

How to engage the public in Multi-functional coastal defence design: The case of Mumbles



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1 Context

1.1 Introduction

During COP26 the World Ocean Initiative (2021: 1) suggested that Coastal and marine environments are like the “canary in the climate change coal mine”. Anthropogenic climate change is causing sea-level change via melting glaciers and thermal expansion (IPCC, 2013; NASA, 2022) and the impact of change is mainly experienced by coastal communities. Coastal communities are some of the most densely populated and urbanising areas on the planet (Neumann et al., 2015) and they need to adapt to the challenges associated with sea-level rise (SLR) (Brown et al., 2018). In particular, coastal erosion is a hazard exacerbated by SLR that needs to be addressed in a new way to create resilient coastlines (Nicholls, 2021). Hence, it is vital to develop coastal protection strategies that address the inevitable hazard of excessive erosion from SLR and yet deal with coastal communities’ human geographical functions (Cool Geography, 2022).

Geographical justification for this research

The coastal erosion processes of hydraulic action, attrition, abrasion and solution work in different locations to cause coastal retreat (RGS, 2022). Although SLR influences coastal erosion, the associated climate change factor of increased storminess seems to have a more pronounced impact (Sear, 2013). Traditionally the Institute of Civil Engineers and others promoted hard engineering approaches because they reassured communities, but these were expensive to build and maintain. More recently, soft engineering has become a sustainable alternative (Internet Geography, 2022) especially linked to Shoreline Management Plans (SMP, 2019). Examples of both approaches and their advantages versus disadvantages can be seen in Tables 1.1 and 1.2 (Images can be seen in Appendix 1)

Table 1.1 Examples of hard engineering (My Tutor, 2022)

Type	Description	Advantages	Disadvantages
Sea Wall	Walls constructed using concrete, steel or stone and built along the shoreline.	Acts as a barrier to prevent erosion and flooding. Sea walls can be used as promenades.	Powerful waves will erode walls over time. Expensive.
Groynes	Wood or rock structures built at right angles to the sea.	Prevent the process of longshore drift. Builds up the beach over time.	Can starve beaches further down the coastline. Difficult to walk along the beach.
Rock Armour	Large boulders placed at the foot of a cliff or sea wall.	Absorb wave energy and reduce erosion. Cheaper hard engineering technique.	Expensive to transport and implement. Look different to local geology.
Gabions	Rocks held in mesh cages to reduce erosion.	Cheap to produce. Absorb wave energy.	Easily damaged by strong waves. Looks unnatural.

Table 1.2 Examples of soft engineering (My Tutor, 2022)

Type	Description	Advantages	Disadvantages
Beach Nourishment	Widening of the beach using sand and shingle.	Increase distance of wave travel which reduces erosion. Blends in with the existing beach.	Sediment has to be sourced and transported. Requires frequent maintenance.
Dune Regeneration	Creating and restoring sand dunes.	Dunes create barriers and absorb wave energy. Provides flood protection.	Creates a barrier to the beach.
Beach Reprofilng	Redistributing the sediment on the beach to stabilise erosion.	Cheap and simple to implement. Reduces wave energy.	Only works in places with low wave energy. Needs to be maintained.
Managed Retreat	Certain areas along the coastline are left to flood naturally.	Natural processes restored. Encourages wetland and salt marsh formation for wildlife.	Compensation for land and livelihood loss required. Agricultural land lost.

Furthermore, several factors are judged when SMPs consider which engineering approach is most appropriate in a particular location. Table 1.3 shows how these factors vary depending on which approach is used. However, some commentators now highlight the importance of multiple coastal functions in designing coastal defences (Williams pers comm, 2022). Hence, multi-functional solutions that can deal with the primary purpose of coastal protection and provide secondary benefits are the preferred option for future coastal management (Evans et al., 2017).

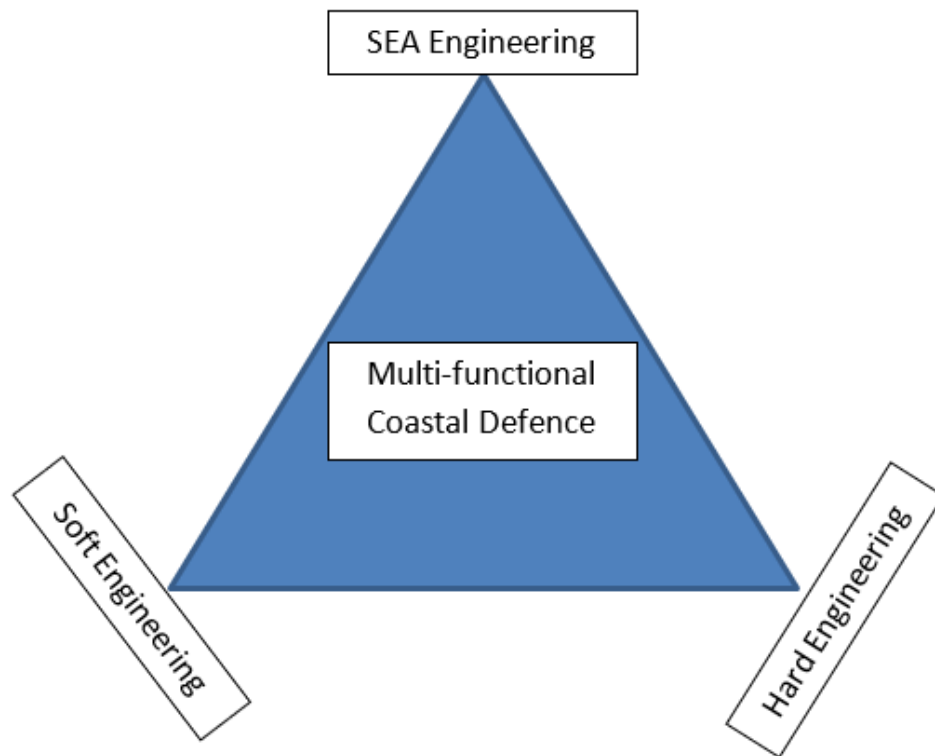
Secondary benefits might include some of the UNs Sustainable Development Goals (SDG, 2022) in areas such as biodiversity (CBD, 2022), well-being, health (UN, 2018), economic prosperity (UN, 2019) etc. which are all issues that are in juxtaposition to the coast. Additionally, these considerations show the need for local public/stakeholder consultation and participation (Coastal Wiki, 2019) to design Multi-Functional Coastal Defences (MFCD) that are fit for purpose within a local and global geographical context. Hence, MFCD is at the vanguard of coastal geography research and is an appropriate field for identifying innovative research conclusions.

Table 1.3 A comparison of the factors that influence traditional coastal protection decisions (My Tutor, 2022)

Factors	Hard Engineering	Soft Engineering
Scale	Typically built on a larger scale.	Smaller-scale operations.
Cost	Very expensive (construction and repairs)	Less expensive but require consistent maintenance.
Coastal Protection	Provide short-term but effective protection from erosion.	Provide longer term solutions to beach erosion issues.
Visual Appeal	Very visible and disrupt the look of the natural landscape.	Blend into the coastal environment and looks natural.
Hazard Risk	Could be dangerous to humans eg: falling on rock armour.	Less harmful to both humans and animals.
Environmental Impact	Can reduce deposition down coast and disrupt habitats.	Remodeling the coastline can disrupt wildlife.

Studying soft and hard engineering strategies highlights the importance of physical processes. However, human geographical studies also show how socio-economic and

aesthetic factors (SEA) are an essential consideration to the public. Hence, multi-functional coastal defences can be used to combine the human and physical challenges in coastal regions. This simple model shows the researcher's view that MFCD can address a multifaceted approach and (Figure 1.1).

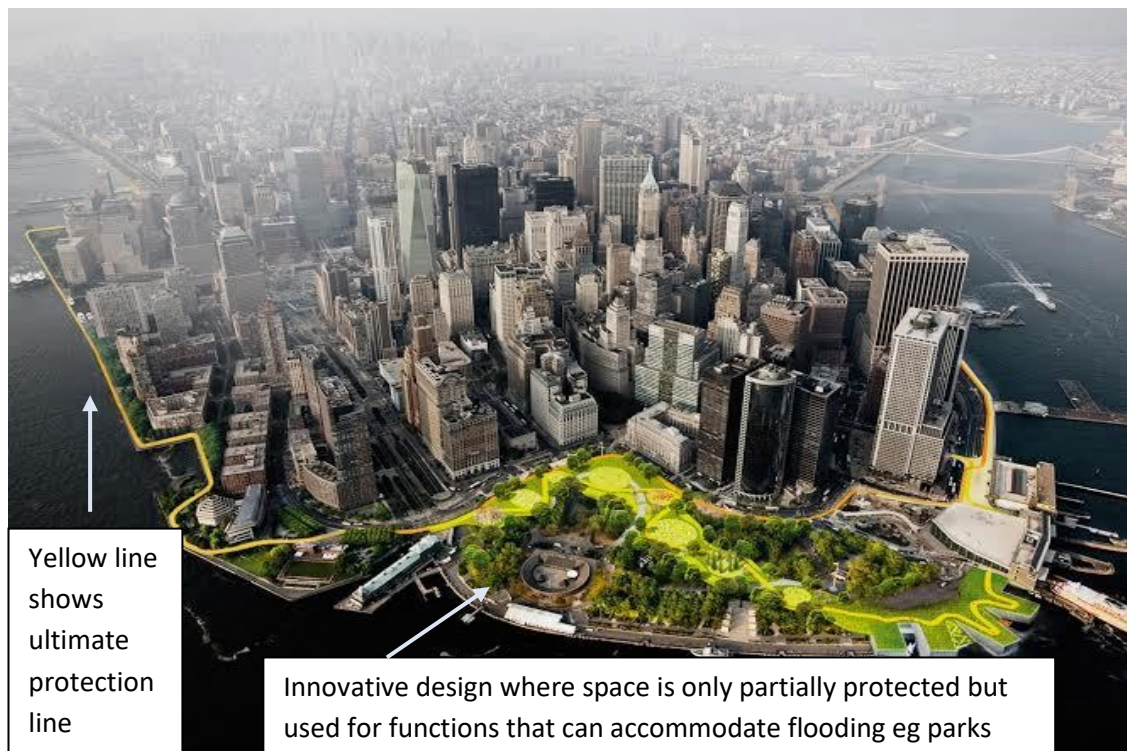


Source Dafydd House

Figure 1.1 Conceptual model of how Multi-functional design can be central to coastal management approaches

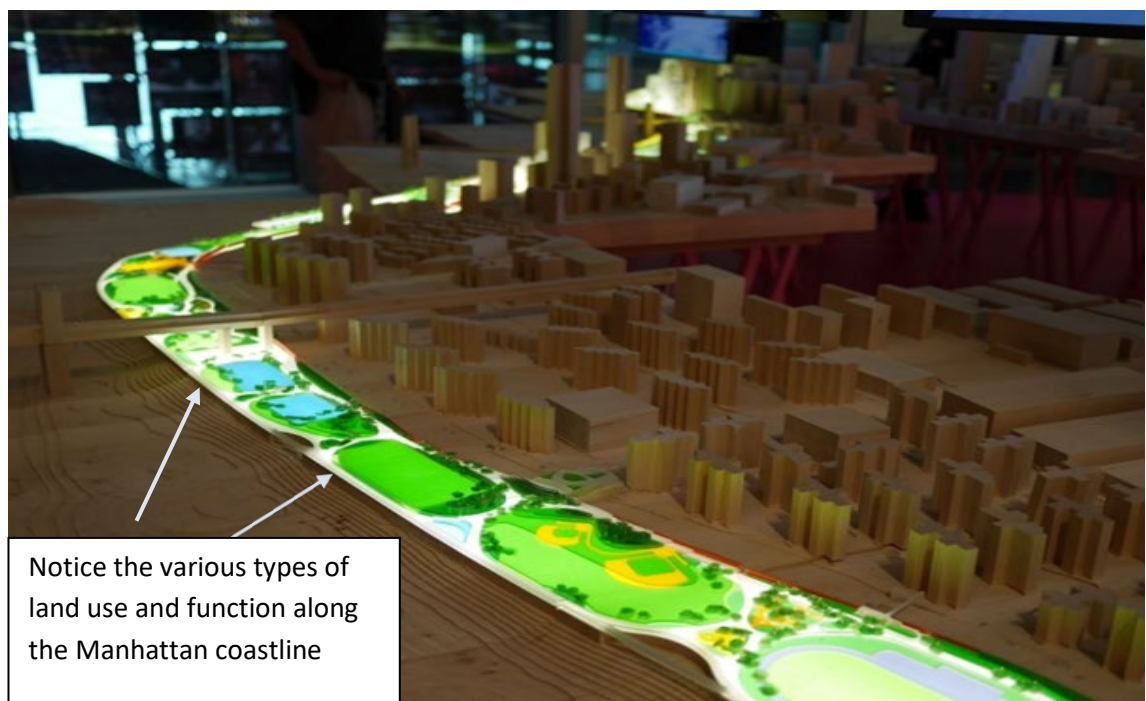
Personal justification for this research

Another reason for this research was that the author visited Denmark and went to the Danish Architecture Centre in Copenhagen in 2019. The centre presented the work of renowned architect Bjarke Ingels. His inspirational proposal for multi-functional coastal defences (Figures 1.2 and 1.3) in response to storm Sandy 2012 Manhattan (NYC, 2020) was a 'new' way of looking at coastal protection. Ingels' proposal included multi-functional public spaces within a coastal protection scheme and the author thought this could be applied to many coastal cities such as Swansea.



Source Archdaily, 2015

Figure 1.2: Bjarke Ingels proposed multi-functional coastal defence for an area the Manhattan coastline



Source: Dafydd House

Figure 1.3: A picture author took while visiting the Danish Architecture Centre of Bjarke Ingels model of his design plan for the Manhattan multi-functional coastal management strategy.

The final justification for this research was that the author studied coasts in A-Level Geography and found hard and soft engineering strategies fascinating, which led to additional study within which the contemporary approach of MFCd was highlighted. Also, the author's desire to become a structural engineer or an architect stimulated the selection of the topic.

Justification for Case Study

To help focus, the research used an exploratory case study approach in Mumbles, Swansea Bay (Geography, 2022) (Figure 1.4). Swansea Bay was selected because this was accessible to Bishopgore school, was populated, so there was a large enough sample to conduct a public participation questionnaire, and the Local Authority had proposed a coastal protection project in 2021 (Swansea City Council (SCC), 2021).

Furthermore, Mumbles coastal refurbishment is a local response to the SDG goals noted in the previous section. Table 1.4 was constructed by the researcher to show how local, national and international strategies are connected and hence the Mumbles case study can be contextualised beyond its locality.

A series of research questions were formulated from these geographical and personal justifications.



Figure 1.4 Location of the study area

Mumbles / Swansea	Wales/UK government	UN and SDG
Swansea's Biodiversity and Development Plan (SC, 2021)	Environment Act (Wales) (WAG, 2016). Environment Act (2021) (Gov.UK, 2021)	UNs Sustainable Development Goal 13, 14,15 (SDG, 2022) Biodiversity (CBD, 2022),
Swansea's Local well-being plan (SC, 2018)	Well-being of Future Generations (Wales) Act 2015 (WAG, 2015)	UNs Sustainable Development Goal 3 (SDG, 2022) Well-being, Health (UN, 2018),
Regeneration and development plans and policies (SC, 2022)	Swansea Bay City Deal Office National Statistics (2020) coastal towns and socio-economic deprivation	Economic Prosperity 9, 10,11 (UN, 2019)

Source: Dafydd House, 2022

Table 1.4 Diagram showing how coastal issues are approached at various spatial scales

1.2 Research questions

Main question:

How to design a multi-functional coastal defence strategy that engages with public views?

Sub questions:

- 1 What are the present coastal defences in Mumbles?
- 2 What is the present need for a redevelopment of coastal defences?
- 3 What is the public's view of their need for improvement?
- 4 What are the public hierarchy of reasons for coastal defences?
- 5 What additional functions would the public like to include in any multi-functional coastal redevelopment?
- 6 What would be the recommendations for developing an MFCD for Mumbles?

The following section evaluates the methods used to answer these questions.

2 Methodology

2.1 Reasons for methodology

A multi-method approach was applied to facilitate answering these research questions. Figure 2.1 notes the reasons for the methods to help justify the selection process. Then Table 2.1 summarises the purpose and delivery of the methods selected and how they linked to the research questions. Also, an initial evaluation of the methods is noted to highlight each approach's limitations, validity, and reliability.

The literature search highlighted the importance of the research onion. Figure 2.1 demonstrates the complexity of the justification process in research and the need to make the work valid and reliable. The researcher was unsure of the outer layers, but the work seemed deductive and was certainly a case study (Mumbles) using a mixed-method approach and was cross-sectional. Combining quantitative and qualitative research strategies is advantageous in that their various strengths can be capitalised upon and weaknesses offset (Bryman, 2007). This approach was deemed appropriate for this research as it allowed the researcher to gain an in-depth insight into the research questions.

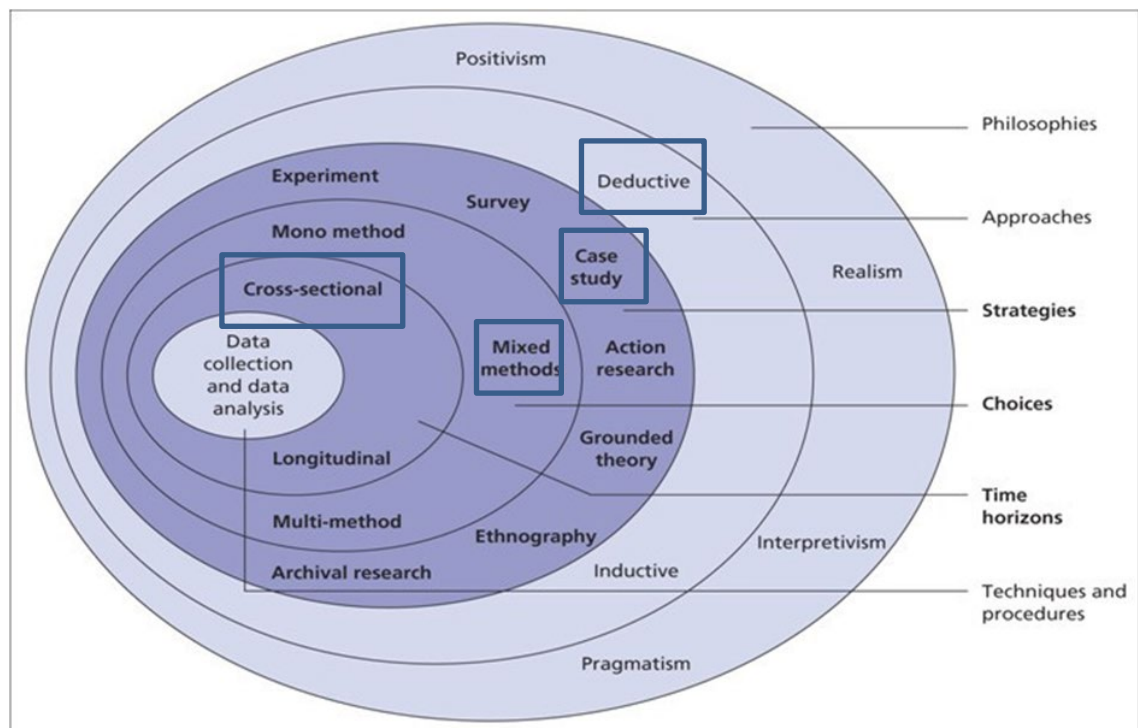


Figure 2.1 how the research Onion was used (blue rectangles) to justify the selected approaches: (Assignment help, 2022)

Table 2.1 Methodology, research question and evaluation

Data collection	Purpose	Methodology	Evaluation
Primary Observation reconnaissance field trip	<u>Data for research questions 1 and 2</u> To select the spatial extent of the field area and to choose different coastal defences for an initial assessment of defence vulnerability.	Walked the coastline proposed for redevelopment (4 miles). Took photos of changing and unusual features of the coastal defences. On analysis of the photos, a stratified sampling strategy was used to select 8 locations (RGS, 2022). The locations selected were representative of the defence features within the research area based on hard engineering examples gained from the review of the literature (Coastal Wiki, 2019, internet Geography, 2022) Figure 2.2 the theory of hard engineering. Figure 2.3 pictures of the selected sites and locations Figure 3.2 diagrammatic analysis of hard engineering design)	This approach worked well. The reconnaissance made it possible to identify critical sites for further assessment. Additional locations could have been used, but photos helped to highlight categories of features that could answer question 1 of the research. On reflection showing the photos to an expert might have led to some re-categorisation of the site selection.

