Cyfoeth Naturiol Cymru
Natural Resources Wales

Developing an approach to determining foot access intensity on the Welsh intertidal zone

Report No: 352

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Mae Cyfoeth Naturiol Cymru (CNC) yn arwain prosiect sy'n bwriadu archwilio effeithiau posibl gweithgareddau didrwydded ar amgylchedd morol Cymru.

Mae mynediad ar droed[1] i'r parth rhynglanw, gyda neu heb gi, wedi ei nodi fel gweithgaredd sydd â photensial i effeithio ar amgylchedd morol ac arfordirol Cymru. Gall mynediad ar droed beri pwysau corfforol a niweidio cynefinoedd sensitif trwy sathru a sgrafellu, neu darfu ar rywogaethau fel adar.

Mae gan CNC wybodaeth sy'n cael ei diweddaru'n barhaus ynghylch cynefinoedd arfordirol ac ardaloedd a ystyrir yn sensitif o ran gweithgareddau penodol. Mae'r data yn cynnwys mapiau manwl o fiotopau lle mae mynediad ar droed yn cael ei ystyried yn sensitif, ac yn y dyfodol, bydd hefyd yn cynnwys lleoliadau adar clwydo ar lanw uchel. I hybu'r ddealltwriaeth o sut y gall mynediad ar droed effeithio ar y nodweddion sensitif hyn, mae CNC angen gwybodaeth ddibynadwy ynghylch y mannau lle mae mynediad ar droed yn digwydd ar hyd arfordir Cymru, ynghyd â'i dwyster cymharol, er mwyn adnabod gwrthdaro posibl gydag ardaloedd sensitif. O ganlyniad, comisiynwyd yr astudiaeth hon er mwyn adnabod y dull gorau o amcangyfrif dwyster mynediad i'r parth rhynglanw gan ddefnyddio data sydd eisoes ar gael.

Gweledigaeth hir dymor CNC yw creu set ddata a ffordd o enghreifftio'r data i adnabod lefelau cymharol dwyster mynediad ar droed i'r parth rhynglanw, gan ddefnyddio'r wybodaeth a nodwyd ac a werthuswyd yn yr ymchwil hwn. Bydd hyn o ddiddordeb nid yn unig i brosiectau sy'n asesu effaith gweithgareddau ar gynefinoedd a rhywogaethau, ond hefyd i adrannau eraill CNC, yn cynnwys Cynllunio Morol a Hamdden. Bydd y contract hwn yn gam cyntaf tuag at hysbysu datblygiad y gwaith hwn.

Cyflwynodd y contract yma waith ar yr adrannau canlynol;

- **Adolygiad data,** i nodi a gwerthuso ffynonellau data allweddol y gellid eu defnyddio i hysbysu ynghylch lefelau mynediad i'r parth rhynglanw yng Nghymru. Roedd yr adolygiad yn cynnwys sbectrwm eang o setiau data traddodiadol ac arloesol.
- **Adolygiad llenyddiaeth**, wedi'i gynnal yn gyfochrog â'r adolygiad data gofodol. Yn eang ei gwmpas, roedd yn cynnwys arolygon hamdden cyhoeddedig cenedlaethol a rhanbarthol, astudiaethau o weithgaredd hamdden mewn lleoliadau ecolegol sensitif, ymchwil academaidd i ymddygiad ymwelwyr â'r arfordir a gwybodaeth ymwelwyr i'n traethau
- Ffyrdd posibl y gellid gwella'r wybodaeth ynghylch dwyster gweithgaredd hamdden oddi mewn i barth rhynglanw Cymru, yn cynnwys;
    - Prynu a dadansoddi 'data mawr';
    - Casglu data ac arolygon newydd; a
    - Model cychwynnol ar sail rheolau yn seiliedig ar wybodaeth o'r adolygiad data a'r adolygiad llenyddiaeth.

Ym mis Ionawr 2019, apwyntiwyd LUC i ymgymryd â'r ymchwil, a bydd y canlyniadau'n cael eu datgelu ym mis Mawrth 2019.

Reference

[1] Yn y contract hwn, mae mynediad ar droed yn cynnwys cerdded at ddibenion hamdden yn y parth rhynglanw, ond hefyd mynediad ar droed ar gyfer nifer o weithgareddau eraill, ar y lan ac yn y dŵr.

Executive Summary

Natural Resources Wales (NRW) are leading a project which aims to investigate possible impacts of non-licensable activities on the Welsh marine environment.

Foot access[2] to the intertidal area, with or without a dog, had been identified as an activity which has potential to impact the Welsh marine and coastal environment. Foot access can exert a physical pressure and damage sensitive habitats through trampling and abrasion, or cause a disturbance to species such as birds.

NRW holds, and is continually acquiring, information on coastal habitats and areas that are considered sensitive to particular activities. This data includes accurate maps of biotopes considered sensitive to foot access and locations of high tide bird roosts within SPAs. To progress our understanding of how foot access may impact these sensitive features, NRW requires good information about the locations where foot access occurs and its relative intensity around the Welsh coast, in order for potential overlaps with sensitive areas to be identified. This study was therefore commissioned in order to identify the best approach to estimate intensity of access to the intertidal area using data that is currently available.

NRW's long term vision is to create a dataset and a way of illustrating the data to identify the relative levels of foot access intensity onto the intertidal area, using the information and approaches which have been identified and evaluated in this research. This will be of interest not only to projects assessing impacts of activities on habitats and species, but also to other departments of NRW, including Marine Planning and Recreation. This contract will be a first step to inform the development of this work.

