of Plymouth is split into a number of neighbourhoods, some of which have longer-term issues with deprivation and poverty. The Stonehouse neighbourhood is located directly adjacent to the city centre. It is amongst the most deprived neighbourhoods in Plymouth and in the top 1% of most deprived neighbourhoods in the UK. We identified the Stonehouse neighbourhood as the focus of our study, due to these characteristics and its close location to the sea. The study took place primarily in an urban coastal space, Firestone Bay, which was selected because of its proximity to Stonehouse. Firestone Bay is a small pebble beach to the West of Plymouth, which was designated a bathing water site in 2022. It has stepped access to the beach and rockpools at low tide, with a number of local species such as crab, anemones, and seaweed. The beach at Firestone Bay is located less than one kilometre from the centre of Stonehouse neighbourhood (walking time of 20 minutes; see Figure 1a), and for many residents is closer in distance.

Figure 1. (a) The location of Firestone Bay, Plymouth. The geographical distance of Stonehouse neighbourhood (indicated by blue shading) to Firestone Bay is 1,000m, equating to an average walking distance of 1,500m or approx. 20 minutes on foot. The red circle indicates the location of the beach where the fieldwork was conducted. (b) Firestone Bay beach at low tide.

3.3. Participants

All participants were recruited because they lived in Stonehouse, Plymouth. This stakeholder group was recruited to understand challenges around access to the sea and barriers to participation in its governance as the identified research participants were amongst the most deprived and excluded groups but also lived geographically close to the sea. The recruitment of participants was through TRP, as a part of a funded Heritage Lottery Fund programme: Blue Recovery (https://www.therockpoolproject.co.uk/blue-recovery), which ran activities for local residents in a coastal city to provide access to the sea. One of the funding requirements was that all participants be from the Stonehouse neighbourhood. TRP was the main point of contact for the activities and ensured that the necessary safeguarding measures were in place.

The participants for the baseline survey took part during a one-day activity organised by TRP in July 2024, where residents from the Stonehouse neighbourhood took part in a community day at Firestone Bay, Plymouth. Participants were asked to complete the survey as part of the day's activities. Forty-eight responses were received, with 23 children (aged 7–16) and 25 adults (aged 27–49).

The co-design activities were run during TRP public programme in Plymouth that was held at Firestone Bay over a period of six months (Figure 2). These were held between July and December 2023 and participants consisted of families and children from Stonehouse. There were three workshops: Workshop 1 took place on 9th July 2023 with nine families, workshop 2 took place on 6th August 2023 with eight families, and workshop 3 took place on 28th October 2023 with nine families.

3.4. Activities and Data Collection

Data was collected using mixed methods using both a survey method and a co-design workshop. The aim of the survey was to understand the participants' relationships with the sea as a place, their perceptions of it, and the barriers to access. The workshop aimed to identify the opportunities to connect with the sea that would overcome these barriers and the requirements for digital technology to facilitate this engagement.

3.4.1. Baseline Survey: Understanding the Barriers to Accessing the Sea

An initial baseline survey was conducted in July 2023 at the beginning of the study to establish people's connection with the sea. This baseline survey was formulated based on Natural England's The Children's People and Nature (C-PANS; Natural England, 2022) survey, which provides information on how young people and children (aged 8–15) experience and think about the natural environment. We used a version of the C-PANS survey with three specific questions added around access to the sea.

3.4.2. Co-Design Workshop: Requirements for Digital Engagement Toolkit

The workshop took place at the beach area of Firestone Bay between July and October 2023, with participants consisting of families with children. It lasted between two and three hours. All the events took place on dates timed so that it was low tide, and, therefore, the rockpools were accessible. The workshop aims were to co-design the requirements of the digital engagement; the first part was a citizen science Bioblitz activity, followed by a second part, which was a participatory prototyping activity.

Figure 2. Bioblitz activity at the seashore in Firestone Bay (all photographs provided with permission).

The first part of the workshop was a digital citizen science activity in rockpools on the beach, which was co-led by volunteers from TRP. The citizen science activity was a Bioblitz, a collaborative citizen science effort aimed at documenting as many species as possible in a predetermined area and time frame (Postles & Bartlett, 2018). In this activity, the participants used the iNaturalist app to identify, record, and save data about species found in Firestone Bay using a mobile phone in a dedicated iNaturalist project. iNaturalist (https://www.inaturalist.org) is a widely available citizen science application which enables projects to be created that can be used for Bioblitz activities.

For the second part of the workshop, families were invited individually to create paper prototypes of a digital toolkit (Figure 3). Participants were given an initial briefing session, followed by low-fidelity paper-based prototyping with the participant groups around engaging with the sea. This involved asking

Figure 3. Participants in co-design workshop at the seashore in Firestone Bay.

families with children to use craft materials to respond to prompts about the things that would help them visit the sea and to create a paper prototype of a digital toolkit. The children then talked about what materials they needed to visit the sea, and they responded to prompts from the researcher about how often they visited the sea and what the barriers were. A thematic analysis was then performed to identify needs and barriers in relation to responses around what would enable the participants to access, engage with, and care for the marine environment and outdoor seaside spaces.

3.5. Limitations of the Method

The main limitations of the study were the small participant numbers, the qualitative nature of data collection, and the focus on a specific urban coastal setting. The study was undertaken with participants from a specific disadvantaged neighbourhood in the city of Plymouth over a six-month period. It was focused on families and young people and did not aim to cover a broad demographic that could be generalisable to a wider population. The baseline survey was mapped to national data, but the participant numbers were small and focused on children aged 8–15. The co-design workshops were run with TRP and took place over three dates, but again, they involved small numbers of participants, and the results were qualitative. The focus on qualitative data means that the outcomes of the study are rich and participatory but do not yield definitive or fully quantitative results.

4. Results

We outline our results in two sections: The first is the results of the survey method, and the second is the findings from the co-design workshops.