Primary Index of decay	<u>Data for research question 2</u> This method allowed the researcher to gather data on which defences are vulnerable to failure and what aspects of the defences are in the highest need of improvement. This data also allowed the sites to be compared on the same categories making it easy to identify which stretches of the coastline should be prioritised for a coastal defence improvement project.	A self-completed index of decay (IOD) was undertaken for the 8 sites (Table 2.2). Each site was scored via a Likert scale from very good to very bad based on 10 categories adapted from the pre-existing IOD table. The scores were added to calculate an overall measure of condition and functionality. These scores were then compared between the defences to rank them all using a strategic method. The researcher undertook the IOD without any other people's influence. This ensured that all the site scores were comparable, and the subjectivity challenges were minimised. This approach facilitated rapid self-assessment.	The IOD was very successful as data was gathered relatively quickly. Also, it linked very well with the questionnaire responses, so it helped their evaluation. However, although the index of decay was adapted for the site, its simplicity did mean that some issues e.g. SLR were omitted. There does seem to be a well-established group of methods that look at coastal vulnerability in more detail and can be applied to various coastal settings e.g. Pethick & Crooks (2000). This could be used to extend this research or focus just on vulnerability.
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Primary Questionnaire	<u>Data for questions 3 and 4.</u> The questionnaire was used to gather quantitative and qualitative data. The questions were designed to assess the public need for improvement in the coastal defences of Mumbles and their perceived reasons for such structures. <u>Data for question 5</u> The questions helped identify a hierarchy of what functions the public preferred so that data on multi-functional approaches could be considered.	A Pilot questionnaire was drafted and tested on school colleagues to assess how understandable the questions were and if they gathered relevant data to enable the answering/analysis of the question. This is important to help improve the structure and wording of the final version (Oppenheim, 1992). Format 6 pages clearly spaced, Colour printed for ease of completion and professionalism Section A included two demographic questions and 4 questions about coastal defences Section B 22 scale questions linked to function and one open question for additional comments (Refer to appendix 2) Implementation The research used an opportunistic sampling method by approaching whoever was available	Opportunist sampling was convenient, which helped gather as much data as possible because the researcher could identify people who were less busy and more likely to answer the questionnaire. Hence, not genuinely representative but convenient (Hodder Education, 2021) The method did result in some experimenter bias as the sample did become unrepresentative of some age groups such as 21 to 40-year-olds. The lack of this age group was linked to surveying on a Tuesday within school time. This meant that workers were less likely to be included. Additional surveys on a Saturday or/and after

		at the time and asking them to answer the questionnaire (Hodder Education, 2021). The questionnaire was implemented on the Mumbles seafront within the designated area and approximately equal numbers were allocated to the 8 sites. Date 6th July 2021 and 31 respondents completed. Sampling may misrepresent the target population, especially if the sample is small; however, over 30 is a minimum target in established research (Bryman, 2007).	5.00 pm would have been more representative of the age range and would have increased the sample size influenced by time constraints on the day. Also, surveying in the summer was good because many people were present, but this meant that a large proportion of the sample were tourists and, hence, less aware of the coastal erosion in Mumbles. The research used some volunteer sampling of self-selected family and friends who lived in the area to address this imbalance.
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Primary Interview	- <u>Data for research questions 5 and 6</u> The interview was firstly used to help contextualise the findings from the questionnaire and IOD. Secondly, the interview was used to help inform the recommendations for MFCD.	After the initial tabulation and preliminary analysis of the questionnaire data, expert interviews were planned. Research of the Swansea Council website and local research experts identified several contacts: Chris Lindley: AONB Team Leader Judith Oakley: Coastal Planning Manager Deborah Hill: Nature Conservation Leader Professor Allan Williams: International Coastal research expert. (Only interview) A telephone interview was arranged using a semi-structured format. This allowed more in-depth contextualisation and clarification of points (Oppenheim, 1992). However, the intrusive nature may lead to the interviewee being put under pressure and not reflect their opinion (Oppenheim, 1992). The themes were based on the 6 research questions but opportunities to elaborate were allowed.	Semi-structured interviews worked well and helped to elaborate on some of the findings from the other methods. However, the data was qualitative, challenging to analyse, and is questionably representative of the expert groups. However, the most significant difficulty was accessing these individuals for a school project. Perhaps a referral from the local MP might have harnessed more of a response.

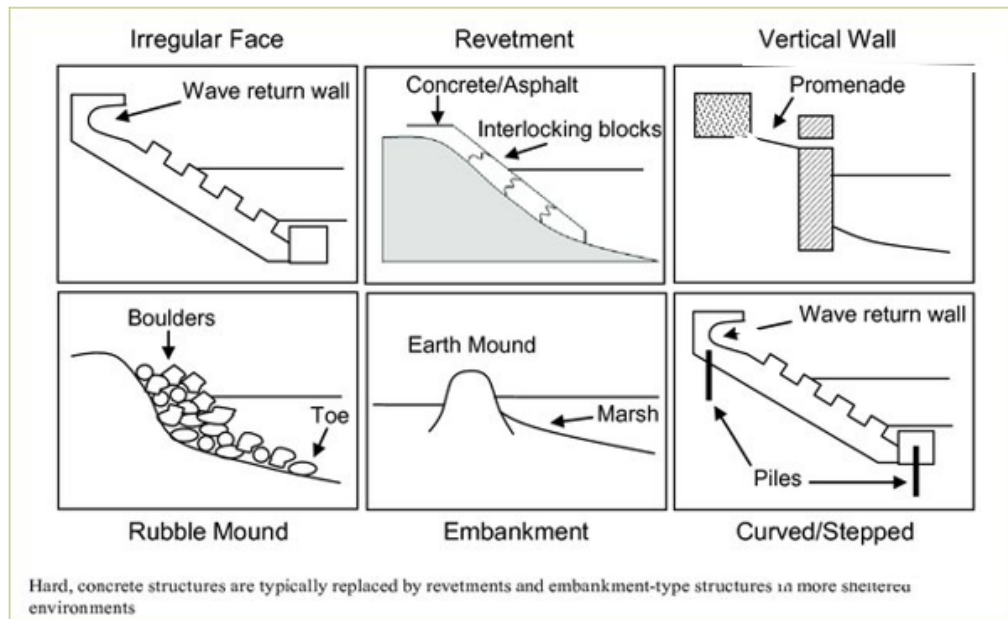
Secondary Swansea Council (SCC) coastal management project: https://www.swansea.gov.uk/mumblescoastalprotection	- <u>Data for questions 1, 2, 4 and 6</u> Outlining the prior research completed for the project to highlight the defences needing improvement and demonstrating the current proposed changes to the sea defences in a video presentation, this source shows the SCC regeneration project of the Mumbles coastline.	The researcher researched the coastal protection plans for Wales from the Welsh Government. From these documents, SCC Mumbles Coastal Management Scheme were identified.	As this source overviews the whole project being completed by SCC, it was the most important of the secondary sources as it showed the details and all the action taken for each part of the project.
Secondary Promenade map of existing coastal infrastructure: https://www.swansea.gov.uk/media/2040/Mumbles-coastal-protection-	- <u>Data for questions 1 and 2</u> This source showed the overall stretch of the coastline being focused upon by SCC for the Mumbles coastal risk management program. Sites identified during the survey project as key individual sections of the overall area allowed the researcher to investigate the current	The researcher acquired an illustrative map from the SCC Mumbles Coastal Management Scheme to analyse and highlight the current coastal defences and infrastructure.	For sub-question one, this source was crucial for analyse in conjunction with the site's data.

scheme--- promenade- map/pdf/Mum bles_coastal_pr otection_schem e_- _promenade_m ap.pdf?m=1628 690263600	coastal defences on the seafront and their need for improvement.		
Secondary - Business news Wales Mumbles Sea Defences initial designs (2021): https://business newswales.com /mumbles-sea- defences- consultation-	<u>Data for questions 3 and 6</u> This online newspaper article published by Business News Wales outlined the most recent design proposals for the SCC programme which was helpful to make recommendations for a multi- functional coastal defence development. There was also interviews with two key players overseeing the project, which provided valuable insights into the	Critically reviewing news articles on the scheme, this Business News Wales article supplied in-depth and current information on the project's progress.	The article's interviews were useful to quote expert opinions involved in the project and compare their reasoning to primary data findings. Furthermore, they highlighted some of the steps taken within the design process and gave an insight into how SCC has undertaken the scheme.

moves-to-next-stage/	reasoning for decisions made throughout the project.		
Secondary - Dezeen article on San Francisco coastal management design and Dutch Water Sector article on Manhattan coastal defence project, both designed by the Bjarke Ingels Group (BIG): https://www.dutchwatersector.com/news/first-of-coastal-projects-lower-manhattan-breaks-ground San Francisco design:	<u>Data for questions 5 and 6</u> Both articles overviewed the multi-functional coastal development design projects by the BIG group in the two coastal urban landscapes in two major cities at risk of Flooding of San Francisco Creek and Manhattan in New York. These two projects are the primary inspirations for this research and were key to investigating multi-functional coastal defences. Analysing the features of each design and the steps taken to reach the designs are essential for outlining the additional functions in coastal redevelopments to investigate the public opinions on Mumbles through the questionnaire. These sources also aided the	The author conducted a review of Bjarke Ingels's coastal management schemes.	The two projects being in major cities in the USA made the scales challenging compared to the project in Mumbles. However, many design features could be implemented in Mumbles and decisions made by SSC and the BIG group throughout the projects are also comparable. The principles of the multi-functional coastal redevelopments used within the projects were practical as well to understand the idea and how it is being achieved within the two cities.

https://www.dezeen.com/2018/01/17/big-one-architecture-urbanism-sherwood-islands-creek-san-francisco-flood-protection-resilient-by-design/ ¹	recommendations for sub-question six by comparing these case studies to the case of Mumbles.		
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¹ Manhattan design:
<https://www.dutchwatersector.com/news/first-of-coastal-projects-lower-manhattan-breaks-ground>



Source Linham & Nicholls (2010)

Figure 2.2 Diagrammatic examples of hard engineering design

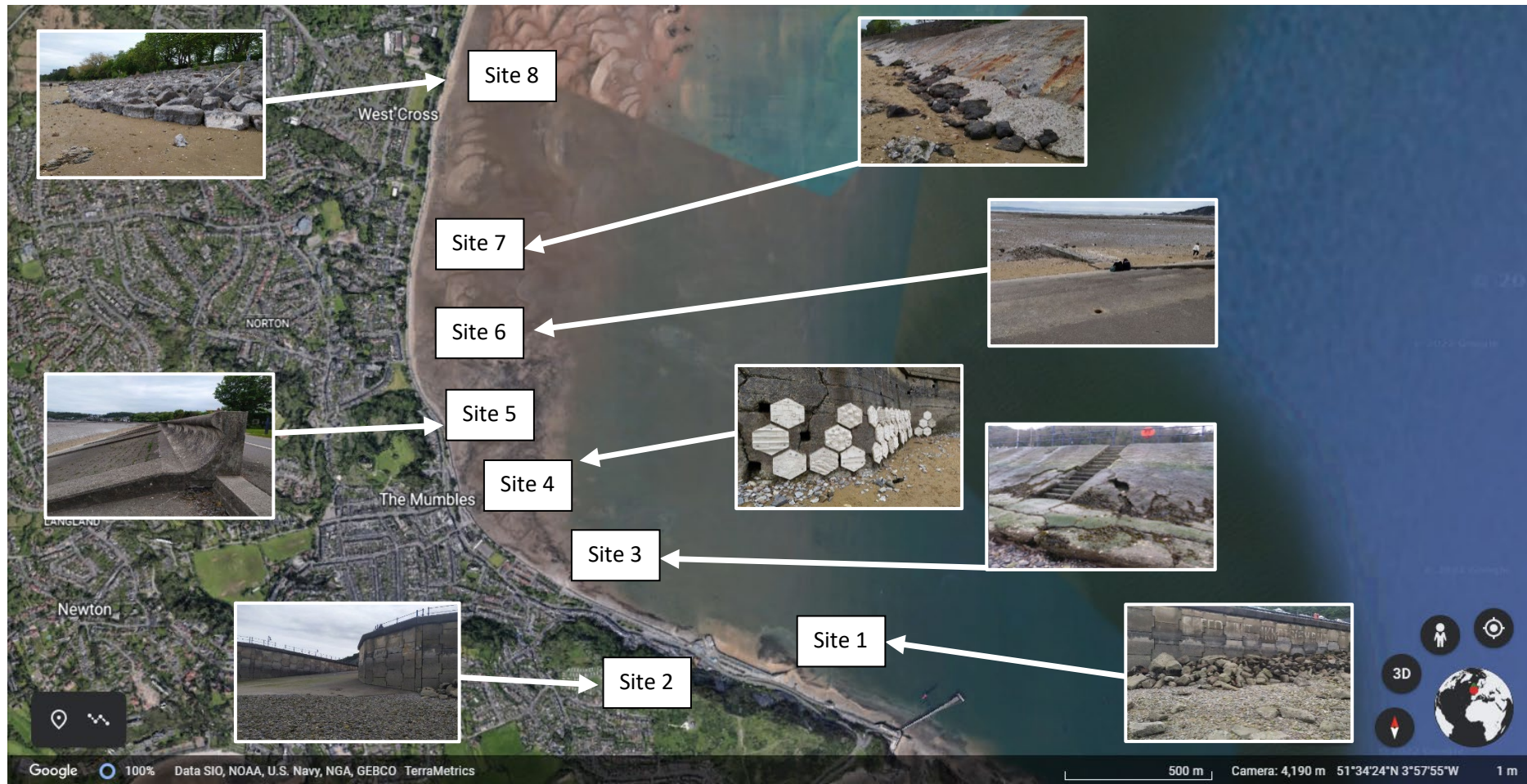


Figure 2.3 Location and hard engineering of selected sites for IOD data

Table 2.2 Index of decay data collection sheet (example)

Index of decay	SITE 7 Knab Rock				
Category	None/ very good (4)	A bit/good (3)	Some/neutral (2)	A lot/bad (1)	Loads/very bad ((1))
Signs of distress					
Undercutting					
Cracks					
Condition					
Risk of erosion					
Risk of Flooding					
Erosion of defence					
Aesthetics					
Extra functionality					
Cost-benefit analysis					
Total	16	12	4	0	0
Overall Score	32/40				

Data analysis

The quantitative data collected was input into Microsoft Excel the software was used to present graphs for statistical analysis (Table 2.3). Qualitative secondary data, including the interview, were used to contextual the interpretation of the results within the framework of the research questions.

Research ethics and risk assessment

It is essential that geographical fieldwork is safe, responsible and ethical (RGS, 2021). Before the research, a health and safety risk assessment was also carried out, supported by Bishopgore Comprehensive school guidelines. Firstly, the research took into account the needs and expectations of others (McKinnon, 2018). The creation and implementation of the questionnaire ensured the work was safely administered, not biased, offensive or condescending. Perhaps the most significant issue was the WAG rules associated with the COVID 19 pandemic. The guidelines were adhered to by wearing a mask and keeping a two-metre social distance. Fortunately, the July research period had limited the regulations (WAG, 2021). GDPR was noted and files are accessible, but no names or contact details were included so not a significant issue (Gov.UK, 2018). Hence, the work complied with the importance of confidentiality (Edmunds, 1996). Secondly, because this research was undertaken within a natural setting, it was essential to be considerate of the environment. Ecological damage was considered on the reconnaissance, but it was deemed low risk. Questionnaires were printed back-to-back to reduce the carbon footprint. Other ethical issues of fairness, power, control, and inequality were noted but not a significant concern for this project (Vivanci, 2022).

Table 2.3 Data analysis techniques and formula used.

Tables, maps, flowcharts and graphs: to graphical show associations, trends and relationships in the data for further analysis.

Mean: the mean of the results of individual respondents to help identify anomalies and patterns in the data which could help identify additional analysis.

Standard Deviation: to statistically identify the variability of the data to identify additional patterns and point at reasons for any patterns.

$$SD = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

T Test (Unpaired): Inferential statistics help provide statistical significance to the differences in the data. *“This function gives an unpaired two sample Student t test with a confidence interval for the difference between the means. The unpaired T Test method tests the null hypothesis that the population means related to two independent, random samples from an approximately normal distribution are equal”*

Assumptions (Andersen, 2016)

Normal distribution, Similar variance, Similar data points and >20 data points

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}}$$

$$s^2 = \frac{\sum_{i=1}^{n_1} (x_i - \bar{x}_1)^2 + \sum_{j=1}^{n_2} (x_j - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

(Stats Direct, 2022)

3 Data Presentation, analysis, and interpretation

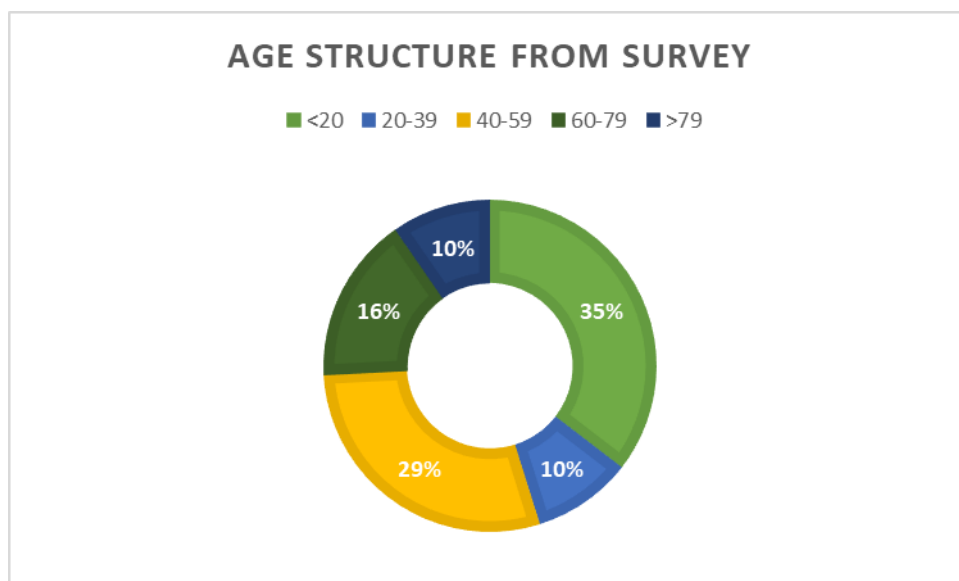
3.1 Results

The following section provides a brief explanation of the surveys demographic patterns to help with the interpretation of results (complete data set Appendix 3).