This contract presented work on the following sections;

- **Data review,** to identify and evaluate key data sources that could be used to inform levels of access onto the intertidal area in Wales. The review included a broad spectrum of traditional and innovative datasets.
- A **literature review**, undertaken in parallel with the review of spatial data. This was broad in scope, including published national and regional recreation surveys, studies of recreation activity in ecologically sensitive locations, academic research into visitor behaviour at the coast and visitor information on Welsh beaches.
- Potential ways in which information about the intensity of recreation activity within the Welsh intertidal zone could be improved, including;
    - The purchase and analysis of 'big data';
    - New survey and data collection; and
    - An initial 'rules based model' based on information from data and literature review.

LUC was appointed in January 2019 to undertake the research, with the results being reported in March 2019.

Reference

[2] In this contract, foot access includes walking recreationally on the intertidal area but also foot access for a range of other activities, both shore and water based.

1. Introduction

The purpose of the research was to assist NRW in developing an approach to recording / calculating / estimating the level of access by foot (including with a dog) to intertidal areas in Wales. This includes walking recreationally and accessing the intertidal area for other activities, including access to shore based and water based activities.

The aim was to provide NRW with an understanding of available data and a proposed method for collating it, so that a subsequent project can create a map showing levels of access to the intertidal at as fine a scale as possible.

The key tasks defined within the project brief were as follows:

- Identify / provide an audit of key data sources that could be used to inform levels of access onto the intertidal in Wales. These data sources should be as diverse as considered necessary and include both information on physical infrastructure (e.g. access points, car parks etc.), visitor numbers and other available products. NRW required basic metadata about each source, including attributes such as date of collection, ownership of the data, spatial extent and associated cost of attaining data.
- Appraise each data source for its use in informing access onto the intertidal area and its intensity. Data should be evaluated in terms of attributes such as cost, accuracy it provides to answer this question, relevance, seasonality, age, spatial coverage, frequency of collection or updating etc.
- Explore different options for combining data sources to enhance the accuracy of our knowledge of the intensity of access onto the intertidal. Consideration should be given to how close it is possible to get to NRW's ideal scenario of obtaining accurate access data to the intertidal area in each scenario (i.e. the accuracy / confidence of the suggested approach). The issue of scale will need to be discussed; the maps of sensitive habitats are at a relatively fine scale of resolution (e.g. a specific rocky outcrop on the lower reaches of a beach could be sensitive, whereas the remainder of the sandy beach is not), whereas the activity data may well be at a coarser scale of resolution (e.g. visitor numbers to the general vicinity of the beach).
- Provide costed options for the various approaches developed (above) which NRW could implement to develop a map to demonstrate the location and intensity of access to the intertidal. The approaches should vary in cost, for example from <£100,000, <£25,000 and <£10,000.
- Highlight where key data sources are not available, for example, identifying gaps in spatial data for certain areas of coastline.
- Outline what new data collection would be necessary to increase the accuracy of the approach and provide an estimated cost for this.
- Develop the thinking as to the process of how the results could be used to develop a map of access by foot which could be used to identify areas vulnerable to impacts from foot access.

1.1. Structure of this Report

The remainder of this report comprises the following four sections:

- Section 2 Data review
- Section 3 Literature review
- Section 4 Options
- Section 5 Conclusions and next steps

2. Data Review

2.1. Aims

The aim of the data review was to identify and evaluate key data sources that could be used to inform levels of access onto the intertidal area in Wales. The review was designed to include a broad spectrum of traditional and more innovative datasets.

For each of the identified data sources, the review:

- gathered basic metadata about each source, including attributes such as date of collection, ownership of the data, spatial extent and associated cost of attaining data (costs given in the following categories <£500, <£1,000, <£5,000, <£10,000, <£25,000, <£30,000, <£10,000); and
- evaluated its potential value in aiding understanding of the location and intensity of access onto the intertidal area. This evaluation considered potential as a stand-alone dataset or as one component of a predictive tool. The latter would draw together a number of different aspects of the coastal environment to predict, for example, differential patterns of recreation activity between and within intertidal zones.

2.2. Overview of Findings

Work already carried out by NRW to identify, classify and map **intertidal biotopes** means there is good information about the location, extent and types of intertidal area around the Welsh coastline. NRW intertidal biotopes mapping distinguishes between sand, shingle and rocks, providing a potential starting point for work to model how the location and intensity of activity varies on different types of beach. There is some inconsistency with the OS spatial definition of the high water mark, but this is considered to be a minor issue.

NRW has also assembled a dataset showing the location of **access points** onto the intertidal zone, together with the location of **coastal recreation infrastructure** (e.g. car parks, campsites, caravan parks, boat parks and the coastal path). While this could provide a useful starting point in modelling visitor activity within the intertidal zone, the mapping of coastal access points is incomplete with a significant number of less formal, but nevertheless well used access points, being omitted. Additional work is therefore required to bring this dataset up to the standard required to inform predictive modelling.

The data review also explored a number of **emerging technologies** and the associated spatial data that might be available. Contact with mobile phone operators confirmed that spatial information is collected and could be purchased. Mobile phones networks use a system of cells associated with phone masts and antennae. Phones communicate with their networks and operators hold data on which phones were present in each cell in the network at a given point in time. In theory, therefore, it would be possible to map activity patterns based on mobile phones carried by people accessing the intertidal zone. The data allow detailed analysis, for example, by time of day or day of the week, and distinguishing between people resident, visiting or working in an area. In practice, there are a number of issues which make the data less useful:

- Collection of mobile data depends on the availability of a mobile signal across the whole of a given study area and sufficient users to generate a representative picture of recreation activity. Phone signal may be poor or absent in remoter coastal areas, with masts located inland.
- The level of spatial accuracy is low, with users' location defined at the level of individual mobile phone 'cells'. These tend to be smaller in heavily populated, urban areas, and very much larger in remoter rural and coastal areas. This means the locational accuracy may vary by up to several kilometres making it impossible to distinguish between locations within the intertidal area, on nearby coastal areas or even further inland.
- Locational accuracy is in part calculated by triangulation between three or more mobile masts. This is more difficult at the coast where masts will be located landward but not seaward.