4.1. Understanding the Barriers to Accessing the Sea (Baseline Survey)

4.1.1. Access and Visits to the Sea

Participants could indicate any amount of time spent in a series of outdoor places in the last week, and the frequency of reported responses was recorded (Figure 4). Of the overall responses ($n = 88$), Beach or Seaside recorded 14 responses. Despite the physical distance to the city being about 1,500 metres (maximum) for Stonehouse residents, the beach or seaside was perceived as walkable in only 35 of the reported responses.

Therefore, the sea as a place was perceived as walkable by only 14 children, whereas parks were perceived as walkable by almost all children, despite the physical distances to both being fairly similar. This suggests the barriers to accessing the sea were not just physical but also based on perceptions of the sea not being accessible by foot.

In terms of visits to the sea, the response to the question "How often do you visit the sea/natural outdoor spaces by the sea?" revealed that only one respondent reported visiting sea/natural outdoor spaces daily ($n = 1$; Figure 5). More than half of the children ($n = 15$) reported visiting the sea/natural outdoor spaces by the sea a few times a month or less. A fifth of respondents reported only visiting the sea a few times a year ($n = 7$). This again highlights a lack of engagement with the sea/seaside despite participants living within walkable distance.
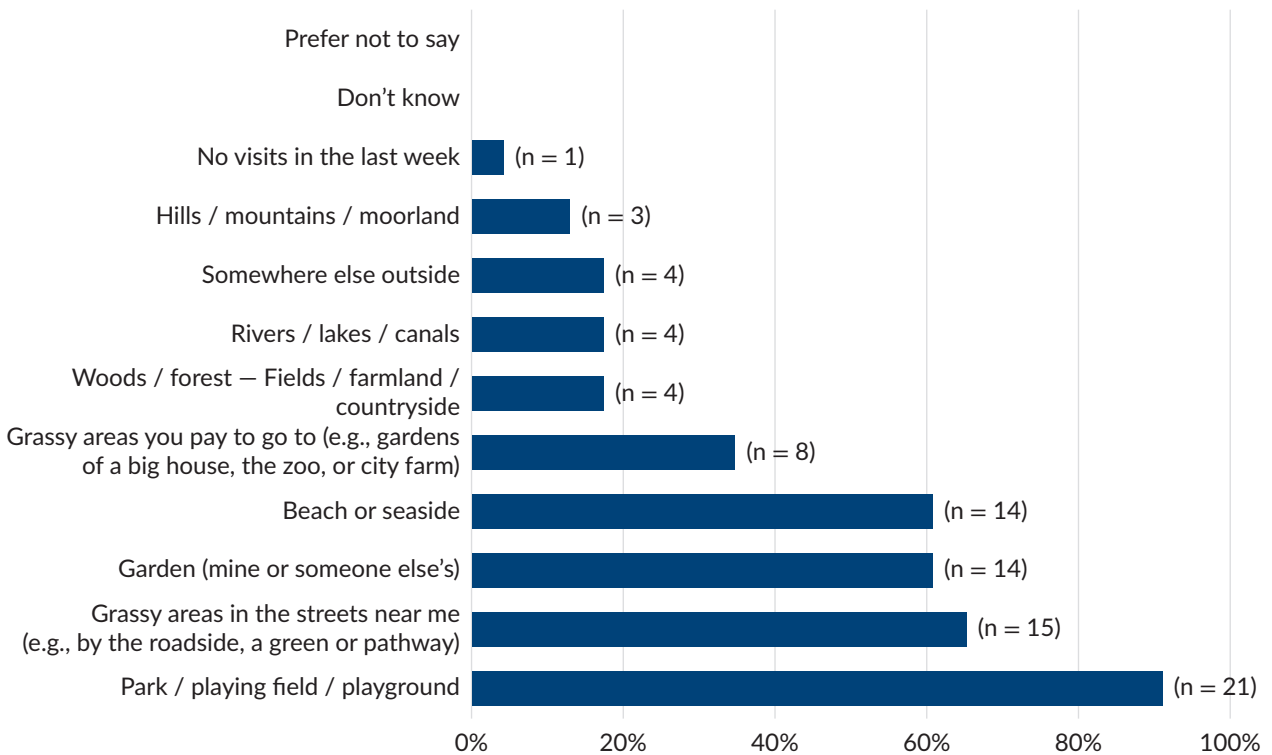
Figure 4. Answers to the question: "Which of these places can you walk to easily from your home (either by yourself or with someone else)?"
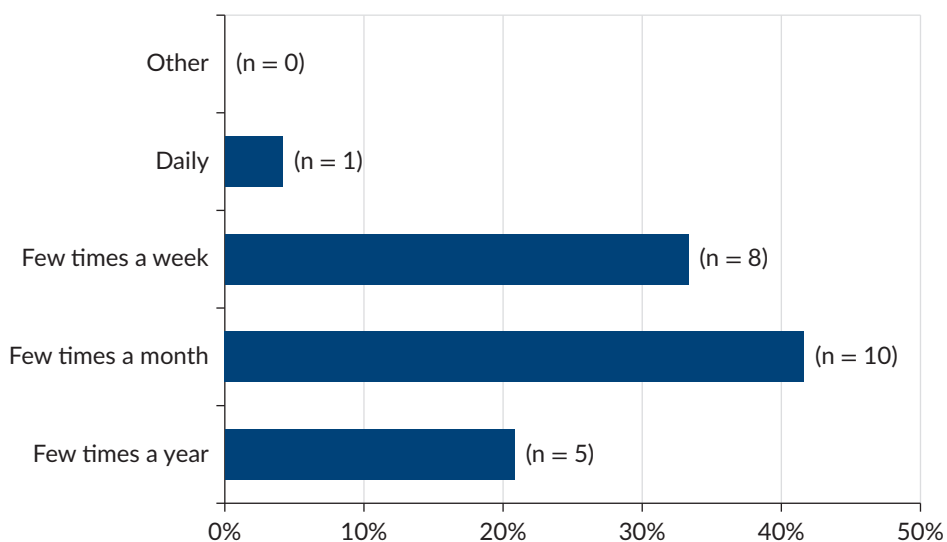

Figure 5. Answers to the question: "How often do you visit the sea/natural outdoor spaces by the sea?"