3.2 Demographics of survey population

Age Structure

The age structure of the respondents represented all age groups with each group being represented by at least 10%. However, compared to the Census (2011) the survey had a higher than expected demographic of people under 20 and a lower than expected group aged 20-39 (Figure 3.1). This anomaly is probably due to peers from school completing the questionnaire and the daytime implementation of the survey when many adults were in work.



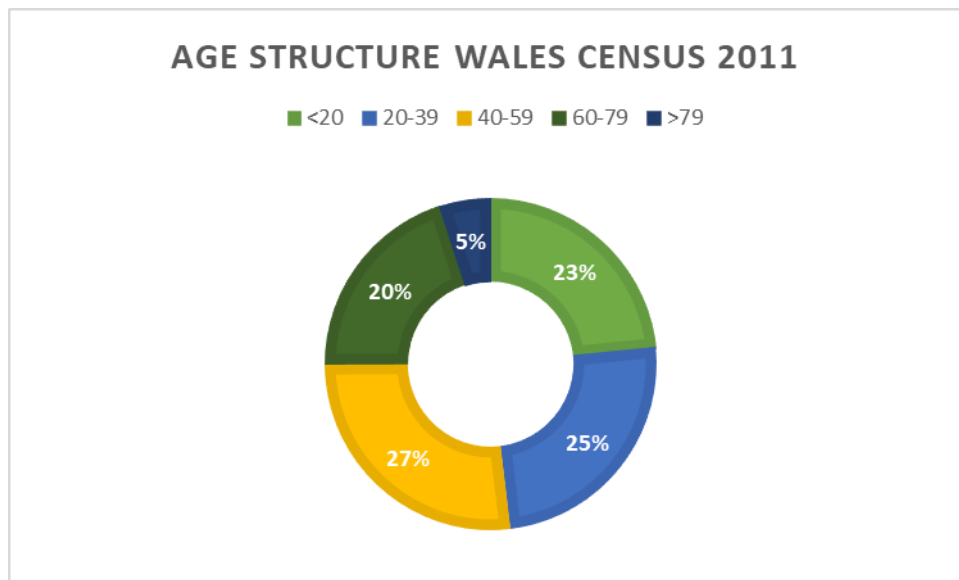


Figure 3.1 Question 1 - Doughnut graph showing age structure in Wales and survey population

Visitors and residents

The data showed 54.8% of respondents were residents and the rest were visitors. This is ideal as the key stakeholders of the development are represented relatively equally. Also, the proportion of residents means people were knowledgeable about the coastline and the needs of the people who use it (figure 3.2).

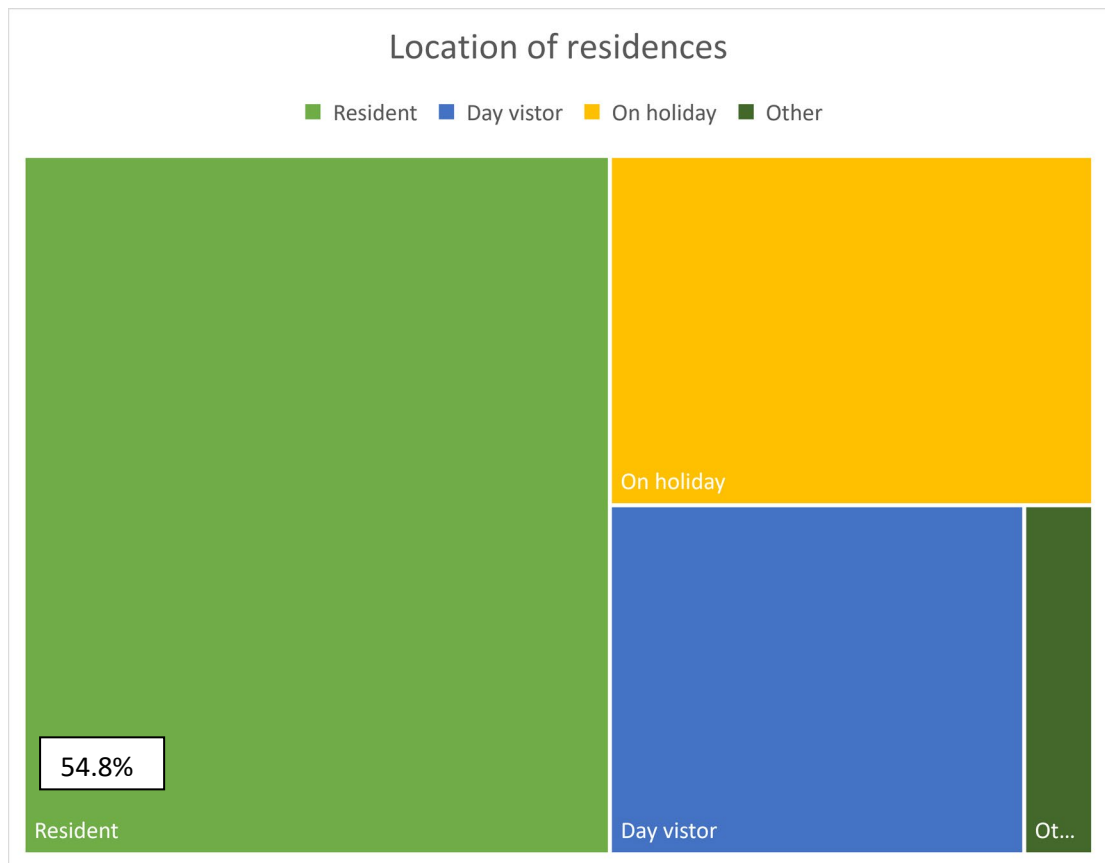


Figure 3.2 Question 2 – Tree map graph showing sample structure proportion of residents, day visitors, people on holiday and others

The distribution in figure 3.3 demonstrates the respondent's lack of awareness of the proposed Mumbles Coastal Defence. Residents are shown to have a higher rate of awareness however most residents are still unaware of the project suggesting more should be done to engage all groups with the project and this could have impacted the results as many respondents are not knowledgeable about the coastal defences in the area. Contrastingly, in an interview with Business News Wales (2021), Lee Selway of Amey consulting ² stated that “*consultation on this project has demonstrated high levels of interest locally in the plans to deliver a scheme*” suggesting that the local community and residents have been active in contributing to the project and are aware of the project. There was no evidence indicated in the consultation to support this claim and figure 3.3 seems to dispute this view.

² the company of consultants, engineers and designers enlisted in designing the sea wall

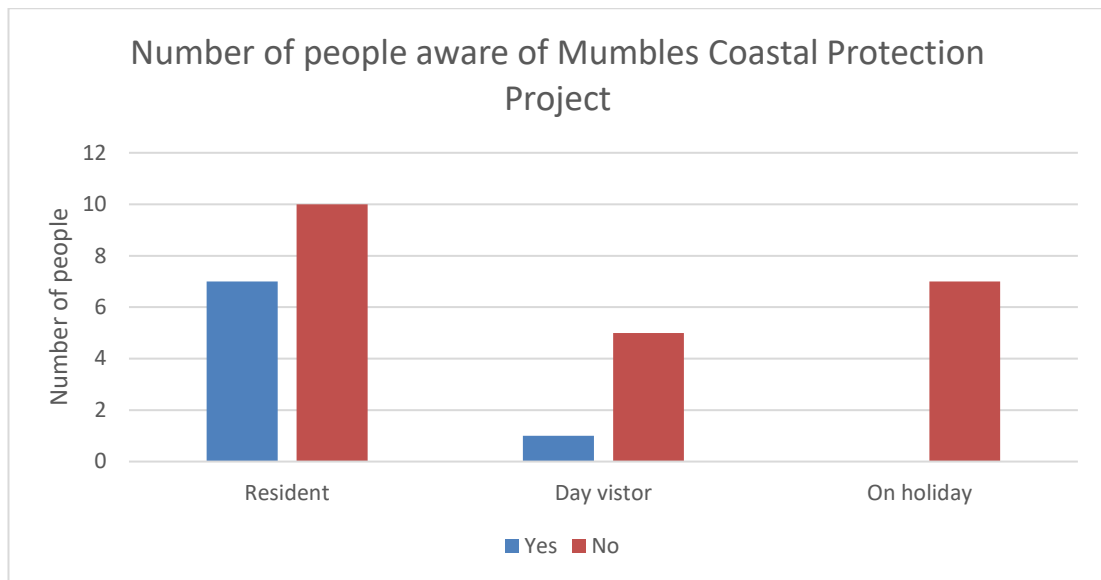


Figure 3.3 Question 3 – Bar graph showing number of people in the sample who were aware of the Mumbles Coastal Protection Project

Table 3.2 shows that section B's answers did not significantly differ according to the TTest results. However, 4 functions showed a statistical difference between residents and visitors with TTest results <0.05 : leisure, greenspace, climate change and education. Closer scrutiny of the results shows that residents do not think leisure, green space or education is particularly important with means > 4 (Table 3.3). Visitors rated these questions < 2.5 . Williams (pers comm., 2022) suggested this is probably linked to their “*perceived areas of importance in their use of the coast. They probably use other coastal locations for leisure e.g. Langland and use mumbles for shopping for groceries, doctors and banking etc.*” The comments for section 3 emphasised the importance of easy access and parking, highlighting that residents saw more green space and leisure detracting from their service accessibility in what is a busy location. The other significant difference was on the importance of climate change. Although both groups thought it was important the residents found it very important with a mean of 1.1. Williams (pers comm., 2022) thought this might be because *coastal communities are at the sharp end of climate change due to the potential impact of sea level rise and increased storminess*. Also, the media coverage of COP 26 might have highlighted the crucial nature of addressing climate change and this awareness might be particularly pronounced in coastal communities e.g. the Maldives.

Questions	Erosion	Flooding	Leisure	Multi- purpose	Fishing	Sailing	Kayak	business	Restaurants	Aesthetics	Seating
T Stat	-0.02	-1.57	2.39	0.18	0.84	0.05	0.56	0.26	0.93	0.50	1.65
P(T<=t)	0.99	0.13	0.02	0.86	0.41	0.96	0.58	0.80	0.36	0.62	0.11
2-tail											
T Critical	2.05	2.09	2.05	2.05	2.06	2.09	2.07	2.07	2.06	2.06	2.05
2-tail											
Questions	Green space	Value	Walking	Cycling	Ecology	Climate change	Renewables	Intertidal	Entertainment	Campervan	Education
T Stat	2.11	-0.36	-0.36	-1.63	0.59	-3.06	-0.97	-0.95	0.56	0.97	2.24
P(T<=t)	0.04	0.72	0.72	0.12	0.56	0.005	0.34	0.36	0.58	0.34	0.03
2-tail											
T Critical	2.06	2.07	2.07	2.07	2.05	2.05	2.05	2.16	2.05	2.06	2.05
2-tail											

Table 3.1 Unpaired T Test results for residents vs non residents responses to section B questions (Details of calculations in appendix 4)

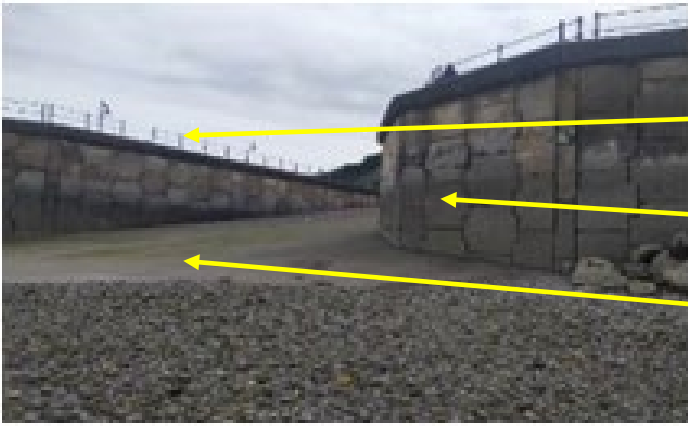
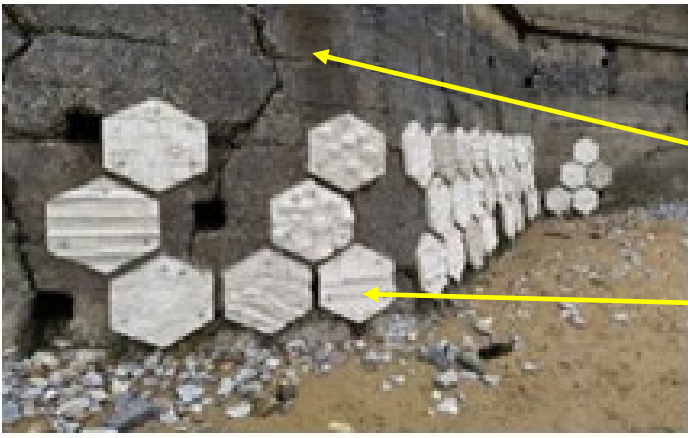
These tables show the results of the unpaired TTest. Means and variance (part of SD) which are compared in the TTest and if the calculated value (t Stat) is above the tabulated value (t critical two-tail with degrees of freedom for reading the critical numbers table) then we reject the Null hypothesis (there is a significant difference between the means). Also, the P(T<=t) indicates the strength/probability of this result. i.e. if the figure is < 0.05 then we can be 95% confident that there is a difference between the means.

Significantly different function	T Test	Mean Resident	Variance Resident	Mean Visitor	Variance Visitor
Leisure	0.02	4.2	5.9	2.1	6.2
Green Space	0.04	4.1	10.5	2.2	3.4
Climate change	0.005	1.1	2.37	2.9	2.9
Education	0.03	4.8	10.39	2.4	7.4

Table 3.2 Significantly different functions from section B (Details in Appendix 4)

3.3 What are the present coastal defences in Mumbles? (Sub question 1)

The reconnaissance field trip findings are shown in figure 3.4. The findings show a constant sea wall along the coastline that varied in structure and condition. Like many coastal defences, they varied in type, form and origin dates “*due to the constant need for coastal protection and the changing approaches of different civil engineers*” (Williams pers. comm, 2022).

	Site 1 Vertical sea wall Innovative shape to reduce lines of weakness Rock armouring to reduce undercutting of defence.
	Site 2 Vertical sea wall with access. Promenade for tourists and fisherman. High defences due to tidal range Boat access
	Site 3 Old wall revetment with signs of severe decay Pedestrian access to the beach Additional retrospective fixes to protect the toe
	Site 4 Old vertical wall with evidence of bioengineering. Degraded protective wall Experiment to assess best shapes for bioengineering. 13 patterns and 135 panels are being assessed (2021-2023). Example of a multi-functional approach. (Phelines & Callaway, 2021)

	Site 5 Reflected recurved revetment Slope and recurve to dissipate wave energy Wall protecting Cycle path and walkway Seems development is newer than sites 3 & 4 (circa 1990)
	Site 6 Concrete stepped revetment wall Steps dissipate energy but also provide access to the beach.
	Site 7 Concrete revetment with multiple fixes Evidence of re-enforced concrete with rust spots Concrete and boulders to fix erosion of the toe. Temporary. Probably why the rock armouring was included in site 7
	Site 8 Recent rock armouring (circa 2019) Designed to protected cycle path and army training facilities. Large limestone boulders are cheaper than concrete walls (Walls £5,000 per metre, Armouring is £1,000 to 3,000 (Internet Geography, 2022)

Figure 3.4 Analysed images of the types of hard engineering design found within the sample area.

3.4 What is the present need for a redevelopment of coastal defences?

(Sub question 2)

Figure 3.5 shows the calculated average rank value for the IOD from the researcher's field data and the average ranks from the survey data. The results show that the researcher's assessment and the public's ranked averages were very similar, suggesting the level of decay was identifiable. However, from figure 3.5, sites 3 and 4 are the most concerning as these have low scores and are protecting built up vulnerable areas. There is a need for redevelopment in these areas especially as site 3 protects a large stretch of the coastline and according to research undertaken by Arup Consulting in 2017 and 2018, the coastal decay is placing around 79 properties at risk of tidal Flooding and could fail in a storm surge.

Furthermore, site 7 had a low score. However, a naturally vegetated berm protects the road and housing is mainly set back off the coast for the northern portion of the coast at this site. However, to the south of site 7 there have been multiple housing developments and renovations on the low-lying seafront which currently have a high risk of Flooding. Therefore, this site could need improvement in future developments as the sea wall is in poor condition and the economic and social value of the land continues to increase due to the properties in the area. Nonetheless, whether private homes should be protected by public money is a debate for many coastal areas, especially where private developments are relatively recent.

Table 3.2 shows that the variability (Standard Deviation) of the survey ranked data was low for each site, suggesting there was a relative agreement between the respondents about the rank of decay. Hence, this shows that the researcher's IOD surveys can be used to represent public views which will speed up data gathering because this question would not need to be included in a survey. The combined scores show an extensive range of 7.6³. This suggests all the coastal defences are in varied conditions reflecting the research of SCC (2021), stating that some of the sea defences were built in the 19th Century and have been *poorly maintained*. The need for coastal defences improvements is also highlighted

³ Combined data set with a low of 4.6 and a high of 12.2. Total range maximum score 16

in the question-and-answer section of SCC (2021). The scheme identifies *“expected environmental trends, environmental issues, and the condition of current defences as reasons for needing improvement to protect people and businesses based on the seafront”*. Due to SLR, the source identifies that the existing sea walls are *“too low, resulting in informal secondary flood prevention measures of stop logs needing to be placed across openings during high tides, costing £10,000 annually”*. The current sea wall also is described as being in *“poor condition with significant cracks and exposed fittings putting the seawall at risk of failure”*. The need to improve these defences is justified by stating that *“the poor condition of the current defences is placing homes, businesses, community facilities, council resources and tourism income for the area at risk”*. Other relevant points noted in the SCC (2021) scheme included: the

- The main sewer pipe is retained by the defences, which could be harmful to the natural environment
- Flooding to the Mumbles Road restricts access to Mumbles, including the lifeboat station.
- The scheme features should be prioritised based on a cost and risk assessment.

Williams (pers. comm., 2022) notes that *“Cost is often the overriding factor in coastal projects”*. The researcher suggests this is a short-term outlook for Mumbles based on annual budgets and political cycles. SLR is an inter-generational issue that needs a long-term coastal strategy and COP 26 seemed to support this view with 2050 guidelines.