Many **mobile phone apps** also collect more accurate spatial data based on GPS capability of handsets. This information is gathered by app developers including Samsung (Health app) and Google (Google Maps). This information is generally not available, or is used to inform retail assessments (e.g. calculations of footfall) or traffic reports. A number of phone (and watch) apps are designed to track individuals' recreation or sporting activity. One of these, Strava, has gained particular traction amongst runners, cyclists and people engaged in watersports. Composite heat maps, showing the combined routes followed by users, are available to view online and can be purchased from Strava. They are spatially very accurate and the dataset is continually updated as new activities are loaded onto the web. The activity categories are fairly broad, though some further subdivision (e.g. distinguishing walking from running or surfing from kayaking) may be possible. Although expensive to procure and keep up to date, this offers significant potential as a spatial dataset in its own right, or as a means of understanding the relationship between access points, distance and intensity of activity. It must of course be recognised that apps such as Strava are more heavily used by people undertaking active recreation. It is likely that the resulting dataset is poorer in representing the activity of people undertaking regular activity (e.g. dog walking) close to home and that older age groups are less likely to be users of these apps.

A number of websites provide **satellite or aerial imagery** (e.g. Google Earth, Apple Maps, Bing) which can also be obtained as part of OS Mastermap. The review explored the potential use of this imagery to identify and map the intensity of people present within the intertidal zone when the photographs were taken. Sampled examination of satellite photographs suggested that under suitable lighting conditions people can be identified and counted. However, there are obvious drawbacks including the state of the tide when the photograph was taken, the time of day, time of year and prevailing weather conditions. Together these suggest that this is not an accurate or reliable source of information on recreation intensity.

One potential way of building a picture of recreation activity and calibrating existing data is to selectively gather new data. In the past, NRW has deployed a number of **automatic people counters** to gather counts of people using the coastal path. This information could be used to inform (alongside other data) an assessment of the levels of recreation activity along different sections of the Welsh coastline. This could, in turn, be used to weight modelling recreation activity within the intertidal area,

elevating the likely intensity within well visited sections of the coastline relative to remote and less visited area. It is understood that NRW is not currently using these people counters and ownership and management has passed to local authorities. A significant proportion of counters have fallen out of use. There is, however, potential to make targeted use of people counters and to explore the deployment of newer technologies which can distinguish between walkers, cyclists, horseriders and dogs.

The data review explored the potential to gather **new spatial information from recreation users**. The team drew on information from the Wales Activity Mapping Project in South West Wales and LUC's own experience of designing and analysing the 2015 Scottish Marine Recreation and Tourism Survey. This allowed participants to provide information on where they had undertaken up to 23 different activities around the Scottish coastline. Interactive web mapping was used to collect over 52,000 items of spatial information, underpinning the development of heatmaps for each of the activities and overall. 'Raw' data such as routes used by walkers, sailors or kayakers could also be analysed. This is potentially a significant exercise, but could be combined with a broader survey of marine recreation (e.g. to inform Marine Planning) or wider countryside recreation. Challenges would include ensuring spatial accuracy on maps of relatively featureless intertidal areas (on larger beaches) and securing sufficient response rates, though neither of these is insoluble. It is significant that while the original focus of the Scottish survey was on supporting the Marine Planning process, the results have found wider application at a variety of scales.

With the advent of **high quality cameras on GPS enabled smart phones** there is an increasing number of ways people can publish photographs linked to specific locations. The density of web-published photographs could be used as a proxy for the levels of activity on different beaches. Examples include photos published to Google Earth, Flickr and Geograph. Preliminary examination indicates that these sources currently do not include sufficient photography locations to provide the basis for analysing activity within the intertidal zone, but they do allow comparison of the differences between different sections of coast. This could inform the weighting of predictions for different locations.

Photos with location tags are uploaded to **social media** sites such as Instagram, Facebook, Twitter and Flickr. While a lot of information is recorded locations can be biased to specific scenic viewpoints and may not provide a good indication of where the photographer has been. In addition, unless carrying waterproof phones cameras will not be taken to areas closer to water. It may be difficult or impossible to obtain useful anonymous spatial information from these sites, particularly following recent concerns about privacy and data harvesting.

A number of web based **'activity logs'** exist for specialist activities, potentially providing spatially accurate information. These include the 'Capturing our Coast' project which encourages participation in marine citizen science and allows people to record information about where they undertake marine ecology field work. To date participation appears to be low and spatial information is not available. UK Climbing includes a spatial log book which allows climbers to record where they have been climbing. Web maps include almost every climbing location in Wales and information on the popularity of routes is available. While useful, these types of activity logs provide a very partial picture of recreation activity and do not reflect much wider patterns of activity.

2.3. Dataset Profiles

2.3.1 Existing aerial and satellite imagery

Datasets

- Satellite Imagery from various online web maps; OS MasterMap Imagery Layer; Planet data

Ownership

- Google, ESRI, Ordnance Survey, Planet.com

What is it?

- OS MasterMap Imagery comprises the best available aerial images which have been edge matched and orthorectified so that features align with OS MasterMap vector layers. ESRI's ArcGIS World Imagery layer displays 0.5m resolution satellite imagery for Wales, dating from between 3 and 5 years ago. Google provides free aerial imagery to view online and this is updated, on the whole, every 1-3 years.