In response to the question "Have you spent time in any of these places in the last week?" participants could indicate any amount of time spent in these places in the last week, and the frequency of reported responses was recorded (Figure 6). Of the total reported visits ($n = 74$), only 12 responded with Beach or Seaside. Overall, the greatest number of visits were reported for urban greenspaces ($n = 58$), and respondents reportedly visited greenspaces substantially more than the seaside ($n = 12$).
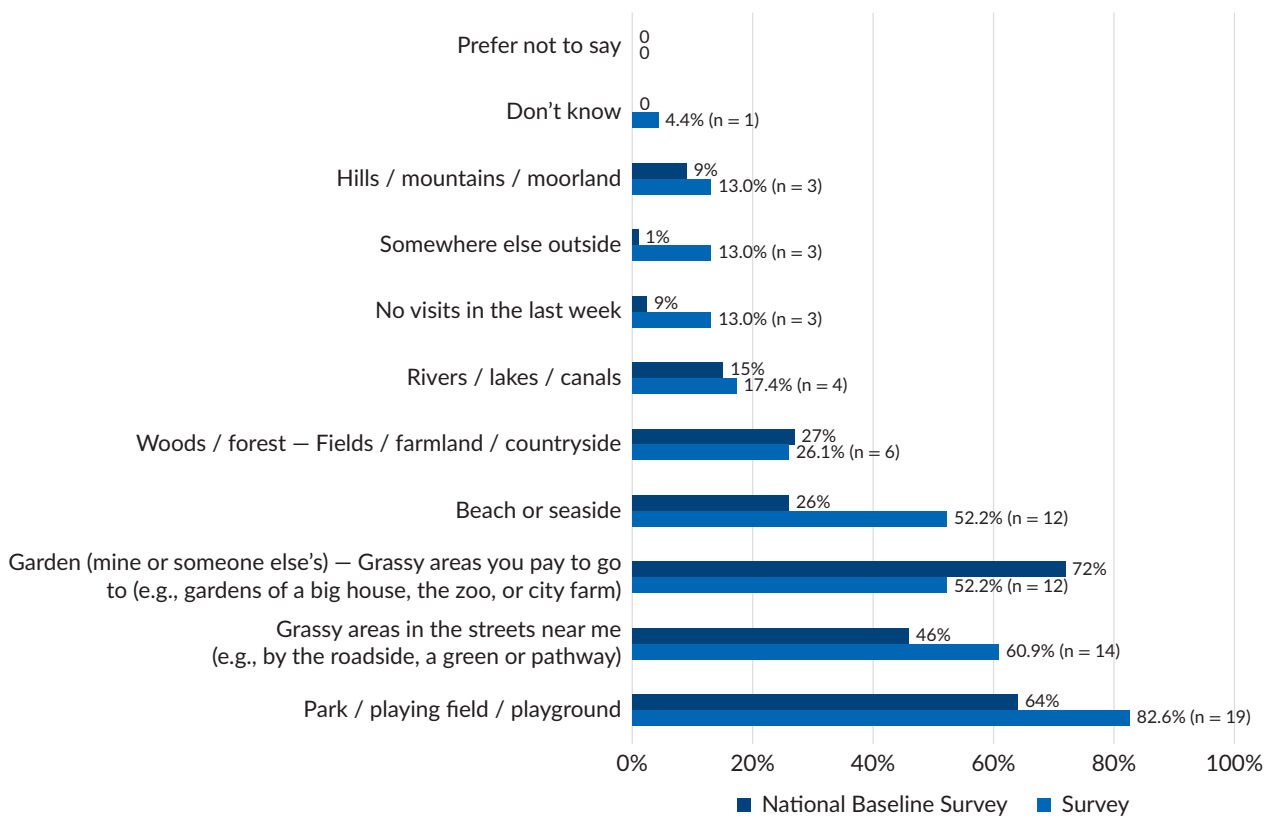
Figure 6. Time spent outdoors by the participants in the last week as compared to C-PANS baseline (based on question: Green and Natural spaces that children and young people said they had visited in the last week [weighted percentage]).

We found that reported visits to the sea in the study (16%, $n = 12$) were lower in comparison to the national dataset (27%). This indicates that although the sea is physically accessible in terms of distance, it is not typically seen as a "natural space" by children in the city.

The question "How connected do you feel to nature?" uses the "Inclusion of Nature Scale," which shows seven diagrams each containing two circles, one with the outline of a person and saying "me" and the other with a nature-filled scene (Kleespies et al., 2021). The highest number of respondents ($n = 7$) indicated a medium nature connection at a mid-point on a 0–6 Likert scale equivalent (Figure 7), followed by $n = 5$ each at a score of 4 and $n = 4$ at 5. Only two responses were recorded with the highest score of six (10%) as opposed to the national average of 14%. Nationally, 26% of respondents reported moderate nature connection at a score of three (Natural England, 2022).