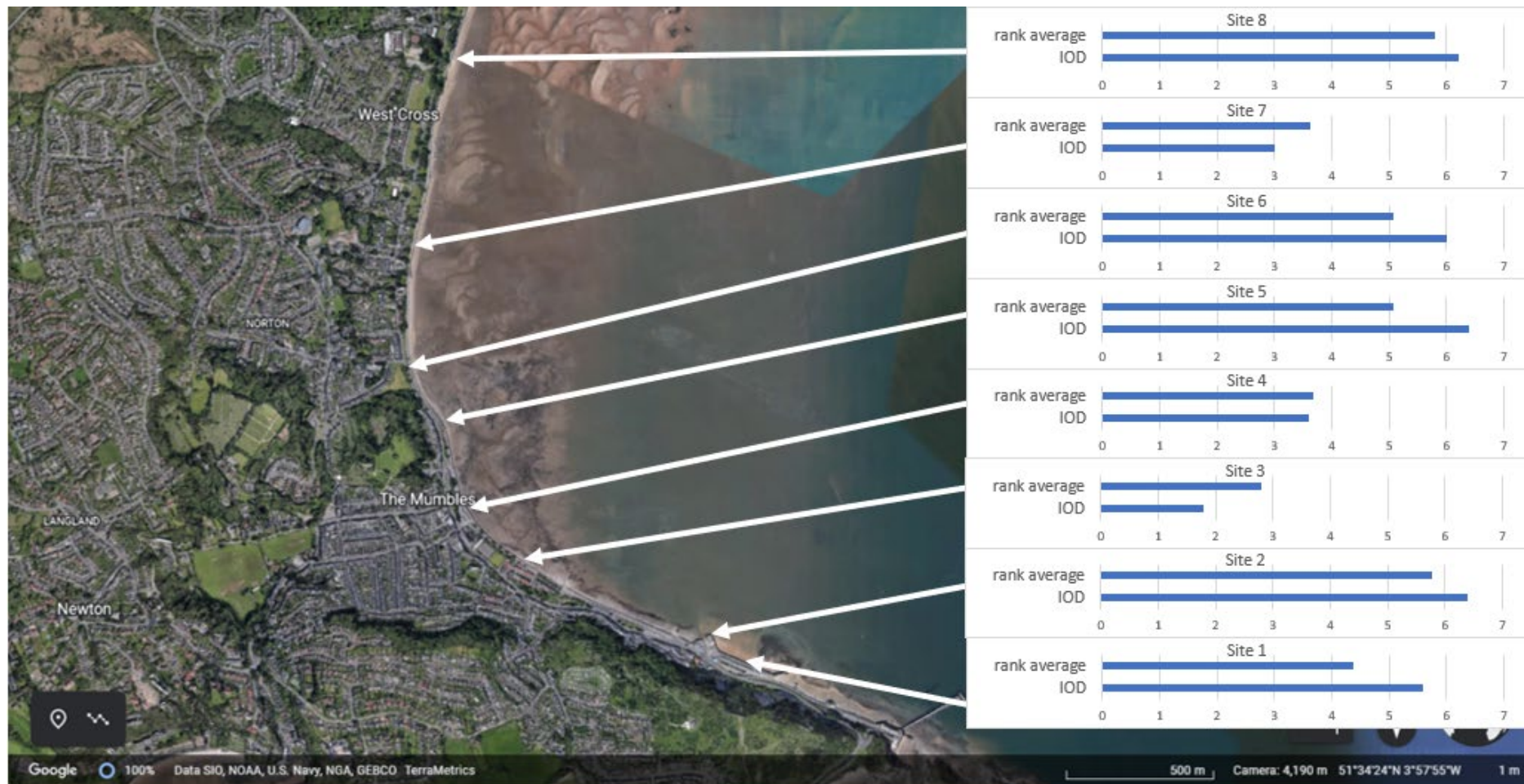


Figure 3.5 Graphs showing index of decay scores and rank means for each site location

Site	1	2	3	4	5	6	7	8
Mean	2.81	5.06	3.68	3.61	5.06	5.81	4.39	5.77
SD	2.69	2.25	1.58	2.17	1.95	1.60	2.22	1.96
Combined Scores ⁴	10.0	12.2	4.6	7.3	11.5	11.1	6.6	12.0

Table 3.2 showing mean and Standard Deviation scores for question 6

Figure 3.6 shows the coastal areas and the specific coastal defences identified for improvement in the Mumbles coastal management scheme (SCC, 2021). The two sites that had the lowest scores from the research were sites 3 and 4 are highlighted on the map with the development protecting the new Oyster Wharf and Southend Gardens. Additionally, the boat and yacht storage are highlighted as an “*obstruction disconnecting the coast to the park and local businesses*” and from the questionnaire data boat and kayak storage was shown to be the least important function. The development also stops at Knab Rock which does not include sites 1 and 2 which, on the combined rank average and index of decay scores, were fourth and eighth sites to be prioritised for improvement. The development excludes all sites onwards of site 5, which from the questionnaire and index of decay results showed only to have a minor need for improvement other than site 7. However, SCC probably excluded this defence as the area’s economic value is much lower than that of Mumbles.

Hence, although there are differences between the SCC (2021) and the research the results both point to a need for coastal defence refurbishment. Therefore, answers to questions 1 and 2 of this research were addressed. However, the research now needs to assess the public’s views.

⁴ Combined scores are the researcher IOD scores and the survey data results normalised.

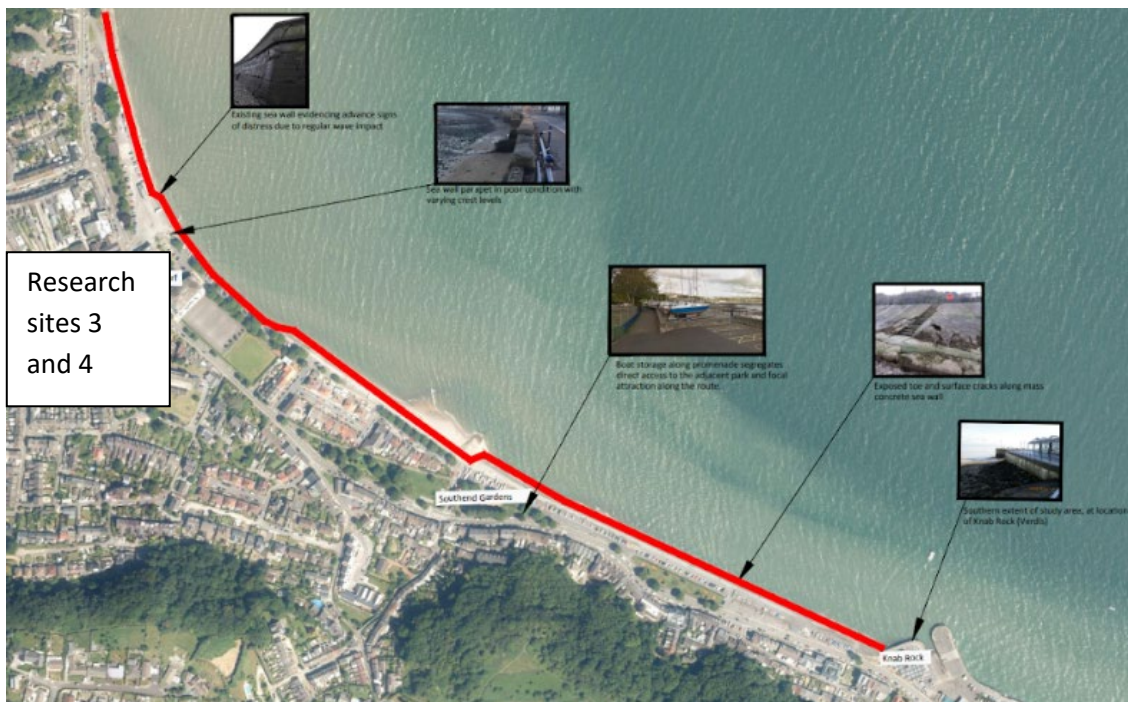


Figure 3.6 SCC Mumbles coastal protection project site location (2018)

3.5 What is the public’s view of their need for improvement? (Sub question 3)

Williams (pers comm.) expressed the view that the lack of maintenance around the UK coastline means that expensive projects are now imminent due to pressures from climate change. Within the study area, Mark Thomas (2021)⁵ stated that “*an initial community engagement process, showed the sea defences in Mumbles were recognised locally to be in need of upgrading*”. Figure 3.7 shows that 55% of the respondents believed that the coastal defences needed improvement, with 16% believing they did not and 29% unsure. Therefore, most of the public thought there was a need for improvement in the coastline’s defences.

⁵ Cabinet member for environment enhancement and infrastructure management, said during an interview with Business News Wales

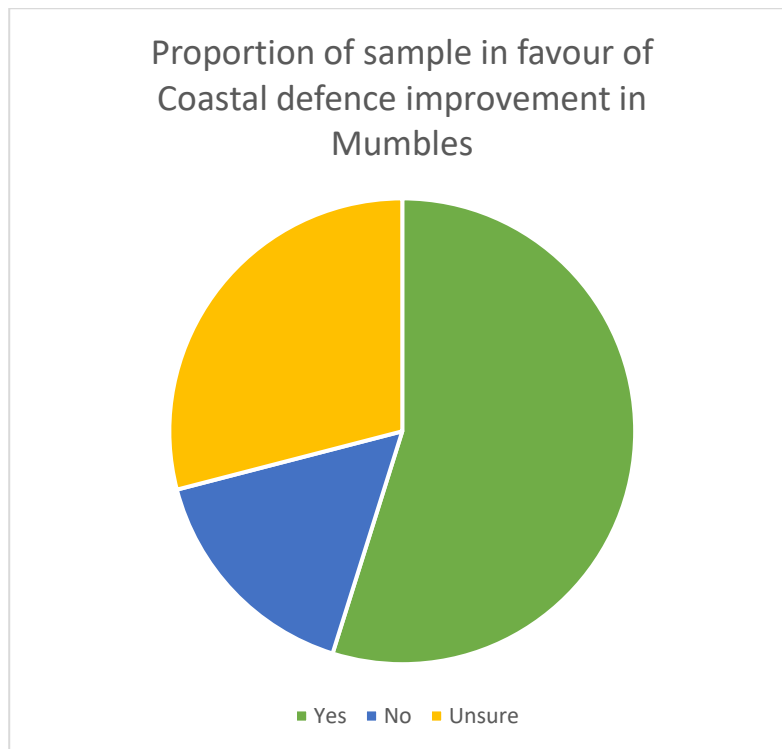


Figure 3.7 Question 4 – Pie graph showing the proportion of the sample who think the coastal defences along Mumbles coastline need improvement

A closer analysis of the survey results highlighted some interesting patterns in the public views. Table 3.3 shows that when the group who wanted coastal defence improvement were compared with the respondents who answered no/unsure there was no significant difference in their answers to section B for most functions. Williams (pers comm.) suggested this might be because the “*public might not associate these functions with coastal defence requirements*”. However, 4 functions did show a significant difference in the mean scores of the two groups (Table 3.4). Interestingly sailing, walking, cycling and campervan facilities were viewed as very important to the group who expressed that coastal defences were needed. This pattern might be linked to their awareness that these activities are directly linked to the quality of the promenade and associated sea access at Knab Rock and hence sea defences. Also, they might be sailors and therefore can see the decay of the defences from the sea and note the need for improvement.

Questions	Erosion	Flooding	Leisure	Multi- purpose	Fishing	Sailing	Kayak	business	Restaurants	Aesthetics	Seating
T Stat	-1.14	-1.21	0.52	-0.04	0.55	-1.90	-0.89	-0.89	-0.20	0.34	-0.21
P(T<=t)	0.27	0.24	0.61	0.97	0.59	0.07	0.38	0.38	0.84	0.73	0.83
2-tail											
T Critical	2.08	2.06	2.07	2.05	2.05	2.06	2.05	2.05	2.06	2.05	2.05
2-tail											
Questions	Green space	Value	Walking	Cycling	Ecology	Climate change	Renewables	Intertidal	Entertainment	Campervan	Education
T Stat	0.26	-0.79	-1.40	-1.92	-0.30	-0.90	0.80	-0.49	-0.18	-1.69	-1.11
P(T<=t)	0.80	0.43	0.17	0.07	0.77	0.38	0.43	0.63	0.86	0.10	0.28
2-tail											
T Critical	2.05	2.05	2.05	2.05	2.06	2.05	2.05	2.05	2.05	2.05	2.06
2-tail											

Table 3.3 Unpaired T Test for respondents who responded there was a need for coastal defence improvement compared to unsure/no (Details of calculations in appendix 5). These tables show the results of the unpaired TTest. Means and variance (part of SD) which are compared in the TTest and if the calculated value (t Stat) is above the tabulated value (t critical two-tail with degrees of freedom for reading the critical numbers table) then we reject the Null hypothesis (there is a significant difference between the means). Also the P(T<=t) indicates the strength/probability of this result. i.e. if the figure is < 0.2 then we can be 80% (Usually needs to be 0.05) confident that there is a difference between the means.

Significantly different function	T Test	Mean Yes coastal defence	Variance Yes coastal defence	Mean No coastal defence	Variance No coastal defence
Sailing	0.07	2.7	2.7	4.35	8.8
Walking	0.176	2.0	3.0	3.1	5.7
Cycling	0.07	2.8	5.0	4.6	9.5
Campervan	0.10	4.1	7.6	6.0	12.4

Table 3.4 Significantly different functions from section B (Details in Appendix 4)

Further analysis shows a positively skewed distribution in figure 3.8, suggesting that public money should improve coastal defences ⁷. Additionally, of the five people who believed the coastal defences did not need improvement (Q4) the average score for question 5 was 4.2, suggesting that the minority who do not support the need for coastal defences base their opinion on cost.

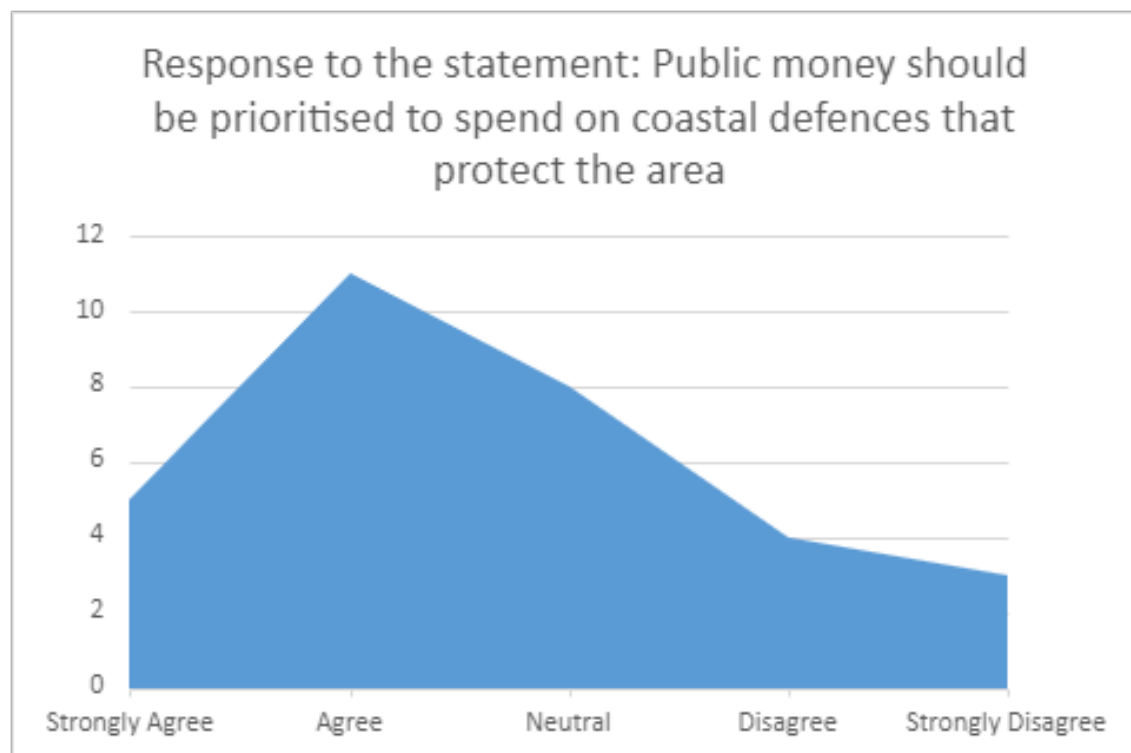


Figure 3.8 Question 5 – Area line graph demonstrating samples views on public money being spent on coastal defences along Mumbles coastline

⁶ The $P(T \leq t)$ indicates the strength/probability of this result. i.e. if the figure is < 0.2 then we can be 80% (Usually needs to be 0.05) confident that there is a difference between the means.

⁷ The modal answer was agreed, and the mean was 2.15 (SD 1.2) both highlighting that the sample agreed with the statement with limited variability.

3.6 What are the public hierarchy of reasons for coastal defences? (Sub question 4)

Mark Thomas (2021) from SCC stated that “*The aim with the new sea defences is to be sensitive to Mumbles as a seaside visitor destination while protecting people and property.*” This indicates that while protecting the coastline is key, the project is also considering other ways in which the coastal defences can help the local area in a multi-functional way.

The survey demonstrated that the most important function of a coastal defence is protection against *Flooding* followed by *effectiveness against erosion* (figure 3.9). The third most important of the average scores was then resilience to *climate change* with all three being voted more important than *value for money*. This suggests that the public prefers resilient coastal defences which will last for a long time, even if they are expensive and these are the primary function of coastal protection. However, Williams (pers comm., 2022) was partially surprised at the lack of an emphasis on cost considering the “*news worthiness of public finances at the minute*”. Perhaps the sample did not equate the level of costs involved or the fact that public funding for education and health competes for these funds. Additionally, it could be because the public connects the coastal challenges of SLR and the need for improved coastal defences. It indicates that the public are socialised into understanding the link between coastal defences and erosion/flooding but less aware of the multi-functional possibilities of coastal design. This is highlighted by Mumbles Coastal Projects (2021) aim “*to reduce the risk of flooding to homes and businesses that are increasingly threatened by rising sea levels brought about by climate change.*” A more detailed analysis of the data showed the prioritises varied by age group, with value for money being highly voted as the most critical function for age groups 20-39 and respondents over 79 possibly linked awareness of public fund limitations by pensioners and students.

This set of results shows that although there could be opportunities for positive economic, social and environmental impacts from other additional functions, the coastal defence should focus primarily on flooding, erosion and climate change goals within a cost-effective remit. Additional functions should be seen as additional benefits rather than priorities.

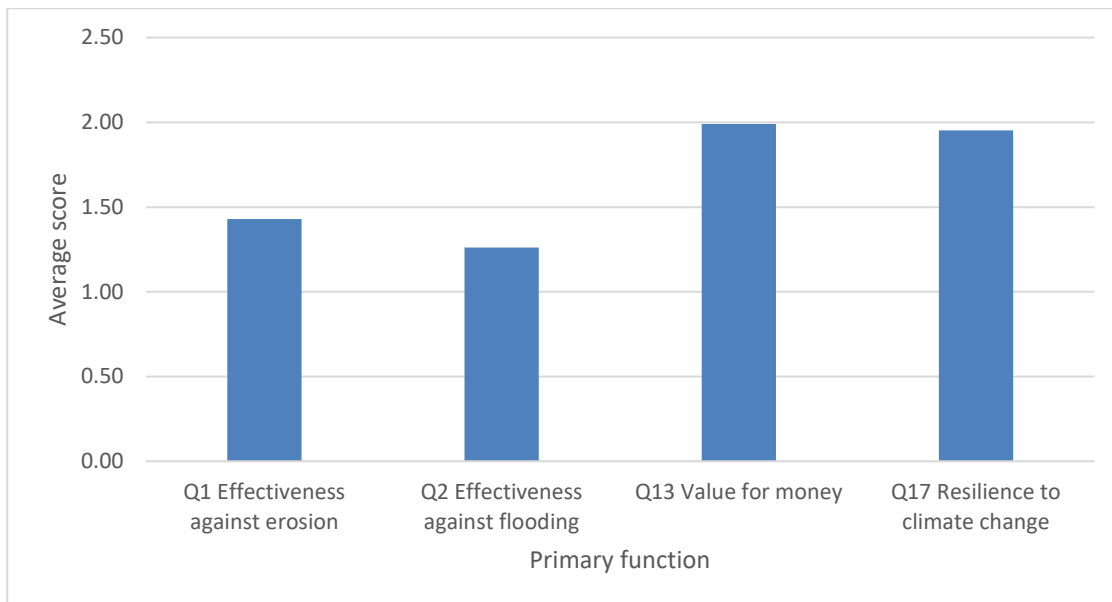


Figure 3.9 The four questions with the lowest mean rating (i.e. very important) of Section B

3.7 What additional functions would the public like to include in any multi-functional coastal redevelopment? (Sub question 5)

Figure 3.10 and 3.11 shows the importance of environmental issues to the public in terms of the function of coastal defences. It highlights that many activity orientated functions are not seen as very important e.g. kayaking. The public does not associate activities with coastal defence and suggests that for multi-functional design to be accepted by the public, there is a need for increased public awareness campaigns.