- Planet (www.planet.com) operates satellites in orbit, collecting information and delivering image data quickly. This up to date, 0.75m resolution satellite imagery is available for purchase together with imagery from their archive.

Why was it collected?

- Multiple sources of varying image quality and costs have been researched with imagery displayed on Google Earth and ArcGIS free, however OS imagery is more costly. This could be used to identify and map the intensity of people and recreation activity within the intertidal zone.

How could it be used?

- In favourable light conditions, people and paths may be identifiable on satellite imagery using a manual or automated process. However, this may often not be possible due to the low resolution imagery or the effects of prevailing weather and tide conditions when the image was taken. The data will have temporal issues in that it is just a snapshot in time so cannot provide an indication of total or average of numbers of people over time. In addition the images are only taken occasionally and at different times of the day leading to very different results depending on these parameters.

- Due to the many issues with imagery data it is not considered a sufficiently reliable way to accurately measure the intensity of activity on the intertidal zone.

Strengths

- People can sometimes be identified and counted under suitable light conditions

- Lots of imagery freely available online
- Can see footpaths and coastal features on OS mapping that are not necessarily official paths

Weaknesses

- State of tide
- Time/date taken is limited
- Prevailing weather conditions
- Good image resolution not guaranteed

Table 1: Comparison between three different digital sources of aerial and satellite imagery. For each component, a rating of 'High', 'Medium' or 'Low' is given per provider. 'Usefulness' is in relation to identifying foot access intensity.

Component	Comment	Rating – OS Master Map	Rating - ArcGIS & Google	Rating – Planet.com
Spatial Coverage	Blank	High	High	High
Spatial Accuracy	Blank	Medium	Medium	Medium
Temporal Coverage	Blank	Low	Low	Medium
Frequency of collection	Planet.com frequency is every few days. Others are every few years.	Low	Low	Medium
Availability	Blank	Yes	Yes	Yes
Cost	OS MasterMap Imagery held by NRW	£0	£0	Less than £10,000
Usefulness	Blank	Low	Low	Low

Figure 1: Example aerial image from Google Earth of a built-up coastal area. Image © DigitalGlobe.

Figure 2: Example aerial image from OS MasterMap of a coastal area. Contains Ordnance Survey data © Crown copyright and database right 2019

2.3.2 Bespoke aerial imagery (Plane or unmanned aerial vehicle - UAV)

Datasets

- Aerial imagery of the coast photographed at high resolution

Company costed

- Property and Land Surveys

What is it?

- UAV Survey can be used to obtain imagery for a selected area (likely fixed wing UAVs rather than quadcopter for larger areas). This data will be at very high resolution so individuals can be identified.
- Aerial image survey from an Aeroplane rather than UAV. Photographs taken at low altitude of the coast to maintain a high cm resolution adequate to identify individuals.
- Both come at a cost. Quoted costs below were provided by Property and Land Surveys as an example. Many other companies exist offering similar services.

Why was it collected?

- To provide a current view of the coastline of wales, at a resolution where individuals can easily be seen.

How it could be used?

- From the imagery provided, a manual digitization of individual person counts could be performed to obtain a view from a specific date, time of day, weather and tidal conditions. All these parameters could change throughout the survey, but the company indicate they could attempt to keep to similar times each day. Careful design would be needed to account for variables such as tide times, weather, holidays and patterns of use associated with lunch breaks and evening walks, for example.

Strengths

- People can be identified and counted.
- Can see footpaths and coastal features.
- Both vertical and oblique imagery are available. Oblique would be useful near sea cliffs to view individuals.

Weaknesses

- State of tide

- Survey would have to happen for a short span during a busy part of the day. Time/date taken is limited.
- Fairly high cost,
- UAV data only capable of surveying smaller areas, not entire coast of Wales.

Table 2: Comparison between Aerial and UAV survey methods. For each component, a rating of 'High', 'Medium' or 'Low' is given per provider. 'Usefulness' is in relation to identifying foot access intensity.

Component	Comment	Rating - UAV	Rating - Aeroplane
Spatial Coverage	Could cover the entire coast	Medium	High
Spatial Accuracy	High enough to see people	High	High
Temporal Coverage	Very low – a single shot in time	Low	Low
Frequency of collection	Low, although depending on cost it could be resurveyed regularly	Low	Low
Availability	Number of companies with similar capacity	Yes	Yes
Cost	Imagery covering entire Welsh Intertidal. It is approximately 25% more expensive for vertical orthrectofied imagery as opposed to oblique imagery	Dependant on survey area size	Less than £25,000
Usefulness	Potentially useful to get an accurate view of the coast but main issue being temporal limits.	Medium	Medium