These findings show that children in Plymouth have a lower sense of nature connectedness than the national average, and we propose that this is more closely related to the levels of deprivation in the city than the physical accessibility of the sea.
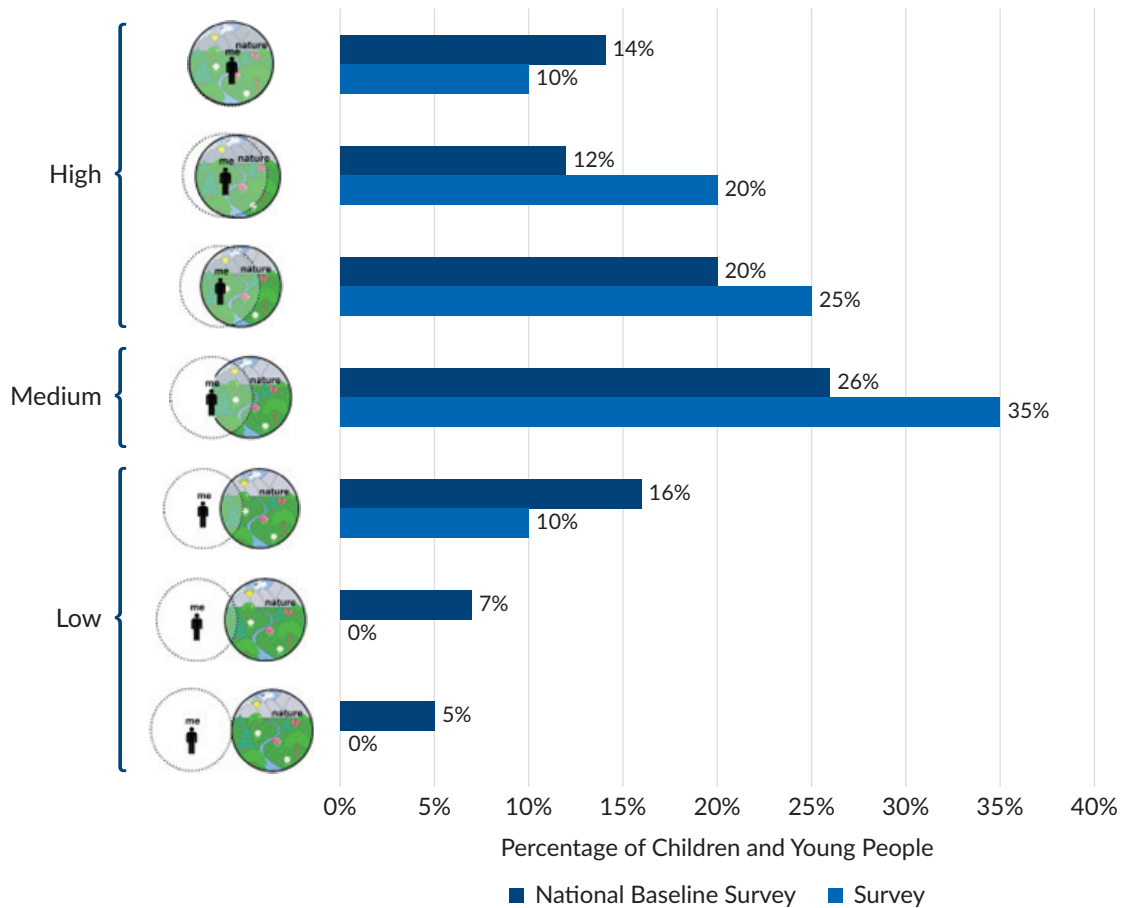
Figure 7. Self-reported levels of nature-connectedness from the C-PANS "Inclusion of Nature in Self Scale" baseline.

4.1.2. Activities at the Sea

In response to the question "What do you like to do when you visit the sea/natural outdoor spaces by the sea?," there were 83 responses overall. Swimming was reported as the most popular activity ($n = 22$), closely followed by sitting on the beach and having a picnic ($n = 17$), doing water sports, and rock pooling ($n = 13$; Figure 8). Participants were given an opportunity to document other activities. However, only one response indicated "other."

The majority of the responses indicated that the seaside was viewed as a place to visit for leisure and engagement with the sea for recreation and physical well-being ($n = 35$) rather than engaging with nature-focused activities such as rockpooling. This indicates that the sea is primarily seen as a place for physical activities or social ones, such as picnics and relaxing on the beach, and much less as a natural environment.

4.1.3. Barriers to Accessing the Sea

Participants were asked an open-ended question "What things have stopped you from spending more time outside in the last week?" to identify barriers to regularly spending more time outside. Of the responses
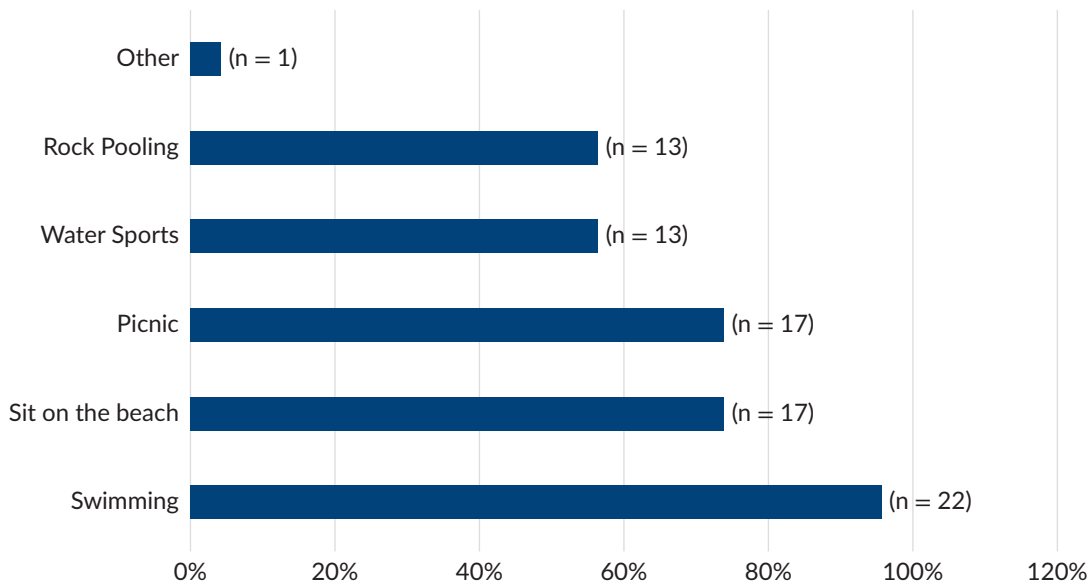
Figure 8. Answers to the question: "What do you like to do when you visit the sea/natural outdoor spaces by the sea?"

recorded, $n = 19$, the highest number of respondents ($n = 7$) indicated in some form that they did not know what barriers prevented them from spending more time outdoors with responses such as "I don't know" or "Nothing," followed closely by time-related reasons after at $n = 6$ (with responses such as "homework," "time schedule," "school," etc.). Both weather- and health-related reasons were mentioned three times in the responses, and one response indicated that transport accessibility was the barrier. Overall, the barriers to participants seemed to struggle to find specific reasons why they did not go to the sea, with the response "nothing" being the most common.