The researcher also categorised the answers into environmental, social and economic functions to assess their relative importance and variability. The box and whisker plots in Figure 3.11 clearly shows that the public believe that multi-functional coastal defences should prioritise positive environmental impacts. The small range and interquartile range imply that the public widely accepts this view. This view is supported by the literature which highlights that coastal management needs to “*devise frameworks within which man may live harmoniously with nature*” (Carter, 1998). At the same time, the opposite is true of the economic factors implying that there are diverse views of its importance.

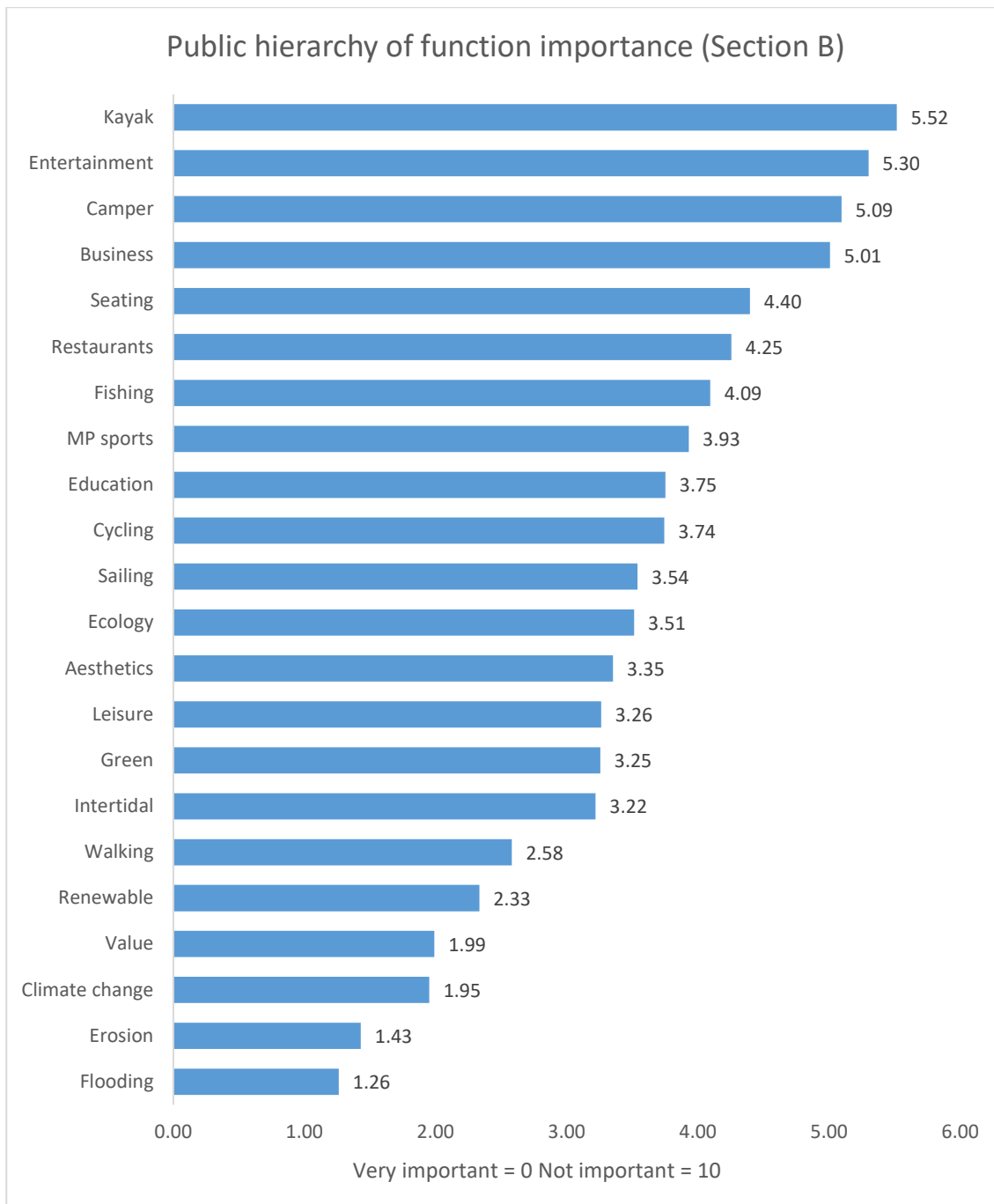


Figure 3.10 Clustered bar graph of the mean scores of each function question in section B

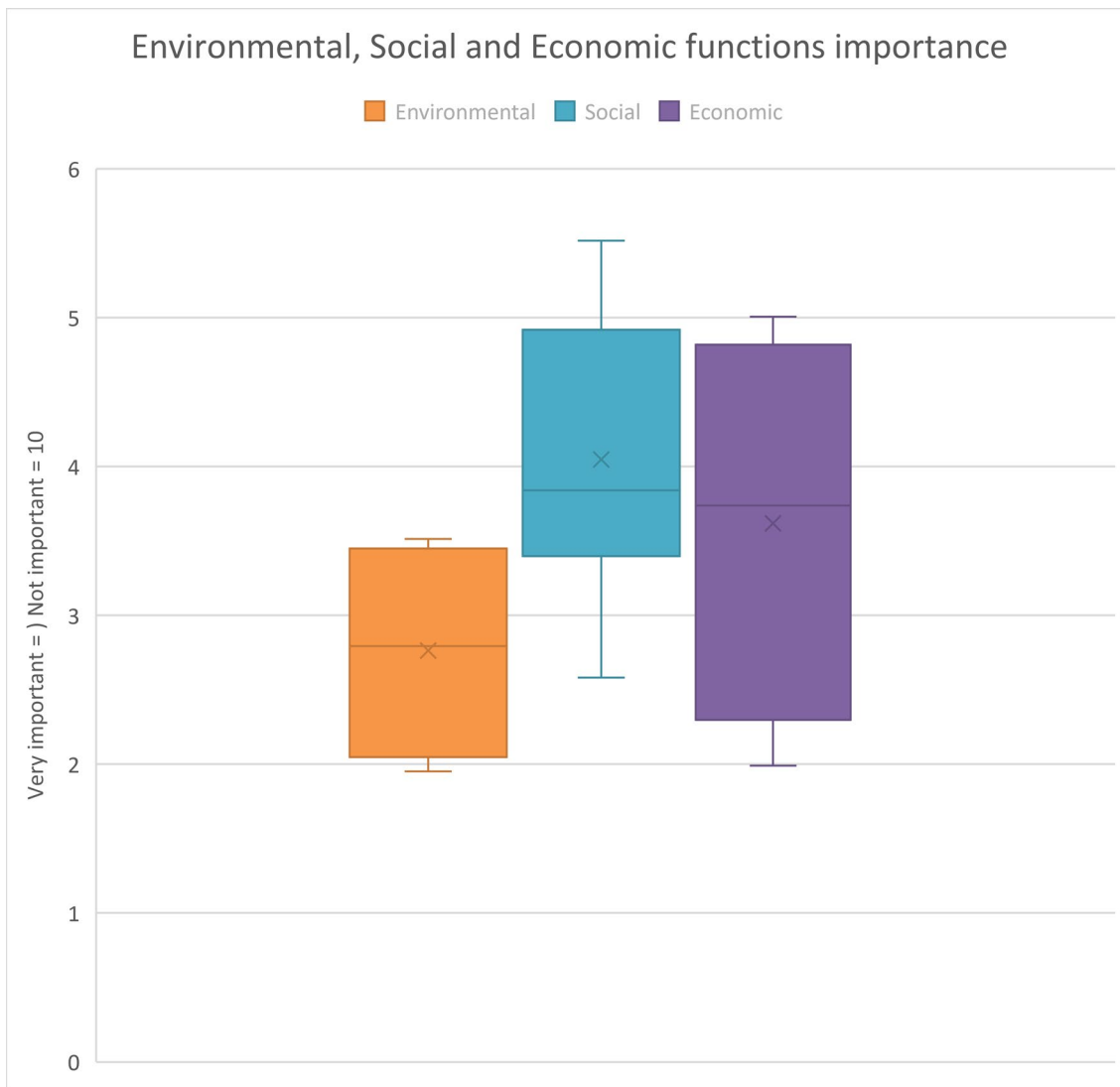


Figure 3.11 Section B box and whiskers plot for Environmental, Social and Economic functions

Further analysis of functions is displayed in figure 3.12. The figure shows that all age groups other than 20-39 had environmental factors as the most important with all age groups other than >79 concluding that social factors were the least important. This trend shows a gradual increase in the importance of social factors throughout the age groups with a similar trend for economic factors other than the anomaly in this trend of >79. Functions other than effectiveness against Flooding and erosion are included in the graph which suggests as the age increases the importance of other functions is more highly

regarded due to the more significant average scores among ages >60 compared to ages <39.

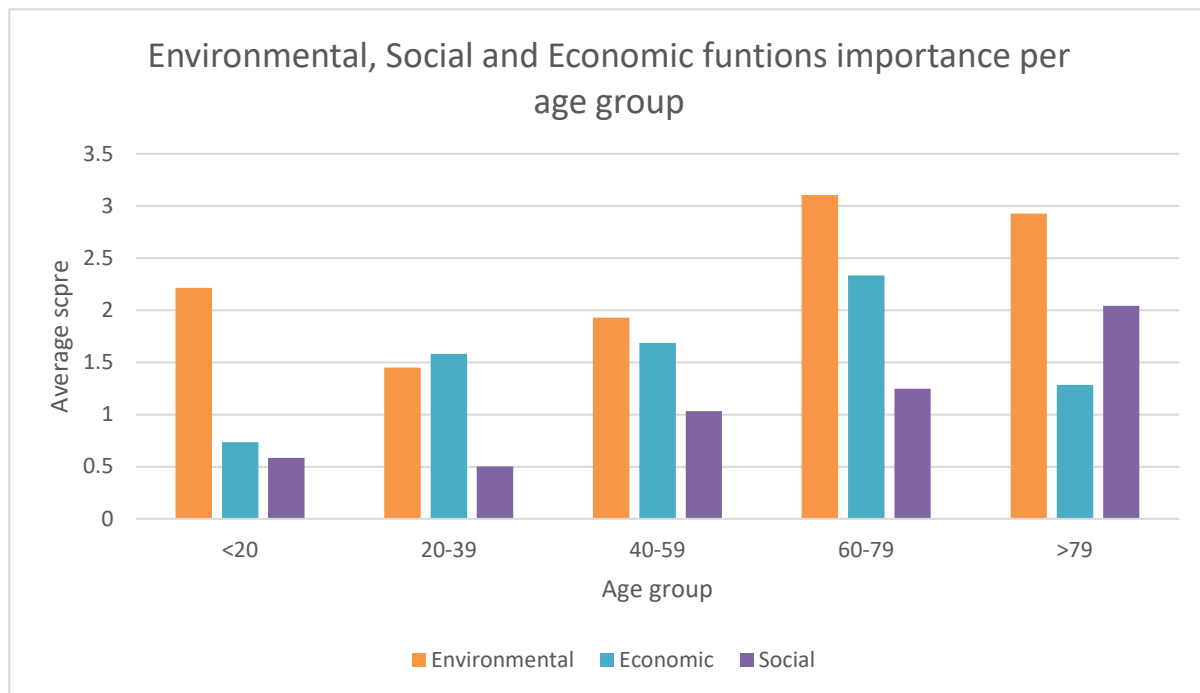


Figure 3.12 Section B bar graph for environmental, social and economic functions per age group

3.8 What would be the recommendations for developing an MFCD for Mumbles? (Sub question 6)

In addition to the primary function mentioned in the previous section there is a hierarchy of secondary functions that the public would like to see included in a redevelopment of Mumbles coastal defence (figure 3.10). The generation of renewable energy, walking paths, and the intertidal zone are the three most important secondary functions. Utilising tidal turbines to harness the power generated from Swansea Bays tidal range, ⁸ has been proposed (Tidal Lagoon Power, 2017) and the current price of global energy might put this form of energy generation back on the agenda.

⁸ the second largest in the world

Walking paths are also viewed as important. Due to the popularity of the promenade along Swansea Bay, walking paths are going to be key to include in a multi-functional coastal defence so people can enjoy the coastline. Walking and renewable energy could be combined with the introduction of energy-generating pavements developed by Laurence Kemball-Cook, the founder of Pavegen (Material district, 2017). As the promenade by Mumbles is a high footfall area, this is a recommendation from this research for the multi-functional design.

Another important secondary function is the use of the intertidal zone. The recurring theme of the status of environmental functions and the secondary function of intertidal zone use (figure 3.11, 3.13) offers some additional considerations in MFCDD. The environmental impacts of hard engineering coastal defences often have a large carbon footprint that could be reduced through soft engineering, particularly bioengineering.

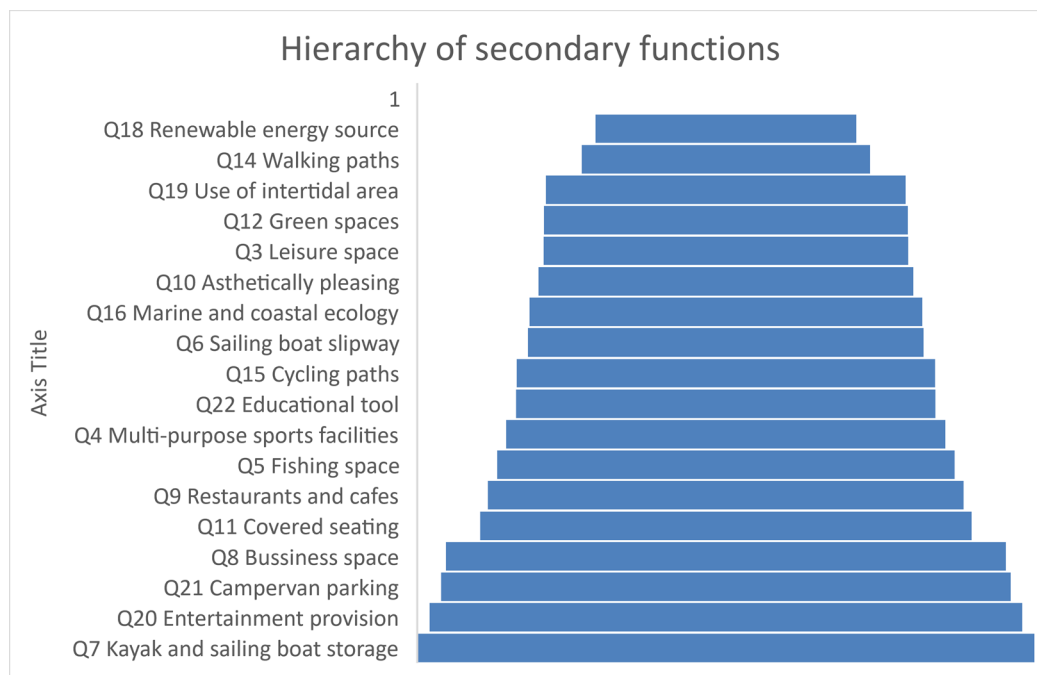
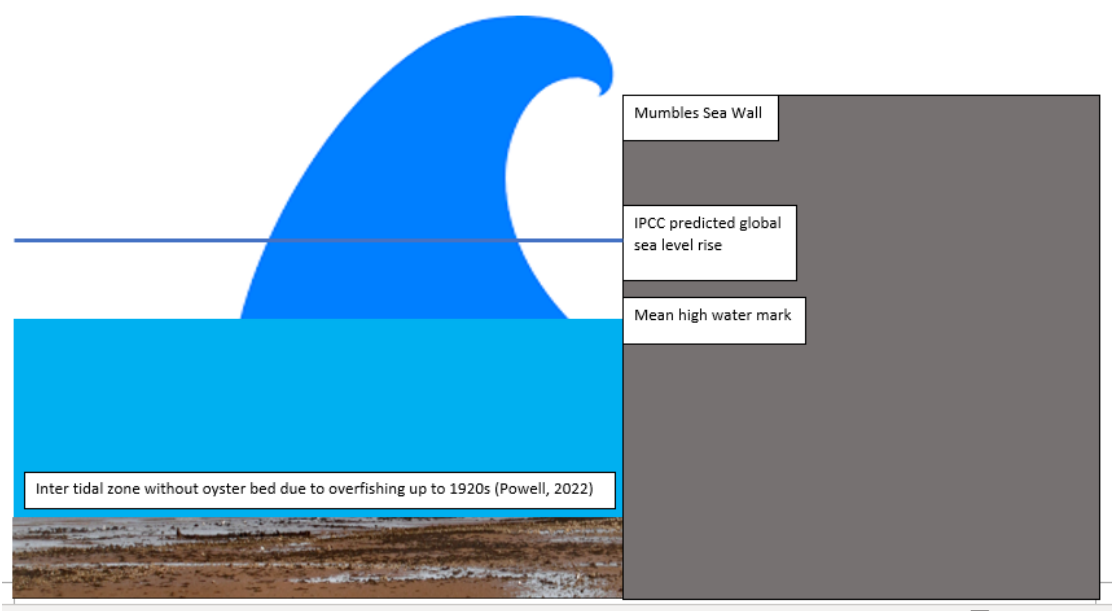


Figure 3.13 Section B secondary functions hierarchy

The reintroduction of an Oyster reef to the intertidal zone would be a good bioengineering approach in the area. The area is known as Oyster mouth however, as they were overfished in the past (1930s), the oyster reef has now been destroyed (Powell, 2022). Mapping Ocean Wealth (2022) suggests that densely packed beds of oysters can form natural water breaks that dissipate waves' energy, significantly reducing wave heights. Figure 3.14 shows how an oyster reef in Mumbles would decrease the pressure on the sea

wall. This is an option for a soft engineering strategy to work in conjunction with the current hard engineering on the coastline and the reduced chance of Flooding and erosion would save the council from needing to spend £10,000 on stop logs along the promenade (SCC, 2021). It is also stated that “*Oyster reefs have saved communities \$85,000 per year per hectare when used in place of artificial water breaks,*” (Scyphers et al. 2011). The additional functions and benefits of this strategy would be cleaning the seawater, which could increase recreational activities for the area and create job opportunities as the oysters can be sustainably farmed and provide nurseries for fish to enhance the local fish stock.