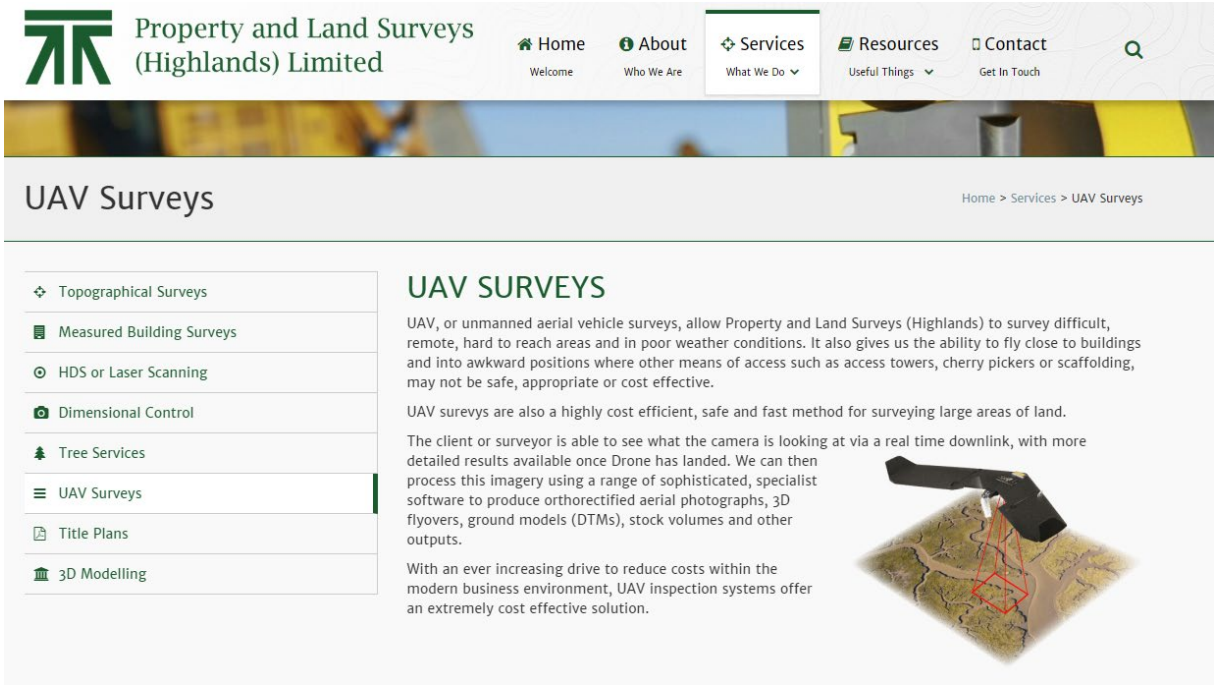


Figure 3: Information from the Property and Land Surveys website describing their UAV surveys process and what information and features are available to the client (found here).

2.3.3 Intertidal biotopes & Intertidal Zone

Datasets

- Intertidal Zone Biotopes and Intertidal Zone boundary GIS shapefiles.

Ownership

- Natural Resources Wales.

What is it?

- The intertidal biotopes GIS layer is an existing dataset held by NRW which details Phase 1 intertidal biotopes. Within this, over 50,000 records are held detailing biotope location, habitat and extent.

- The intertidal zone GIS layer is defined by the intertidal biotopes GIS layer above. It illustrates the location and spatial extent of all the intertidal zones around the Welsh coast.

Why was it collected?

- Dataset designed to characterise intertidal habitats along the Welsh coastline.

How it could be used?

- Work carried out by NRW means this dataset is already available to use for investigating footfall intensity on intertidal zones in Wales. From this data, mapping can distinguish different types of beaches and provide a starting point for investigations into the relationships between recreation activity, intensity and beach type.

Strengths

- Defines the Intertidal Zone

- Dataset exists

- Can be used to define basic levels of sensitivity

Weaknesses

- None

Table 3: Assessment of the suitability of Intertidal Zone Biotopes and Intertidal Zone boundary GIS shapefiles for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Whole of Welsh coast	High
Spatial Accuracy	Mapped at a scale of 1:5,000, survey is based on using a combination of aerial photographs and Ordnance Survey (OS) maps.	High
Temporal Coverage	While this is less important the intertidal zone is constantly in flux and some sandy beaches can appear or disappear in a single storm.	Medium
Frequency of collection	One-off collection	n/a
Availability	Owned by NRW and freely available on Lle	Yes
Cost	Blank	£0
Usefulness	Blank	High