4.2. Co-Design Workshop: Requirements for a Digital Toolkit for Accessing the Sea

4.2.1. Bioblitz Citizen Science Activity

The second part of the co-design workshop was a bioblitz activity, where families used the iNaturalist app with a dedicated project for the bioblitz activity, to record species found in the rockpools (Figure 9). For many of the participants, this was the first time they had ever been rockpooling, and using the citizen science app was vital for identifying what was found as they had little knowledge of any of the species.

Figure 9. Bibioblitz activity in rockpools at Firestone Bay, with TRP volunteers.

Children took pictures of the species they identified and also learned the importance of leaving the rockpool as they found it by turning back rocks and being careful where they stepped as they moved around. The following day, the participants were sent a summary of the species they had spotted and a series of pictures of the species they had recorded (Figure 10).
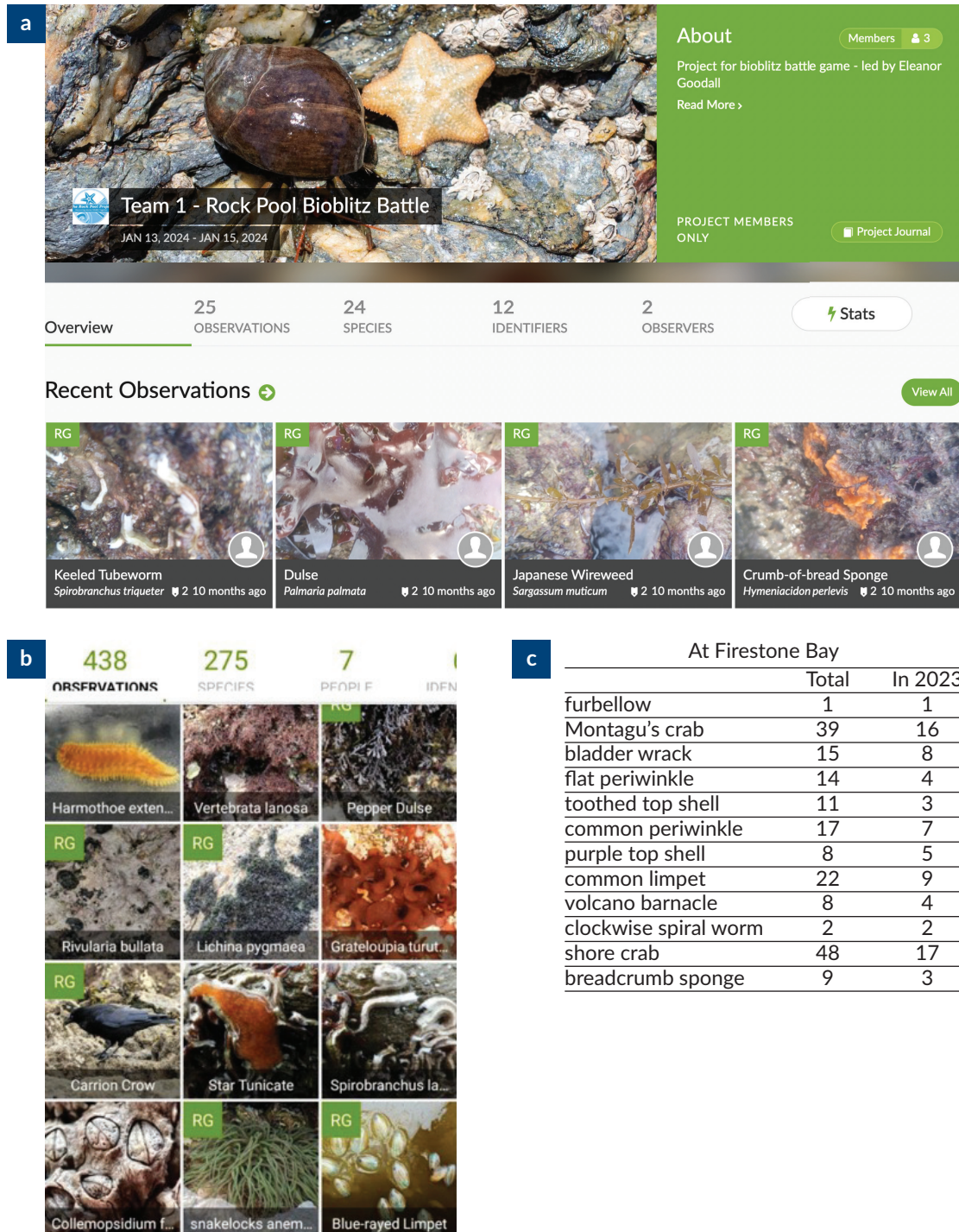

	Total	In 2023
furbellow	1	1
Montagu's crab	39	16
bladder wrack	15	8
flat periwinkle	14	4
toothed top shell	11	3
common periwinkle	17	7
purple top shell	8	5
common limpet	22	9
volcano barnacle	8	4
clockwise spiral worm	2	2
shore crab	48	17
breadcrumb sponge	9	3

Figure 10. (a) Results of the Bioblitz from 10th August 2023 in iNaturalist project; (b) examples of species observations made in the Bioblitz in iNaturalist project; (c) summary of species identified as a total. Source: iNaturalist (n.d.).