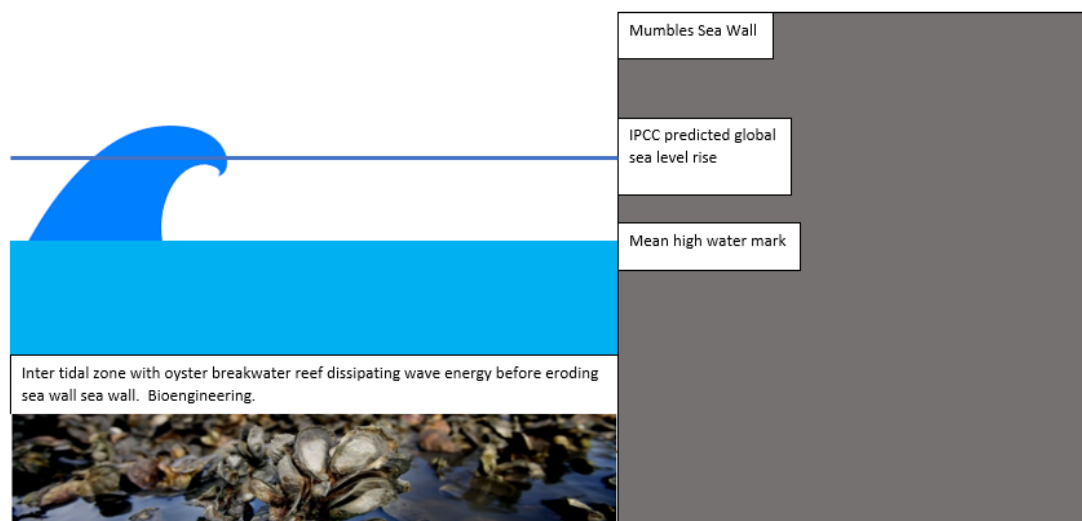


Figure 3.14 Oyster reef bed diagram

Therefore, a public survey shows that engagement with the stakeholders to help inform MFCF can be innovative and community orientated. However, the current plan listened to public views (Business News Wales, 2021) and suggested “*new seating, resurfacing, other environmental issues, parking, active travel, play, and aesthetic factors including landscaping and lighting*”. There was no mention of the public engagement methodology and indeed, the results seem obvious and traditional rather than innovative and forward-looking. Hence this research proposes a series of recommendations for the enhancement of the current project (Table 3.5)

Recommendation	Reasoning
Pavegen walkways converting kinetic energy from steps into electric energy	Renewable energy sources and walkways were the top of the hierarchy of secondary functions and the high footfall along the front can result in the walkways generating renewable energy for the area.
Use of intertidal zone to generate renewable energy	As Swansea has the second largest tidal range globally, use of the intertidal zone was the third most important secondary function, so there is an opportunity to generate renewable tidal energy as part of the coastal defence functions.
Reintroduction of Oyster breakwater	As functions improving environmental and then economic sustainability of coastal areas were shown to be the most

reef to intertidal zone	important, the introduction of soft engineering strategies alongside the sea wall is a key recommendation. This can be achieved by reintroducing an oyster reef to the area as it is a native species of the area, will dissipate wave energy as shown in figure 3.1, reducing the erosion and Flooding in the area by lowering the pressure on the present hard engineering sea defences and create economic opportunities by creating jobs in the oyster farming and fishing industries.
Extensive cost benefit analysis research	The most important function from the age groups 20-39 and >79 was value for money which was overall the fourth most important function. To achieve this cost-benefit analysis, research will be vital in ensuring the development is improving the most critical areas of the coastline socially and economically and ensuring secondary functions will benefit the local area.
Investment in landscaping raised green parkland areas	Green and leisure spaces were shown to be the fourth and fifth most important secondary functions, so these can be achieved through creating raised green parkland spaces, such as in the design of San Francisco creek by Bjarke Ingles to create permeable areas which can infiltrate water to reduce flood risk according to Dezeen (2018).
Integrated community approach	The results of question three, show that 71% of the respondents were not aware of the Mumbles coastal management project. However, Bjarke Ingles highlighted through his approach to Manhattan that citizens' participation is key to successful multi-functional coastal defence projects, according to Dutchwatersector (2021). Also, in the Mumbles coastal management scheme question and answer, there is interest in asking for the community's opinions and feedback on the design, yet more effort must be put in to properly integrate the community into decision-making. This could have been achieved during the three-week consultation with people,

businesses, and organisations across Mumbles by
companies involved in planning the project, according to
Business Wales (2021).

**Table 3.5 recommendations and reasoning for multi-functional coastal defence
project in Mumbles**

4 Conclusions

4.1 Research question 1:

The coastal defences along the 1.5-mile seafront of Mumbles consisted of only hard engineering sea walls. The walls are currently in varying conditions with few secondary functions outside of beach/sea access at limited points and the promenade walk/cycle way. The features, structure, and condition of each section of the sea wall is highlighted in figure 3.4.

4.2 Research question 2:

From the questionnaire and IOD, some of the coastal defences are effective and in reasonable condition with evidence of some upgrading. However, sites 3, 4 and 7 were in poor condition without any significant improvements since being built in the 19th Century and hence are particularly vulnerable to climate change. These areas also had elevated economic and social value with a high density of homes, businesses, tourism income and facilities relying on the coastal defences. Therefore, sites 3 and 4 were identified as needing improvement and redevelopment. Results demonstrated that site 7 had some land-use zoning techniques with permeable, sloped and vegetated areas behind the defences. This zoning significantly reduces the impact of flooding/erosion on the area; however, continued pressure for housing development could result in the need for significant future improvements to coastal protection and hence public cost. Local Development Plans and SCC should consider this in their decision making.

4.3 Research question 3:

The public's view of the need to improve the coastal defences along Mumbles seafront showed that the majority believed the coastal defences needed improvement. However, the group who wanted improvement particularly highlighted the importance of activities e.g. walking to be included in any design. The survey also showed that the public favoured public money spending on the redevelopment.

4.4 Research question 4:

The public hierarchy of reasons for coastal defences showed that protecting the coastline from flooding and erosion is the priority. Then resilience against climate change and value for money were the next two in the hierarchy, although their level of priority varied throughout the age groups showing that all the primary functions and some key secondary functions are important reasons for coastal defences. Furthermore, it seemed the public did not fully associate coastal protection with the opportunity of MFCD. Hence, public awareness campaigns need to be included to help the public understand its potential (see some examples in appendix 6)⁹.

4.5 Research question 5:

A range of additional secondary functions for a multi-functional coastal redevelopment were regarded as important. The most significant additional functions were those that would improve the environmental sustainability of coastal defences. Although some economic factors were regarded as highly important by specific age groups, socio-economic factors were not considered a priority in coastal development, but the importance of economic and social factors did show an approximate increase as age increased. However, this could be due to the overall trend that additional functions were more highly regarded in importance among ages over 60 compared to ages below 39.

4.6 Research question 6:

Table 3.5 presents an overview of the recommendations for developing a multi-functional coastal defence for Mumbles. In conclusion, the most important recommendation is to use an integrated community approach to the design process by engaging stakeholders to identify and comment on additional functions in coastal protection schemes. Vulnerable defences should consider functions that will benefit the local area environmentally, economically and socially.

⁹ Public awareness should not just be signage. Social media, QR codes, augmented reality on mobiles to show the public the potential e.g. Oyster beds

5 Evaluation

Although there is an evaluation of the literature, methodology, and results throughout this research, this section evaluates the process and my own experiences. Therefore, this section is written in the first person.

5.1 Research questions and title/conclusion:

The work of architect Bjarke Ingels' on multi-functional coastal defence allowed me to investigate a topic I found very interesting and will aid me in my future studies at university. My project title was suitable as I am interested in the geography of coastal areas and how multi-functional design can improve the human and physical geographical application of coastal management. Also, focussing on the case of Mumbles was ideal as I am connected to Mumbles allowing me to gather valid and reliable data on the area and I am knowledgeable of the current development of the coastline. Also, the Council's plans (2021) to improve the coastal defences in the area showed that my investigation would be contemporary and relevant and allow me to compare my findings to the proposed coastal redevelopment. My sub-questions were well planned, which was helpful in systematically analyse the extensive range of data collected to conclude each sub-question individually, which aided me in concluding my overall investigation findings in a practical structure.

However, the topic was surprisingly comprehensive and there was much information on coastal management, public engagement in decision-making, and multi-functional design. Also, my initial idea was to apply the findings to designing my MFCD for Mumbles, but this proved beyond the scope of the study. On reflection, perhaps I should have focused on assessing the SCC (2021) proposals and introduced multi-functional design into the recommendations.

Methodology:

My data collection was comprehensive, reliable and valid however, all research has limitations (Williams pers. comm., 2022). Therefore, there were areas where I could have improved the methodology¹⁰. Firstly, during my data collection, I could have collected

¹⁰ Table 2.1 includes a column on the evaluation of methodology and should be considered within this section.

more respondents for my questionnaire to increase the small sample size (Bryman, 2007). The small sample size resulted in the age group of 20-39 not being appropriately represented in my questionnaire compared to the overall demographic of the area which reduced the reliability of the data and possibly skewed the results. I could have collected more questionnaires that generally make the data set more representative i.e. a normal distribution (Wheater & Cook, 2000). Furthermore, once I identified the groups lacking in representation, I could have gathered more data specifically for these age groups. However, I could have changed my opportunistic sampling strategy, to a stratified sampling method, based on the age group proportions from the 2011 census¹¹. The mixed-methods approach was practical because it collected both qualitative and quantitative data; however, gaining interviews was problematic due to the pandemic and even my attempts at online interviews were only partially successful. Finally, using table 2.1 to describe, justify, and evaluate the methodology was advantageous but challenging. It helped to show which methodologies were used for each research question which I found [particularly useful. However, the methodology literature was complex, and it showed me that no methodology is truly without limitation. Nonetheless, we need to make decisions based on the best methodology available to our resources at a point in time and space.

Data collection:

I also discovered that my questionnaire did confuse some of the respondents due to the wording. The COVID-19 measures in place at the time of the field work presented problems as section B of the questionnaire required the respondents to put a cross on a line which meant that I could not verbally ask the questions from a distance and write their answers myself. Although many respondents were comfortable and willing to complete the survey using my equipment, others, especially in the older age groups, understandably did not want to complete the survey at a distance. Therefore, I asked them to give each function a score out of ten and then place the cross roughly on the line that their score responded to. This adaptation in the field created an inaccuracy in some of the responses. I could therefore make the necessary changes of changing the section B responses to just give a score out of ten which would have addressed the issue. Completing a pilot survey in the field rather than just with my peers would have allowed me to identify these problems with the questionnaire before the field work day. A more

¹¹ 2021 Census not available until summer 2022 due to Covid <https://census.gov.uk/>

significant focus on coastal redevelopment, including and integrating coastal defences, would have been a better way to consider some respondents' multi-functional coastal defence design. Finally, collecting data after 5.00 pm and on the weekend might have made the data collection more representative because it would include more 'workers' who were not available when the survey was undertaken.

Nonetheless, the data collection was generally sound and showed some interesting patterns that contributed to understanding the topic and answered the research questions.

Data analysis:

To facilitate the research analysis, I used Excel effectively to summarise, present, and statistically analyse the data effectively. Although various graphs were used I learnt that certain graphs are only applicable to certain types of data e.g. continuous data and bar graphs. Also, I learned that the graphs need to be understandable to the audience and easy to interpret. The range of graphs and tables displayed relevant data showing patterns effectively so that secondary data could be used to help contextualise the data's meaning. While I only had one in-depth interview, the fact that I had collected the primary data and applied some analysis before the meeting helped me focus the questions and interpret my results. Nonetheless, I need to integrate my secondary research further to correlate/explain the findings of the primary sources.

Finally, I enjoyed applying my A-level Mathematics knowledge to the project. I previously understood statistical calculation, but this research helped me to apply that understanding to an actual research project and identify significant patterns. I did consider using non-parametric tests and Linear regression, but the Student T-Test and Standard Deviation allowed me to support my evaluation more appropriately.

Overall evaluation:

In conclusion, I have learned a lot about how coasts' physical and human geography facilitates a comprehensive coastal management approach. Also, I understand how MFCDD can help improve coastal developments, protect communities and urban

landscapes while also improving areas environmentally, economically and socially. This project has provided me with a sound basis for further investigations into coastal areas and how to make future research projects valid, reliable and applicable to the real world. In the opening lines, I mentioned that COP26 suggested that Coastal and marine environments are like the “canary in the climate change coal mine”. This research has helped me appreciate the complexities of what they meant with this statement and consider solutions to save the ‘canary’ and make our coasts a better place.¹²

¹² Project 6256 words excluded contents page, tables, references and appendices

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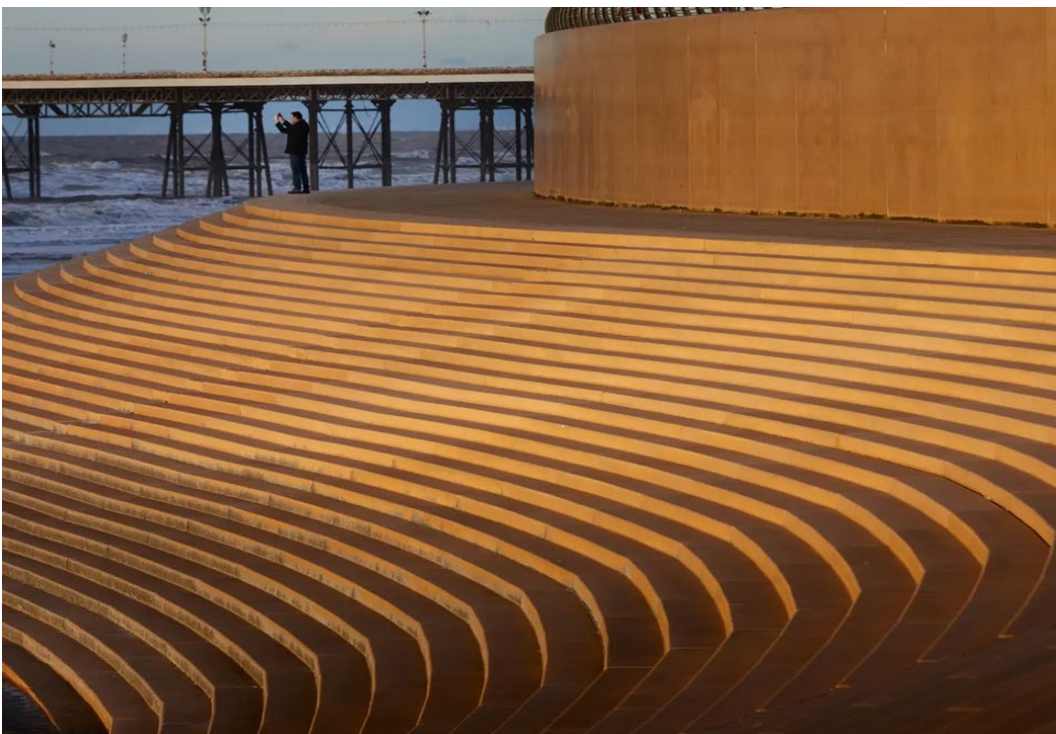
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Appendices

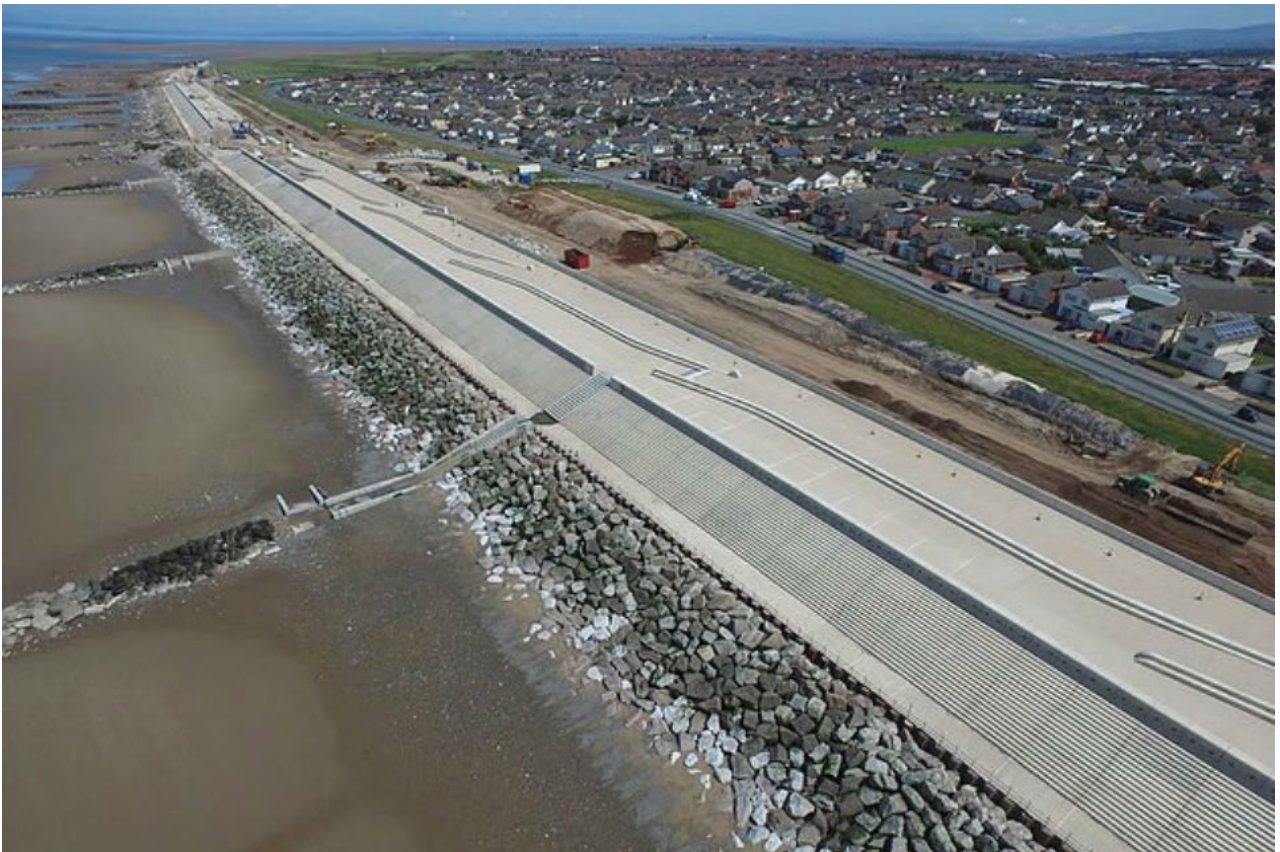
Appendix 1 Images of various types of coastal defence