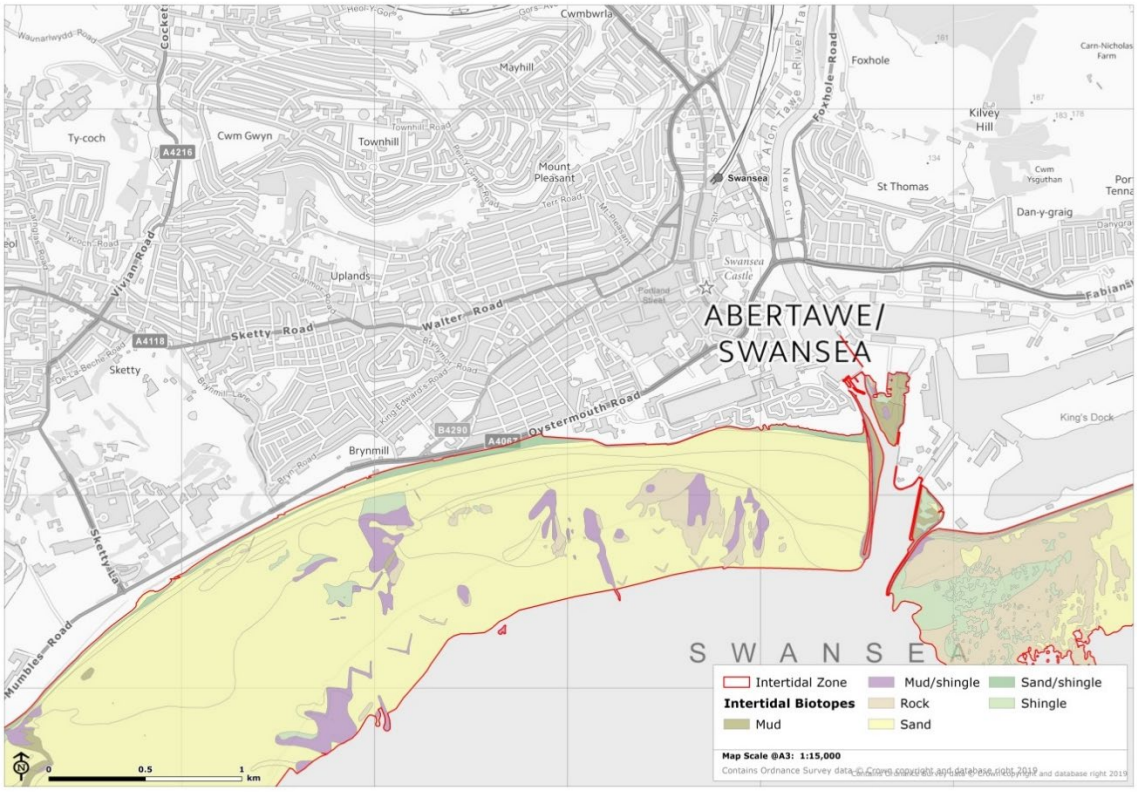


Figure 4 : Example map of an urban coastline overlaid with the Intertidal Biotopes & Intertidal Zone Area GIS shapefiles. Contains Ordnance Survey data © Crown copyright and database right 2019.

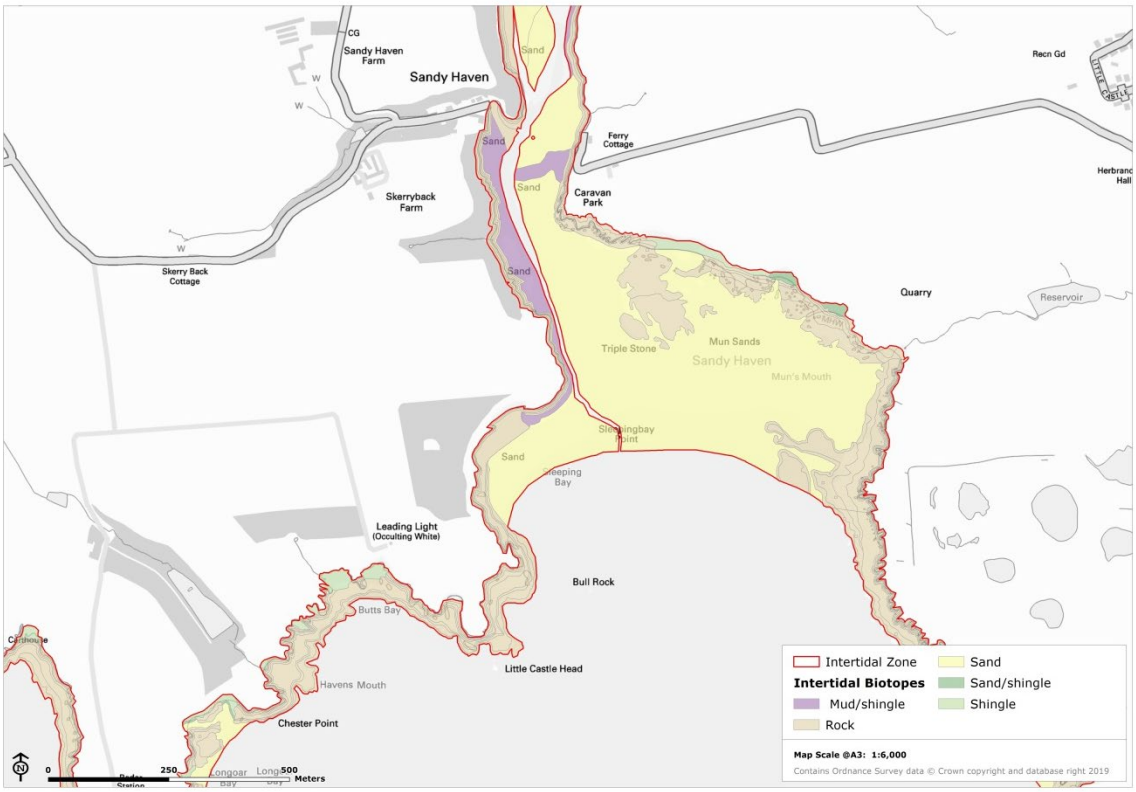


Figure 5: Example map of a rural coastline overlaid with the Intertidal Biotopes & Intertidal Zone Area GIS shapefiles. Contains Ordnance Survey data © Crown copyright and database right 2019.

2.3.4 Access point and path datasets

Datasets

- Access points; Public rights of way and National trails; Long Distance Walking Paths; National Cycle Network

Ownership

- NRW, Sustrans, LDWA, Ordnance Survey

What is it?

- NRW have assembled a number of datasets which gather information on access points and paths around the coastline. This includes public rights of way, national trails and coastal access points.

- The Ordnance Survey Highway Layer is included in the Public Sector Mapping Agreement (PSMA) so free for NRW to use. It contains an up to date path network that is more detailed than the current NRW PRoW dataset. OpenStreetMap also contains a more detailed path network than the current NRW dataset.

- The Wales coast path is a dataset from the Long Distance Walkers Association online database.

- The National Cycle Network (NCN) is a freely available dataset from Sustrans – a UK sustainable transport charity.

Why was it collected?

- NRW already have this information available which provide a useful starting point in modelling visitor activity within the intertidal zone.

How it could be used?

- These datasets could be used as baseline information and used in combination with other datasets in predictive modelling. They also have the potential to identify locations to deploy other technologies such as sites for people counters.

- However, the access point dataset is incomplete and unofficial access points are not captured. Therefore, the task of updating this dataset would need to be undertaken to establish all access points along the Welsh coast.

- Alongside this it might be useful to use the OS Highway layer and/or the OpenStreetMap paths and tracks to provide more accurate distance measurements of access points to car parks/public roads rather than as the crow flies distances. They could also be used to pinpoint access locations.