The Bioblitz activity demonstrated that the existing digital iNaturalist app was a valuable way for children to access nature since it was easy to use and well-resourced. Bioblitzes are, by nature, participatory, and this is what distinguishes them from traditional ways of recording observations. They also have the advantage of a volunteer network of experts who verify species once they have been submitted, giving a wider sense of community ownership.

4.2.2. Paper Prototyping Activity

The child participants created paper or low-fidelity prototypes, which included things they felt they needed to access the sea in the form of a 'toolkit.' We explained to the children that their ideas would help us design the digital toolkit that would be used in the future to access the sea. The creative nature of the exercise was useful in helping them develop their ideas, and it also enabled qualitative conversations about what barriers they had to accessing the sea and what helped them enjoy it once they were there. Over the course of the three workshops, we collected over 25 prototypes from children, and this included 83 "ideas" for the contents or nature of the toolkit (Figure 11).
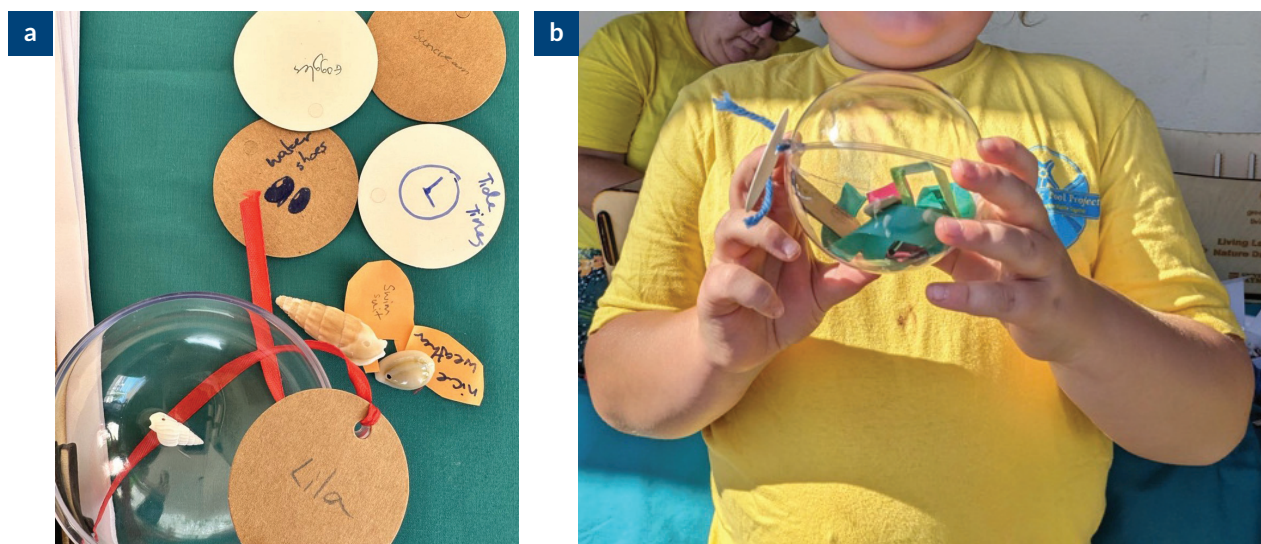
Figure 11. (a) Example of a participant's paper prototype—including ideas for "water shoes, tide times, nice weather, goggles, sun cream"; (b) low-fidelity or paper prototypes developed during the co-design workshop.

4.2.3. Paper Prototype Themes

The responses captured in the paper-based prototyping exercise and dialogue with participants during the co-design workshops are presented in Figure 12.

4.2.4. Accessing the Sea and Activities

One of the main observations of the workshop was that many of the children and adults were unfamiliar with the sea as a place to visit regularly. Although the children were primarily from Stonehouse, within walking distance from the sea, many talked about not having been before or only visiting rarely. This aligned with the results of the baseline survey. Therefore, in many cases, the participants struggled to think of things they required and needed prompting as they simply did not have any regular experience of visiting the sea. Although
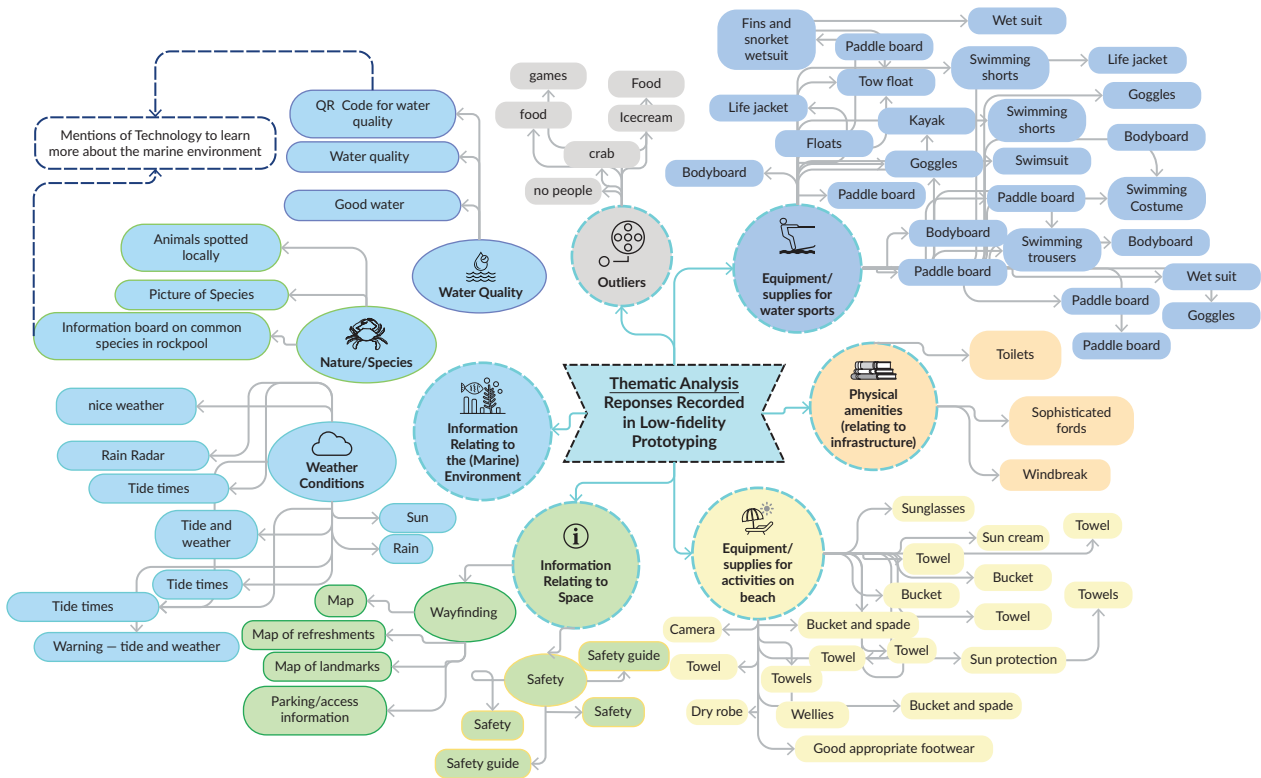
Figure 12. Thematic analysis of responses recorded in co-design workshops (low-fidelity prototyping).