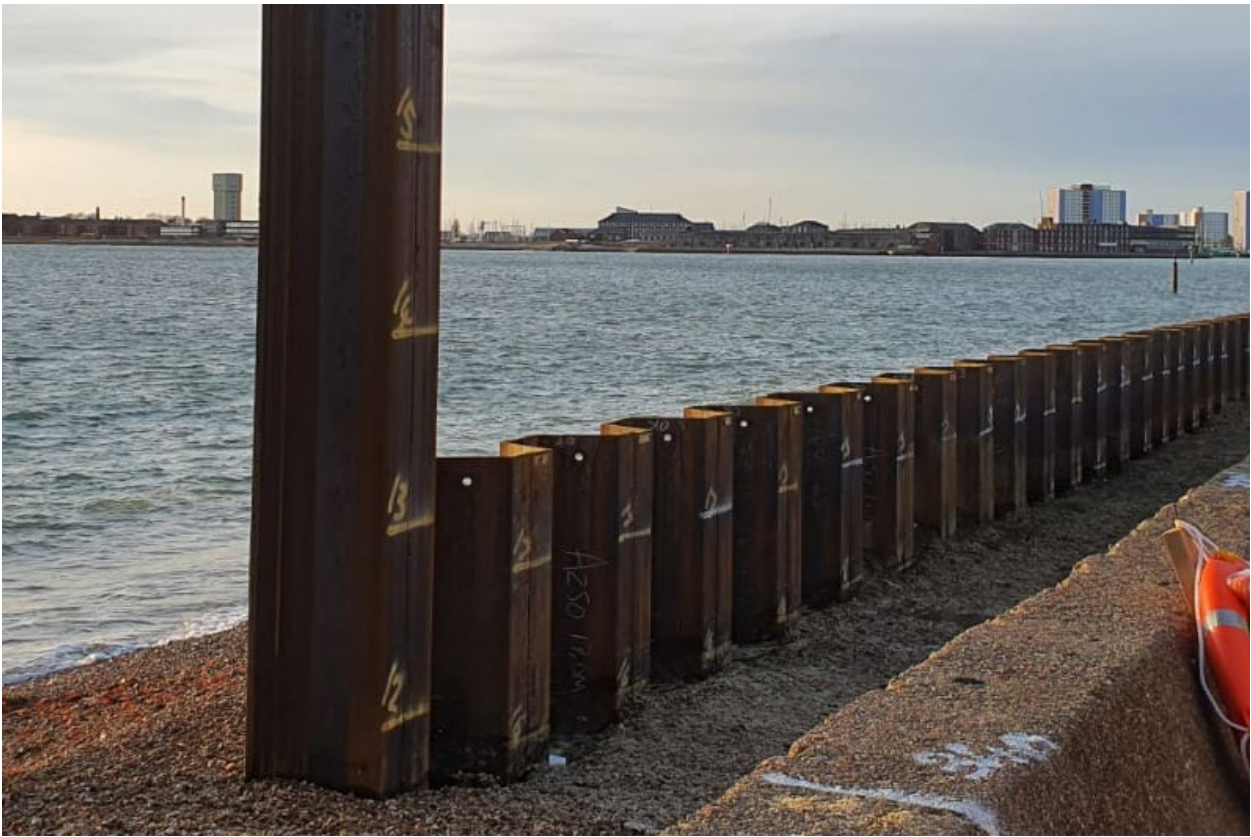
Hard engineering





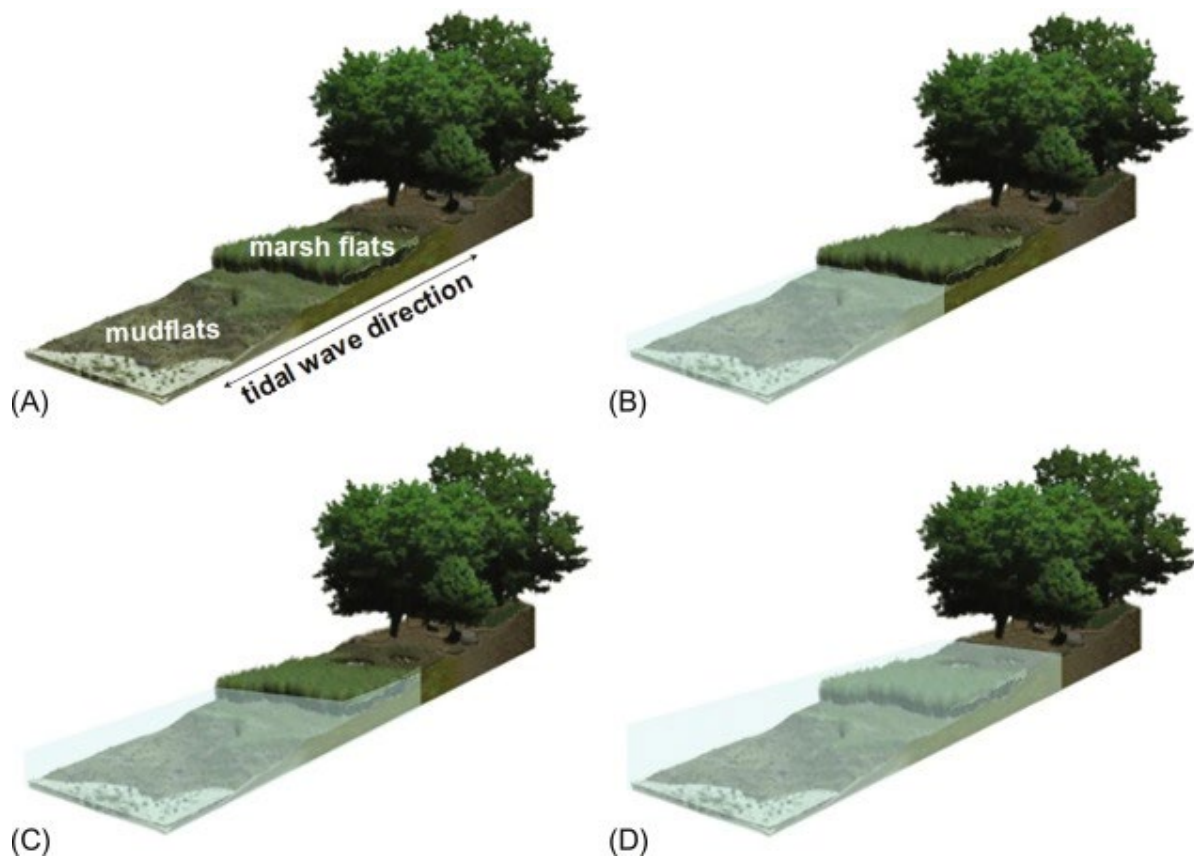






Soft engineering







Appendix 2 Questionnaire

Attitudes towards multi-functional coastal defences questionnaire

My name is Dafydd and I am undertaking a research project on the attitudes towards multi-functional coastal defences in Mumbles from various stakeholders to fulfil the requirements of my geography A-Level. I would be very grateful if you could complete the following questionnaire.

All data collected will remain completely confidential and anonymous and the interview will be conducted under Covid 19 Welsh government guidelines.

SECTION A

PLEASE TICK THE RELEVANT BOX

Question 1: What is your age?

☐ Under 20 ☐ 20-39 ☐ 40-59 ☐ 60-79 ☐ above 79

Question 2: Are you a

☐ resident ☐ day visitor ☐ staying in the area on holidays ☐ other

Question 3: Are you aware of the Welsh Government's coastal protection project for Mumbles?

☐ Yes | ☐ No

Question 4: Do you think the coastal defences along Mumbles seafront need to be improved?

☐ Yes | ☐ No | ☐ Unsure

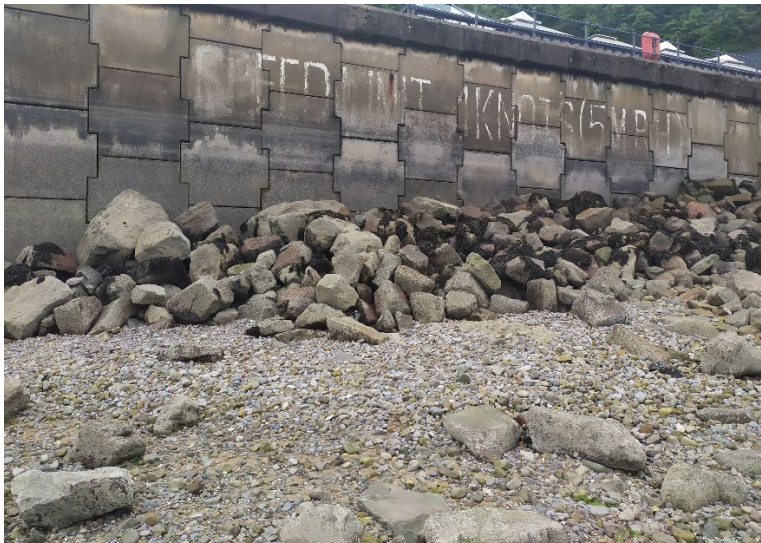
Question 5: To what extent do you agree with the following statement?

Public money should be prioritised to spend on coastal defences that protect the area.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree

Question 6: Rank the following coastal defences in order of need for improvement (1 being the most significant need for improvement and 8 being a minor need for improvement)





SECTION B

PLEASE PUT A CROSS ON THE LINE INDICATING TO WHAT EXTENT YOU THINK THE FUNCTIONS ARE IMPORTANT IN A MULTI-FUNCTIONAL COASTAL DEFENCE ALONG MUMBLES SEAFRONT

1. Effectiveness against erosion

VERY IMPORTANT

NOT IMPORTANT



2. Effectiveness against flooding

VERY IMPORTANT

NOT IMPORTANT



3. Leisure space

VERY IMPORTANT

NOT IMPORTANT



4. Multi-purpose sports facilities, e.g. Basketball courts, tennis, netball, 5-a-side football

VERY IMPORTANT

NOT IMPORTANT



5. Fishing space

VERY IMPORTANT

NOT IMPORTANT



6. Sailing boat slipway

VERY IMPORTANT

NOT IMPORTANT



7. Kayak and sailing boat storage space

VERY IMPORTANT

NOT IMPORTANT

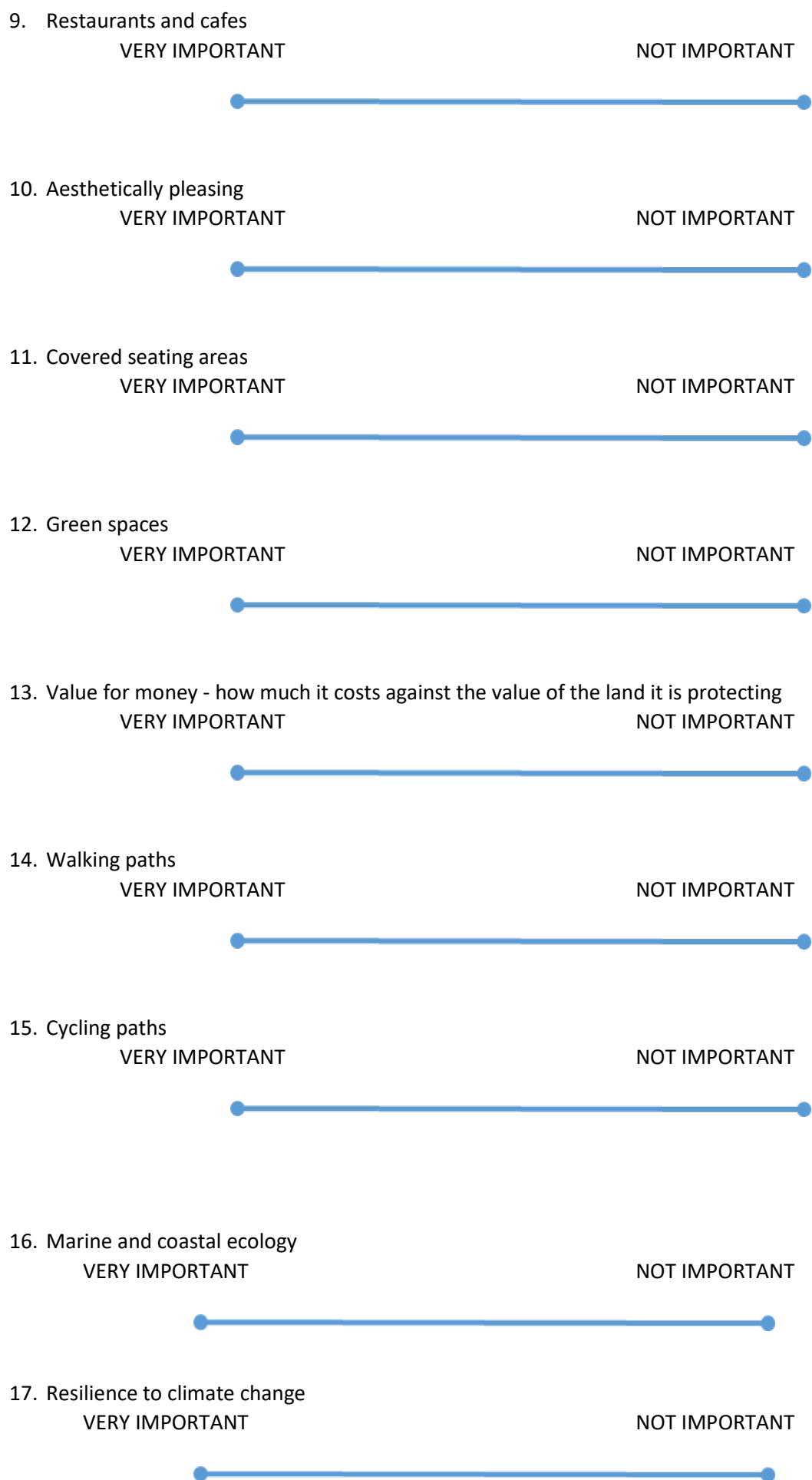


8. Business space

VERY IMPORTANT

NOT IMPORTANT





18. Renewable energy source

VERY IMPORTANT

NOT IMPORTANT



19. Use of the intertidal area e.g. Multi-functional Artificial Reefs

VERY IMPORTANT

NOT IMPORTANT



20. Entertainment provision e.g. outdoor theatre, music venues

VERY IMPORTANT

NOT IMPORTANT



21. Camper van parking and facilities

VERY IMPORTANT

NOT IMPORTANT



22. Educational tool e.g. history of Mumbles fishing industry

VERY IMPORTANT

NOT IMPORTANT



Question 23: Are there any other functions you would want in a multi-functional coastal defence? If so, what?

☐ No

☐ Yes

.....
.....

Thank you. Your help has been very much appreciated.

Kind regards, Dafydd

Appendix 3 Full Excel spreadsheet

Dafydd House		Geography A Level											
SECTION A													
Questionnaire	1	2	3	4	5	6a	b	c	d	e	f	g	h
1	2	1	2	2	4	2	6	1	3	4	5	7	8
2	5	2	2	1	1	1	7	3	2	4	5	6	8
3	3	1	2	3	2	1	8	6	3	2	4	5	7
4	3	1	1	1	1	1	5	3	2	8	4	6	7
5	4	3	2	1	2	1	8	4	3	2	7	5	6
6	1	1	2	3	3	1	4	2	3	5	6	7	8
7	1	1	1	1	2	1	7	3	2	4	8	6	5
8	2	2	2	1	2	1	6	3	2	7	8	4	5
9	1	1	1	1	3	1	6	3	2	5	8	4	7
10	5	2	2	3	2	1	4	2	3	5	6	7	8
11	3	3	2	3	2	1	6	3	2	5	8	4	7
12	3	1	2	1	1	2	8	3	1	7	6	4	5
13	1	2	1	3	3	1	8	3	2	6	4	5	7
14	3	1	1	1	3	7	5	3	2	7	4	8	6
15	5	3	2	3	4	2	8	4	1	6	7	3	5
16	4	3	2	1	1	1	5	2	3	8	7	6	4
17	1	1	2	1	5	1	5	3	2	4	7	6	8
18	1	1	2	2	5	2	5	6	1	4	3	8	7
19	1	1	2	1	3	1	4	7	3	2	6	8	5
20	4	1	2	1	2	1	8	2	3	6	7	5	4
21	4	1	1	1	3	1	6	2	5	7	8	4	3
22	3	3	2	3	2	3	5	6	7	1	4	2	8
23	3	1	1	1	1	8	1	6	7	3	4	2	5
24	1	2	2	3	3	1	5	4	3	7	6	2	8
25	2	1	2	1	2	8	1	5	7	4	6	2	3
26	3	2	2	2	4	5	2	3	7	6	4	1	8
27	1	1	2	3	2	8	2	4	7	3	6	1	5
28	3	1	1	2	2	8	1	2	7	6	5	3	4
29	4	3	2	3	5	3	5	4	7	8	6	2	1
30	1	3	2	3	3	8	1	6	7	4	3	2	5
31	1	4	1	2	4	4	5	6	3	7	8	1	2
mean	2.55	1.74	1.71	1.87	2.65	2.81	5.06	3.68	3.61	5.06	5.81	4.39	5.77
SD	1.39	0.93	0.46	0.92	1.20	2.69	2.25	1.58	2.17	1.95	1.60	2.22	1.96

SECTION B												
1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	3.5	1.9	7	3.1	3.4	1.4	4.6	9.8	9.6	8.9	0.6
0	0.6	0	0.2	0	0	0	0	0.1	0	0	0	0
0.3	0.2	2.8	1.1	1.3	1.3	3	1.5	1.3	1.4	1.8	2.1	1.9
0.6	2.2	1.9	0.8	5.5	3.9	2.5	7	7.9	0.5	4.1	0.5	2.7
0.4	0.5	2.7	4.4	2.2	0.4	0.5	3.5	3.7	0.5	0.6	0.7	2
0	0	4.5	0	0	4.5	10	0	0	0	3.2	0	0
0.3	0.5	1.5	1.7	4.3	4.2	8.9	7.2	7.6	5.5	8	2	0.4
0	0.2	2	2.3	7.6	5.1	8.8	4.5	4.5	10	5.1	0.6	0.7
1.2	1.4	4.7	3	3.5	2.8	5.3	3.7	3.3	3.3	3.2	1.8	0.7
4.5	0	0	1.6	1.4	1.4	1.5	10	10	2.7	2.3	2.2	0
3.2	3.1	4.2	6.4	2.6	5	4.3	6.2	3.8	5	7.2	2.2	1.9
0	0	2.9	7.8	1.1	2.3	2.9	7.2	7.4	9.1	3.3	8.5	2
0	0	0	0	0	0	10	0	0	0		0	0
0.1	0	2.4	1.3	3.9	2.4	5.5	4.9	4	1.5	3	1.8	0
0	1.2	8.6	7.4	10	8.4	9.5	6.2	5	2.8	3.4	4.9	1
0	0.1	5.2	5	8.4	2.6	8.7	4.1	1.4	0.9	1.8	3.3	1.2
1.3	0	6.1	9.1	10	2.7	10	6.7	6.9	2.6	10	5.4	2.9
7.5	0.5	10	10	8.7	6	8.2	9.5	8	6.1	5.4	9.6	3.4
3.6	2.5	4.6	3.1	1.9	4	6.4	8.3	4.7	0.3	7.3	9.1	2
0.5	0.5	5.1	5	4.6	4.9	4.7	4.8	4.7	4.7	8	2	2.1
2.3	0	3.6	4.9	7.1	3.5	5	3.6	2.2	2.4	5.2	5.3	3.4
0	0.2	0.1	7	2.5	7.7	10	0	0	7.2	2.9	4.8	4.5
2.3	2.2	4.4	7.6	0	0	3.1	6.1	2.1	6.4	1.9	5.4	5
1.8	3.1	2.2	2.3	6.8	4.7	10	9.6	9.3	9.3	9.2	3.4	3.6
3.1	3.1	5.6	2.4	6.3	1.7	1.7	7.6	1.6	5.7	2.7	4.5	1.1
3.6	5.1	1.9	6.2	1.6	6.6	4.5	1.5	1.5	1.6	1.6	4.7	4.8
0	0.2	0	0.6	4.5	5.8	10	2.9	10	0.6	9.3	1.8	2
1.1	1.2	8.1	8	7.6	7.4	8.9	5.1	4.2	1.7	1.6	1.6	1.9
4	4.9	1	6.3	6.5	0	0.3	9.6	0	0	6.4	2.6	0
1.5	4.4	0	0	0	7.3	3.4	2.5	4.5	0	0.4	1.2	5
1.1	1.2	1.5	4.4	0	0	0	10	7.6	2.3	3.4	0	4.9
1.43	1.26	3.26	3.93	4.09	3.54	5.52	5.01	4.25	3.35	4.40	3.25	1.99
1.80	1.56	2.63	3.00	3.25	2.52	3.53	3.19	3.11	3.23	2.98	2.83	1.66