Strengths

- Datasets already exists
- Access points, if complete, will be used by almost everyone who enters the Intertidal zone therefore the ideal locations to set up people counters.
- Public Rights of Way can indicate if access points are official or non – official.

Weaknesses

- Access point dataset is incomplete and requires improvement
- NRW PRoW data does not contain all the paths used by the public and would benefit from more accurate data.

Table 4: Assessment of the suitability of Access Point and Footpath datasets for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Whole of Welsh coast	High
Spatial Accuracy	Fairly accurate but could be improved	High
Temporal Coverage	Blank	n/a
Frequency of collection	Blank	n/a
Availability	Blank	Yes
Cost	Free to purchase but requires time on improving available datasets	£0
Usefulness	Blank	High

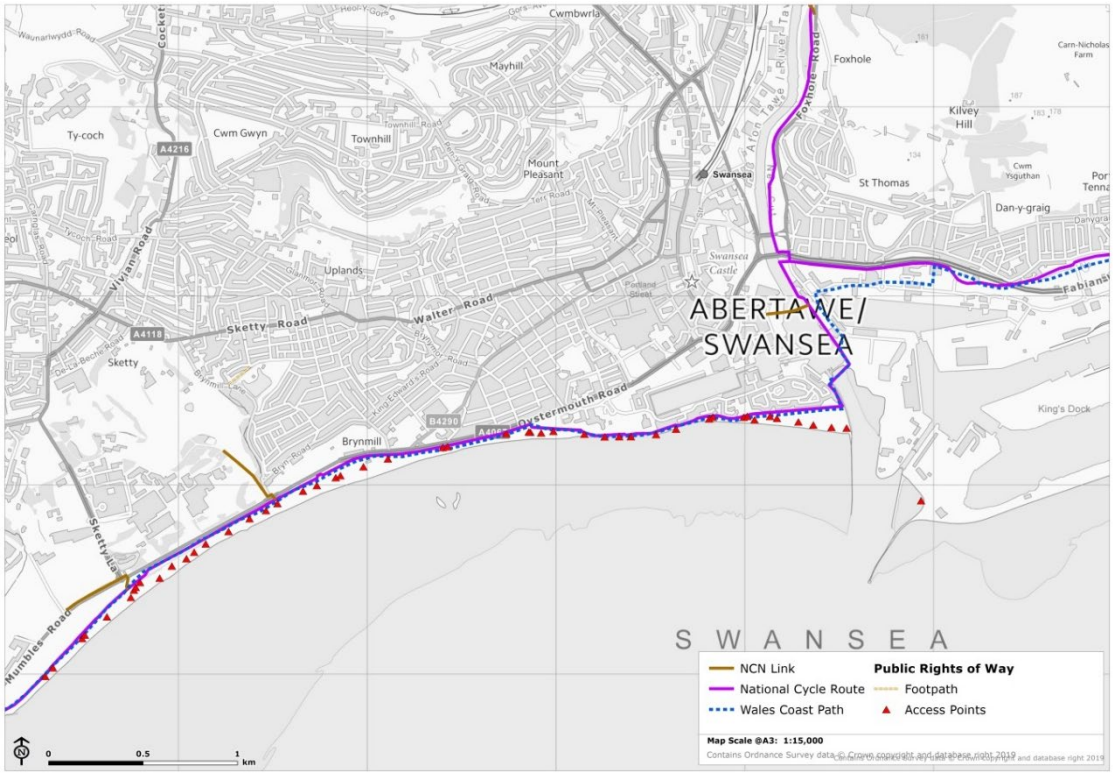


Figure 6: An example of the Access Points and Footpaths datasets in an urban coastal setting. Contains Ordnance Survey data © Crown copyright and database right 2019.