the beach at Firestone Bay is located in the city, the main ideas that emerged were based on activities at the sea that are more typical of stereotypical beach activities, such as water sports, and physical activity and active play were key features of beach visits for children and parents, which aligns with Ashbullby et al. (2013). None of the children had ideas for information related to the sea as a natural space, such as a guide to the species locally or a description of the marine environment.

For example, the prototype by Lila (see Figure 11a) included the following items/ideas: water shoes, swimsuit tide times, nice weather, goggles, and sun cream, all of which were themed around equipment for leisure activities at the beach. Only three ideas across all participants were received for ways to engage with nature, and this suggests that children would benefit from having access to tools or ways for children to engage with the sea as a natural space. Although the participants did not give any references to specific citizen science tools, the children also verbally talked about wanting to identify nature and species on the seashore.

The ideas relating to physical access to the sea related to prompts for maps or wayfinding and also to safety advice or guides. The children reported needing information about the sea as a destination and a physical amenity. Three ideas were stated for information about water quality. This showed that there needed to be some form of guide or information about how not only physically to access the sea but also about the sea in terms of safety, both practically and also in terms of the health aspects relating to water quality.

Ideas for how to get information about weather and tide were the main ones identified in relation to the sea as a natural environment. It became clear that the sea space was inaccessible not only in terms of access to the sea initially but also literally the sea would become a dangerous and physically inaccessible space in ways

that were unpredictable and temporal. Participants identified tide times as useful information that could be provided so that they would know when it was safe to get to the beach. At high tide, the rock pools and most parts of the beach were inaccessible, which meant that the beach became a very different space, and here, the concept of the seas as a natural space was viewed in terms of it being a barrier rather than an opportunity. Ideas for the digital tools, therefore, identified real-time tide information, weather reports, and prompts for when the rock pools would be accessible to allow people to do this safely.

4.2.5. Requirements for a Digital Toolkit for Accessing the Sea

We combined the outcomes from the co-design workshop, the bioblitz, and the paper prototyping activity and mapped these against the barriers to accessing the sea. We had originally planned to develop a new digital stand-alone app, but instead, the outcome of the co-design was the need to provide a digital guide or toolkit that enabled families to visit the sea independently, when not supported by TRP volunteers (Table 1).

Table 1. Toolkit components mapped against marine citizenship.

Digital Toolkit component	Activity	Marine citizenship
iNaturalist app and Bioblitz guide	Citizen science app for digital identification and recording of marine species	Marine Literacy
Mobile phone with magnifying lens attachment	Digital capture of nature	Marine Literacy
Digital map specific to the nearest coastal beach or shore	Digital access to the coastal space with walkability aspects	Access to the sea
Safety guide and live weather, tide times and water quality display	Safety and information about tide and water quality levels and when the beach or coastal site is physically accessible (e.g., at low tide)	Access to sea

5. Discussion

5.1. SDG's and Participatory Methods: Marine Citizenship and Sea as a Public Space

To advance towards SDG's, including the goal of making cities inclusive, safe, resilient, and sustainable by 2030, coastal cities must enhance all aspects of their unique natural and social capital including adjacent marine spaces. Coastal cities have the potential to create a connection between people and the city seascape in a way that will bring positive socio-economic benefits and more inclusive participation whilst simultaneously facilitating greater stewardship of the marine environment. Creating ways to access the sea is seen as one way to achieve this and addresses the challenge that most people only spend a limited part of their lives experiencing ocean environments (Cigliano et al., 2015). Our findings from the baseline survey show that simply living near the sea does not enable access, and in fact, our baseline survey found that participants had lower levels of access compared to the national average despite living near the sea. If we consider that one way to enable marine citizenship is to enable access to the sea, commons, or public spaces through a marine park-type model, then this shows that the challenge lies in fostering feelings of connectedness and stewardship and promoting cultures of urban marine citizenship (Pittman et al., 2019) rather than just enabling access. Our findings from the baseline survey showed that the participants perceived the sea as primarily a

place for physical and leisure activities and not as a space to engage with nature. We also found lower levels of nature connectedness compared to the national average, suggesting a lack of sense of place in living in an urban coastal community. Our co-design workshops found that people lack the tools and experience of accessing the sea as a natural space, and that there is a need for new ways to engage and inform people about the sea where digital tools such as citizen science, information about species and real-time data about water quality and tide times could provide new ways to connect with the sea.