SECTION B Cont'd																	
14	15	16	17	18	19	20	21	22	23	Comment							
0.3	4.9	4.7	0	0	5.1	10	4.4	10	2								
0	0	0	0	0	5	4.8	0	0	2	shops							
1.4	1.5	1.3	1.9	1.8	2	3.8	3.9	2.7	1								
1.7	6.1	1.7	0.5	2.1	1.2	4.2	8.1	3	2								
0.5	0.5	0.4	0.4	0.6	1.5	5.3	5.1	0.6	2								
0	0	0	0	0	0	0	9.8	10	1	parking, sheltered seating, asthetically pleasing buildings, bird watching hides							
0.8	1.1	5	0.6	0.9	1.7	9.5	4.6	4.7	1								
0.6	2	1.7	5.1	4.8	4.7	2.2	2.5	1.6	1	easy access to the beach							
2	1.5	2.2	1.2	1	5.1	5.5	5.5	6.9	1								
1.3	1.5	1.4	1.4	0	0	0	0	0	2	wave deflection							
3.7	5	4.1	3.5	1.9	5.4	2.1	5.5	3.9	1								
5.2	4.9	5.2	2.5	3.7	1.1	8.6	2.8	0.7	1								
0	10	4.3	4.4	4.6	4.6	10	0	0	1	information boards about wildlife							
1.4	1.3	2.8	0	2.8	2	1.3	4	0.7	2	art installations, fitness circuit, paddle board, artificial surf reef							
7	7.7	7.5	3	4.5	7.3	9	9	5	2								
1.1	5.4	1.4	3	5.1	1.6	1.7	3.7	1.3	1	waterpolo courts							
1.4	1.5	3.1	0	1.5	4.8	10	10	5	2								
2.7	4	2.6	1.3	3.2	3	9.4	9	6.3	2								
1	6.9	10	6.2	6.7	5.6	6.4	0.5	4.3	1								
2.4	2.9	0.3	0.4	0.4	2.6	4.7	4.6	4.9	1								
2.4	2.4	2.5	1.6	0.5	1.6	6.6	6.7	4.9	1								
4.4	4.6	7.9	3.2	5	2	7.5	6	2.5	1								
4.5	0.5	8.5	1.3	4.6	2.4	2.2	2.1	6.5	1								
1.6	5.1	4.6	0.6	0.7	1.7	4.7	9	9.4	1								
5.6	4.8	5.7	1.9	4.7	4.6	4.8	1.4	1.5	1								
7.2	2.1	3.8	4.9	1.9	1.9	7.8	8	1.9	1	adequate parking, bird hides							
2.7	0	6.2	0	0.5	6.2	0	10	10	1								
6.2	6.5	2.1	0	0	4.9	8.4	8.1	0	1	recycling plant/hut							
5.4	5	1.3	3.3	2.8	2.4	3	5.5	5.5	1								
3.5	6.3	3.9	3.8	3.8	6.7	0.8	8.1	0	1								
2	10	2.7	4.5	2.2	1.1	10	0	2.5	1								
2.58	3.74	3.51	1.95	2.33	3.22	5.30	5.09	3.75	1.29								
2.13	2.83	2.58	1.82	1.95	2.034932	3.385951	3.268734	3.193209	0.461414								

Appendix 4: Unpaired T Test for Residences vs Non-Residences

t-Test: Two-Sample Assuming Unequal Variances

Erosion		
	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	1.423529	1.435714
Variance	3.755662	2.880934
Observations	17	14
Hypothesized Mean Difference	0	
df	29	
t Stat	-0.01865	
P(T<=t) one-tail	0.492623	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.985245	
t Critical two-tail	2.04523	

Flooding		
	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	0.852941	1.757143
Variance	1.087647	3.765714
Observations	17	14
Hypothesized Mean Difference	0	
df	19	
t Stat	-1.567	
P(T<=t) one-tail	0.066809	
t Critical one-tail	1.729133	
P(T<=t) two-tail	0.133618	
t Critical two-tail	2.093024	

Leisure space

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	4.217647	2.1
Variance	5.857794	6.146154
Observations	17	14
Hypothesized Mean Difference	0	
df	28	
t Stat	2.392269	
P(T<=t) one-tail	0.011849	
t Critical one-tail	1.701131	
P(T<=t) two-tail	0.023698	
t Critical two-tail	2.048407	

Multipurpose sports

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	4.017647	3.821429
Variance	10.92404	7.331044
Observations	17	14
Hypothesized Mean Difference	0	
df	29	
t Stat	0.181696	
P(T<=t) one-tail	0.428542	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.857085	
t Critical two-tail	2.04523	

Fishing

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	4.547059	3.542857
Variance	9.073897	12.57341
Observations	17	14
Hypothesized Mean Difference	0	
df	26	
t Stat	0.83921	
P(T<=t) one-tail	0.204501	
t Critical one-tail	1.705618	
P(T<=t) two-tail	0.409001	
t Critical two-tail	2.055529	

Sailing

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	3.558824	3.514286
Variance	3.426324	10.4444
Observations	17	14
Hypothesized Mean Difference	0	
df	20	
t Stat	0.045753	
P(T<=t) one-tail	0.48198	
t Critical one-tail	1.724718	
P(T<=t) two-tail	0.963961	
t Critical two-tail	2.085963	

Kayak boat storage

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	5.852941	5.107143
Variance	8.587647	17.77764
Observations	17	14
Hypothesized Mean Difference	0	
df	23	
t Stat	0.559788	
P(T<=t) one-tail	0.290518	
t Critical one-tail	1.713872	
P(T<=t) two-tail	0.581035	
t Critical two-tail	2.068658	

Business space

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	5.147059	4.835714
Variance	7.102647	14.74093
Observations	17	14
Hypothesized Mean Difference	0	
df	22	
t Stat	0.256729	
P(T<=t) one-tail	0.399887	
t Critical one-tail	1.717144	
P(T<=t) two-tail	0.799773	
t Critical two-tail	2.073873	

Restaurants and cafes

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
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Mean	4.735294	3.671429
Variance	8.044926	11.79912
Observations	17	14
Hypothesized Mean Difference	0	
df	25	
t Stat	0.927373	
P(T<=t) one-tail	0.1813	
t Critical one-tail	1.708141	
P(T<=t) two-tail	0.3626	
t Critical two-tail	2.059539	

Aesthetics

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	3.623529	3.021429
Variance	9.365662	12.27412
Observations	17	14
Hypothesized Mean Difference	0	
df	26	
t Stat	0.503917	
P(T<=t) one-tail	0.309281	
t Critical one-tail	1.705618	
P(T<=t) two-tail	0.618563	
t Critical two-tail	2.055529	

Seating Areas

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	5.152941	3.407692
Variance	8.663897	7.969103
Observations	17	13
Hypothesized Mean Difference	0	
df	27	
t Stat	1.647158	
P(T<=t) one-tail	0.055558	
t Critical one-tail	1.703288	
P(T<=t) two-tail	0.111117	
t Critical two-tail	2.051831	

Green space

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	4.135294	2.185714
Variance	10.45743	3.341319

Observations	17	14
Hypothesized Mean Difference	0	
df	26	
t Stat	2.109895	
P(T<=t) one-tail	0.022323	
t Critical one-tail	1.705618	
P(T<=t) two-tail	0.044647	
t Critical two-tail	2.055529	

Value for money

	Variable 1	Variable 2
Mean	1.888235	2.114286
Variance	1.816103	4.093626
Observations	17	14
Hypothesized Mean Difference	0	
df	22	
t Stat	-0.35776	
P(T<=t) one-tail	0.361966	
t Critical one-tail	1.717144	
P(T<=t) two-tail	0.723932	
t Critical two-tail	2.073873	

Walking paths

	Variable 1	Variable 2
Mean	2.452941	2.735714
Variance	3.462647	6.199396
Observations	17	14
Hypothesized Mean Difference	0	
df	24	
t Stat	-0.35776	
P(T<=t) one-tail	0.361966	
t Critical one-tail	1.717144	
P(T<=t) two-tail	0.723932	
t Critical two-tail	2.063899	

Cycling paths

	Variable 1	Variable 2
Mean	2.988235	4.657143
Variance	5.399853	10.19802
Observations	17	14

Hypothesized Mean Difference	0
df	23
t Stat	-1.63174
P(T<=t) one-tail	0.058176
t Critical one-tail	1.713872
P(T<=t) two-tail	0.116351
t Critical two-tail	2.068658

Ecology

	Variable 1	Variable 2
Mean	3.758824	3.214286
Variance	7.593824	5.852088
Observations	17	14
Hypothesized Mean Difference	0	
df	29	
t Stat	0.585592	
P(T<=t) one-tail	0.28134	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.56268	
t Critical two-tail	2.04523	

Climate Change

	Variable 1	Variable 2
Mean	1.141176	2.935714
Variance	2.370074	2.867088
Observations	17	14
Hypothesized Mean Difference	0	
df	27	
t Stat	-3.05874	
P(T<=t) one-tail	0.002486	
t Critical one-tail	1.703288	
P(T<=t) two-tail	0.004973	
t Critical two-tail	2.051831	

Renewable energy

	Variable 1	Variable 2
Mean	2.023529	2.707143
Variance	3.916912	3.696099
Observations	17	14
Hypothesized Mean Difference	0	

df	28
t Stat	-0.97222
P(T<=t) one-tail	0.169632
t Critical one-tail	1.701131
P(T<=t) two-tail	0.339265
t Critical two-tail	2.048407

Intertidal Use

	Variable 1	Variable 2
Mean	3.170588	7.564286
Variance	3.547206	299.4471
Observations	17	14
Hypothesized Mean Difference	0	
df	13	
t Stat	-0.94542	
P(T<=t) one-tail	0.180842	
t Critical one-tail	1.770933	
P(T<=t) two-tail	0.361685	
t Critical two-tail	2.160369	

Entertainment provision

	Variable 1	Variable 2
Mean	5.611765	4.921429
Variance	11.64235	11.84643
Observations	17	14
Hypothesized Mean Difference	0	
df	28	
t Stat	0.557918	
P(T<=t) one-tail	0.290667	
t Critical one-tail	1.701131	
P(T<=t) two-tail	0.581334	
t Critical two-tail	2.048407	

Campervan parking

	Variable 1	Variable 2
Mean	5.617647	4.457143
Variance	9.641544	11.99495
Observations	17	14
Hypothesized Mean Difference	0	
df	26	
t Stat	0.972528	

P(T<=t) one-tail	0.169875
t Critical one-tail	1.705618
P(T<=t) two-tail	0.339749
t Critical two-tail	2.055529

Educational tool

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	4.829412	2.442857
Variance	10.38596	7.384176
Observations	17	14
Hypothesized Mean Difference	0	
df	29	
t Stat	2.236803	
P(T<=t) one-tail	0.016577	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.033153	
t Critical two-tail	2.04523	

Appendix 5: Unpaired T Test for respondents who believed there was a need for coastal defence improvement compared to unsure/no

t-Test: Two-Sample Assuming Unequal Variances

Erosion		
	<i>Variable</i>	<i>Variable</i>
	<i>1</i>	<i>2</i>
Mean	1.046667	1.806667
Variance	1.47981	5.17781
Observations	15	15
Hypothesized Mean Difference	0	
df	21	
t Stat	-1.14077	
P(T<=t) one-tail	0.133404	
t Critical one-tail	1.720743	
P(T<=t) two-tail	0.266807	
t Critical two-tail	2.079614	

Flooding		
	<i>Variable</i>	<i>Variable</i>
	<i>1</i>	<i>2</i>
Mean	0.92	1.58125
Variance	1.140286	3.552292
Observations	15	16
Hypothesized Mean Difference	0	
df	24	
t Stat	-1.21124	
P(T<=t) one-tail	0.118798	
t Critical one-tail	1.710882	
P(T<=t) two-tail	0.237595	
t Critical two-tail	2.063899	

Leisure

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	3.513333	3.025
Variance	3.096952	10.85667
Observations	15	16
Hypothesized Mean Difference	0	
df	23	
t Stat	0.519091	
P(T<=t) one-tail	0.304328	
t Critical one-tail	1.713872	
P(T<=t) two-tail	0.608657	
t Critical two-tail	2.068658	

Multi-purpose

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	3.906667	3.95
Variance	7.19781	11.30667
Observations	15	16
Hypothesized Mean Difference	0	
df	28	
t Stat	-0.03978	
P(T<=t) one-tail	0.484275	
t Critical one-tail	1.701131	
P(T<=t) two-tail	0.968549	
t Critical two-tail	2.048407	

Fishing

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	4.426667	3.78125
Variance	9.393524	12.10963
Observations	15	16
Hypothesized Mean Difference	0	
df	29	
t Stat	0.548802	
P(T<=t) one-tail	0.293671	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.587342	
t Critical two-tail	2.04523	

Sailing

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	2.7	4.325
Variance	2.697143	8.827333
Observations	15	16
Hypothesized Mean Difference	0	
df	24	
t Stat	-1.89994	
P(T<=t) one-tail	0.03476	
t Critical one-tail	1.710882	
P(T<=t) two-tail	0.069521	
t Critical two-tail	2.063899	

Kayak

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	4.933333	6.0625
Variance	10.07667	14.78917
Observations	15	16
Hypothesized Mean Difference	0	
df	29	
t Stat	-0.89377	
P(T<=t) one-tail	0.1894	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.3788	
t Critical two-tail	2.04523	

Business

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	5.28	4.75
Variance	4.733143	15.83867
Observations	15	16
Hypothesized Mean Difference	0	
df	24	
t Stat	-0.89377	
P(T<=t) one-tail	0.1894	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.3788	
t Critical two-tail	2.04523	

Restaurant

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	4.14	4.3625
Variance	6.016857	13.74517
Observations	15	16
Hypothesized Mean Difference	0	
df	26	
t Stat	-0.1982	
P(T<=t) one-tail	0.422214	
t Critical one-tail	1.705618	
P(T<=t) two-tail	0.844428	
t Critical two-tail	2.055529	

Aesthetics

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	3.56	3.15625
Variance	10.39686	11.02529
Observations	15	16
Hypothesized Mean Difference	0	
df	29	
t Stat	0.343421	
P(T<=t) one-tail	0.36688	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.733759	
t Critical two-tail	2.04523	

Seating

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
Mean	4.28	4.513333
Variance	8.643143	9.662667
Observations	15	15
Hypothesized Mean Difference	0	
df	28	
t Stat	-0.21122	
P(T<=t) one-tail	0.417124	
t Critical one-tail	1.701131	
P(T<=t) two-tail	0.834248	
t Critical two-tail	2.048407	

Green space

	<i>Variable</i> <i>1</i>	<i>Variable</i> <i>2</i>
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Mean	3.393333	3.125
Variance	8.24781	8.260667
Observations	15	16
Hypothesized Mean Difference	0	
df	29	
t Stat	0.259876	
P(T<=t) one-tail	0.398398	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.796796	
t Critical two-tail	2.04523	

Value		
	Variable 1	Variable 2
Mean	1.746667	2.21875
Variance	1.906952	3.616292
Observations	15	16
Hypothesized Mean Difference	0	
df	27	
t Stat	-0.7944	
P(T<=t) one-tail	0.216945	
t Critical one-tail	1.703288	
P(T<=t) two-tail	0.433889	
t Critical two-tail	2.051831	

Walking		
	Variable 1	Variable 2
Mean	2.04	3.0875
Variance	3.001143	5.739833
Observations	15	16
Hypothesized Mean Difference	0	
df	27	
t Stat	-1.40126	
P(T<=t) one-tail	0.086263	
t Critical one-tail	1.703288	
P(T<=t) two-tail	0.172526	
t Critical two-tail	2.051831	

Cycling		
	Variable 1	Variable 2
Mean	2.786667	4.6375
Variance	5.044095	9.547833

Observations	15	16
Hypothesized Mean Difference	0	
df	27	
t Stat	-1.91612	
P(T<=t) one-tail	0.032997	
t Critical one-tail	1.703288	
P(T<=t) two-tail	0.065993	
t Critical two-tail	2.051831	

Ecology

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	3.366667	3.65
Variance	8.806667	5.062667
Observations	15	16
Hypothesized Mean Difference	0	
df	26	
t Stat	-0.29808	
P(T<=t) one-tail	0.384007	
t Critical one-tail	1.705618	
P(T<=t) two-tail	0.768014	
t Critical two-tail	2.055529	

Climate Change

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	1.646667	2.2375
Variance	3.518381	3.197167
Observations	15	16
Hypothesized Mean Difference	0	
df	29	
t Stat	-0.89646	
P(T<=t) one-tail	0.188695	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.377391	
t Critical two-tail	2.04523	

Renewable

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	2.626667	2.05625
Variance	4.604952	3.154625
Observations	15	16

Hypothesized Mean Difference	0
df	27
t Stat	0.803355
P(T<=t) one-tail	0.214393
t Critical one-tail	1.703288
P(T<=t) two-tail	0.428785
t Critical two-tail	2.051831

Intertidal

	Variable 1	Variable 2
Mean	3.033333	3.39375
Variance	2.862381	5.543292
Observations	15	16
Hypothesized Mean Difference	0	
df	27	
t Stat	-0.4917	
P(T<=t) one-tail	0.313451	
t Critical one-tail	1.703288	
P(T<=t) two-tail	0.626902	
t Critical two-tail	2.051831	

Entertainment

	Variable 1	Variable 2
Mean	5.186667	5.40625
Variance	7.401238	15.99663
Observations	15	16
Hypothesized Mean Difference	0	
df	27	
t Stat	-0.1797	
P(T<=t) one-tail	0.429366	
t Critical one-tail	1.703288	
P(T<=t) two-tail	0.858733	
t Critical two-tail	2.051831	

Campervan

	Variable 1	Variable 2
Mean	4.106667	6.01875
Variance	7.60781	12.38163
Observations	15	16
Hypothesized Mean Difference	0	

df	28
t Stat	-1.68937
P(T<=t) one-tail	0.051127
t Critical one-tail	1.701131
P(T<=t) two-tail	0.102255
t Critical two-tail	2.048407

Educational		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	3.106667	4.35625
Variance	5.394952	14.55196
Observations	15	16
Hypothesized Mean Difference	0	
df	25	
t Stat	-1.10919	
P(T<=t) one-tail	0.138952	
t Critical one-tail	1.708141	
P(T<=t) two-tail	0.277904	
t Critical two-tail	2.059539	

Appendix 6 some examples of public awareness signs within the study area.



New covered bike racks to encourage health and well being



Evidence it is an SSSI. However, poorly presented and does the public understand what it means?



Access and use of the sea information. Rusty needs upgrading.



New business developments increase value and the need for protection. Notice secondary wall protection with slats for wooden additions during storms/spring tides



An experiment of bioengineering to encourage intertidal ecology. Information and featured on Michal Portillo's (2022) BBC TV programme