5.2. SDG's and Inclusion: Overcoming Barriers to Accessing the Sea

Coastal and marine spaces are unique not just in their constraints, but also in their natural assets—the coastal and marine environments—that are available to them and can be an engine for the regeneration of the communities that inhabit them (Balata & Vardakoulias, 2016; Barton et al., 2022; Carpenter & Balata, 2018; Corfe, 2017). Evidence suggests that the sea and the coastal spaces can become a landscape to address these inequalities and cater for the varied needs of the community (Ashbullby et al., 2013; Bell et al., 2015). Our study focused on an urban community that is categorised as deprived and within walking distance of the sea. However, despite living within walking distance of the sea, we found that only 16% of children living in a deprived neighbourhood visited the sea once a week, and anecdotally, we talked to a number of families who reported never having visited the sea. According to the literature, deeper connections to place in the context of marine environments and marine awareness are related to a higher likelihood of pro-marine conservation behaviours, which is needed to build stewardship (Day et al., 2022; Toomey et al., 2023). Therefore, creating pathways to physically access the sea is one of the key first steps. However, the baseline survey results showed that even when the participants did spend time at the sea, they reported almost no activities related to nature. They were primarily focused on leisure or social activities such as picnics or swimming. The opportunities to overcome barriers lie in overcoming perceptual barriers and creating activities that are accessible and easy to repeat and that create engagement with the sea. Through our co-design activities, we found that children's ideas for enabling access to the sea included information about the sea condition and safety, as well as ideas or guides as to what to do, as the main barriers were more perceptual.

5.3. The Potential of Digital Engagement to Create a Sense of Place

According to Kelly et al. (2022, p. 135), the use of technology "has significant potential to enhance sharing and uptake of comprehensible information about the ocean." Whilst there is a public perception that technology separates us from engaging with place, studies have found that digital technology, when used in a place (rather than remotely), can increase engagement with nature and emotionally connect people with their local environment (Crawford et al., 2017). Citizen science and digital tools for nature engagement can be valuable methods for engaging people with nature and developing modes of citizenship (Unger et al., 2021). However, the impacts are underexplored in marine spaces. We propose that there is a current gap in knowledge relating to the role that digital engagement can play in marine citizenship studies and therefore, we seek to define digital marine citizenship as:

> "*engagement with digital technologies that enable participation and access to the sea and foster marine citizenship.*"

Kelly et al. (2022, p. 137) outline how the five interlinked drivers of ocean literacy, education, cultural connections, technological developments, and knowledge exchange "will achieve most impact when applied together in diverse engaging and innovative activities." We found that it is not a single digital tool or app that is needed but a toolkit that brings together a range of information and engagement opportunities which could be undertaken by the sea. A digital toolkit can be a useful method for engagement, if it is part of an activity, and can provide pathways for them to perceive the sea as a place for them and feel a greater sense of ownership. The other aspect of the mode of digital engagement was that it needed to be used in the place, which in this case was the seashore, and this was not about providing information about the seas from remote locations such as at home or school. Our focus on place-based technologies that were used at the shore or marine space, such as the bioblitz activity did create a connection to the marine environment. In particular, the use of the iNaturalist citizen science app enabled the digital information to relate directly to what participants were observing in the real space and create new ways of engaging. According to Toomey et al. (2020), citizen science has the potential to deepen connections between participants and the natural world. Citizen science has the potential to foster further engagement in pro-environmental actions, and Newman et al. (2017) argue that it can be perceived as a type of "place-making" whereby citizen scientists are actively and continually involved in the production of place. In our study, the requirements for the digital engagement identified through the co-design activity related to the desire for live or real-time data about the place, such as the weather and tides. Practically, tide times emerged as a critical piece of data that was often not even understood by the participants as a factor in their visit to the sea. However, the rock pools were only accessible at low tide, so knowing when it was safe to go rockpooling and being aware when the tide was coming in were vital. The use of the iNaturalist app as part of a bioblitz activity provided a valuable and engaging way for children to observe and engage with nature. However, our study identified the need for a digital guide and prompts as to how to get started, and a follow-up with a record of their data was an additional part of the toolkit that would make it accessible to those families who may only have limited experience of visiting the sea.

6. Summary

The SDG11 around Sustainable Cities and Communities sets out the challenge to develop better models of participatory planning and governance of coastal cities and also to address issues of inclusivity and who benefits. We propose that digital technologies offer an opportunity to address these challenges by enabling new modes of participation in connecting to the sea. This article explored pathways to creating marine citizenship using place-based digital technologies in the context of the sea as a public space or "city marine park" (Pittman et al., 2019). It worked with the idea of the seascapes and the coast as a "blue urban commons" which celebrates the sea and the connection between the marine environment and the city facilitating the community's participation in activities cantered around caring, understanding, valuing, and enjoying the city seascapes. Therefore, the city seascape does not treat the coast as a marine park area where human activities are restricted but instead as a place that is embedded in the geographical and socio-economic context. We explored how digital technologies can facilitate engagement with and access to the marine environment by identifying requirements for a digital toolkit.

In the article, we discussed the results of a mixed methods study in Plymouth, given its leading role as the first NMP in the UK, in order to generate findings that can be shared with other coastal towns and cities. The study partnered with a local marine organisation, TRP, to undertake a series of co-design workshops in a

deprived urban coastal area. The findings of this study indicate a range of barriers to accessing the sea and also identify how digital tools can enable access to temporal and biodiverse marine spaces such as rocky shores. In so doing, they can create new ways for communities to access and engage with the sea/marine environment. We propose that an integrated approach using digital technologies in the form of a digital toolkit to build and nurture relationships between people and marine environments. We introduce the concept of digital seascapes, where digital technologies enable participation and access to urban coastal spaces and foster marine citizenship. In this context, it can help contribute to broader challenges around participation by establishing stewardship of city seascapes as a "blue commons."

Conflict of Interests
The authors declare no conflict of interests.

Data Availability
The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

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