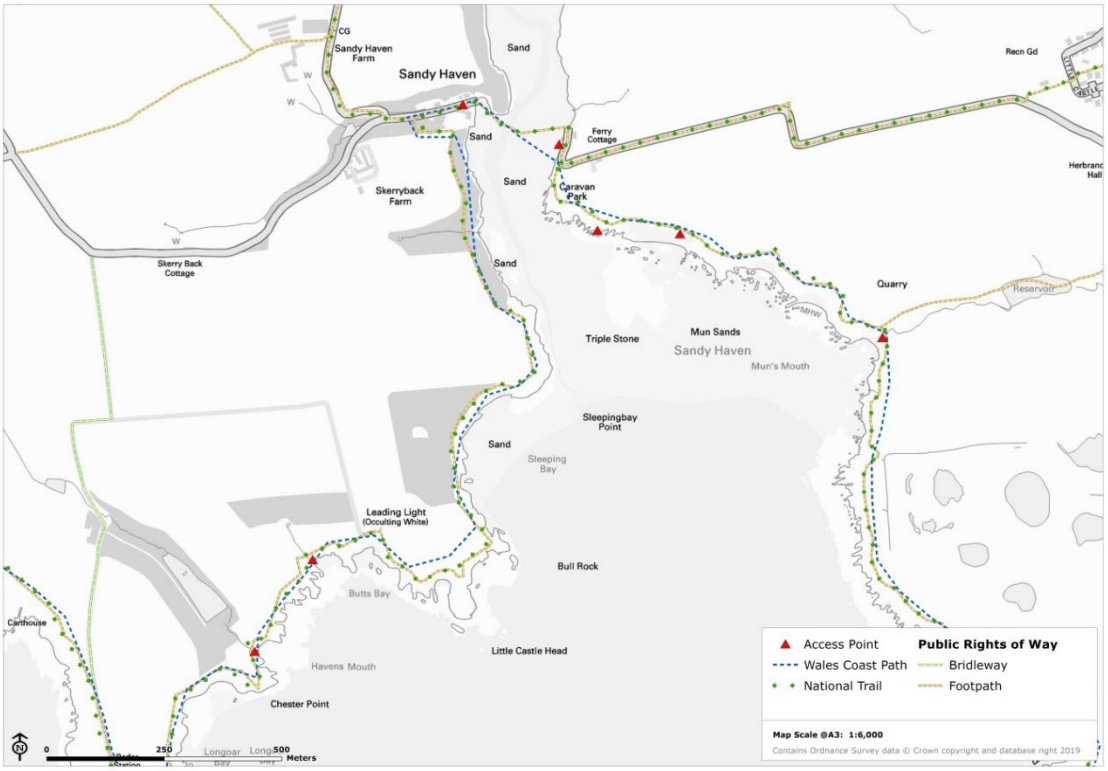


Figure 7: An example of the Access Points and Footpaths datasets in a rural coastal setting. Contains Ordnance Survey data © Crown copyright and database right 2019.

2.3.5 Coastal Recreation Infrastructure

Datasets

- Car parks, camp sites, marina, moorings, pontoons, slipway, boat parks

Ownership

- Natural Resource Wales, OpenStreetMap, OS

What is it?

- Natural Resource Wales hold a GIS dataset which contains polygon shapefiles of different coastal features across Wales. This includes the location of caravan parks, parking and marinas.

- NRW also hold a GIS dataset for Blue Flag Award Beaches which contains information on the location, name and year of blue flag beaches across the Welsh coastline.

- OpenStreetMap is an open source web map where vector data can be downloaded and used for other purposes. The data would include Car parks, Campsites, caravan parks, railways.

Why was it collected?

- To give an indication of where coastal recreation features are as this may influence where certain activities are undertaken and the volume of people here.

How it could be used?

- Could potentially be used as a way to find suitable people counters locations, or used in combination with other datasets as a starting point to infer recreational activity. All these would benefit from updates now and in the future.

Strengths

- Datasets already exists

Weaknesses

- Some of the datasets are not complete. Additional car parks and camp sites were found in freely available OpenStreetMap data

- Blue flag data needs to define entire beach area rather than point data

Table 5: Assessment of the suitability of Coastal Recreation Infrastructure datasets for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Whole of Welsh coast	Medium
Spatial Accuracy	Fairly accurate but could be improved	High
Temporal Coverage	Blank	n/a
Frequency of collection	Blank	n/a
Availability	Blank	Yes
Cost	Free to purchase but requires time on improving available datasets	£0
Usefulness	Blank	High

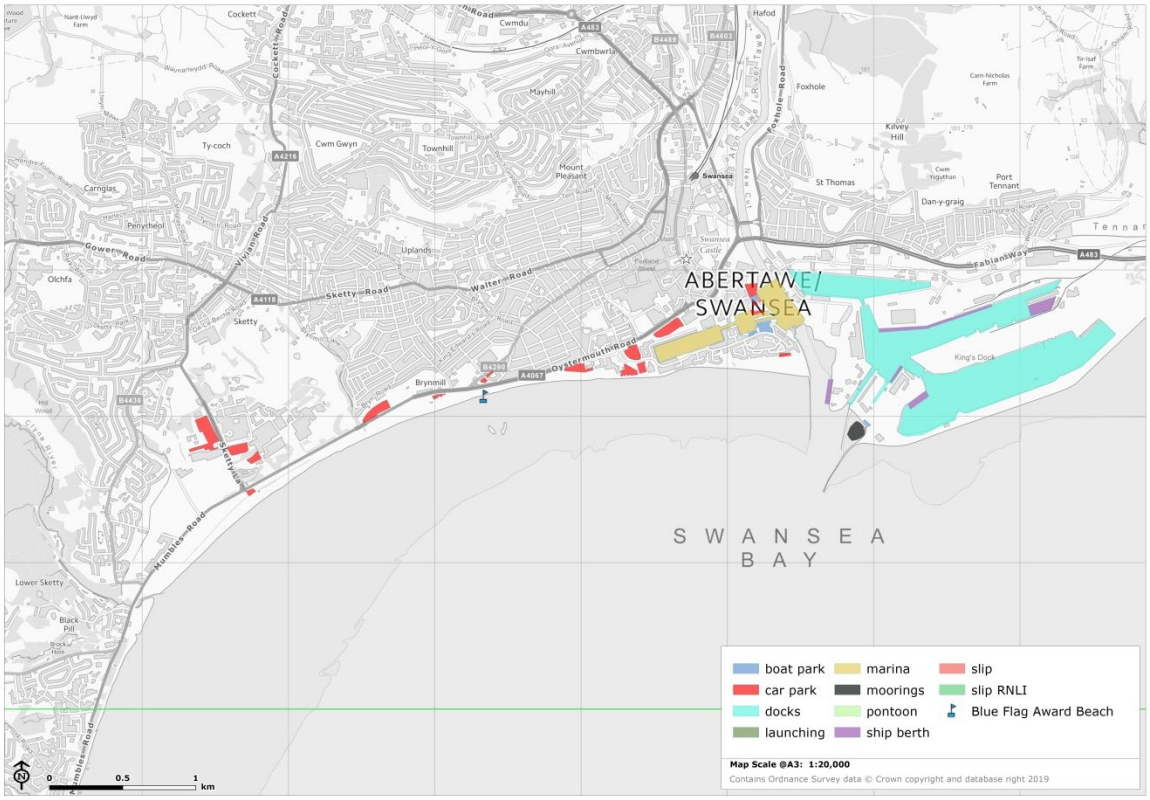


Figure 8: Coastal recreational infrastructure features for an urban coastal setting. Contains Ordnance Survey data © Crown copyright and database right 2019.

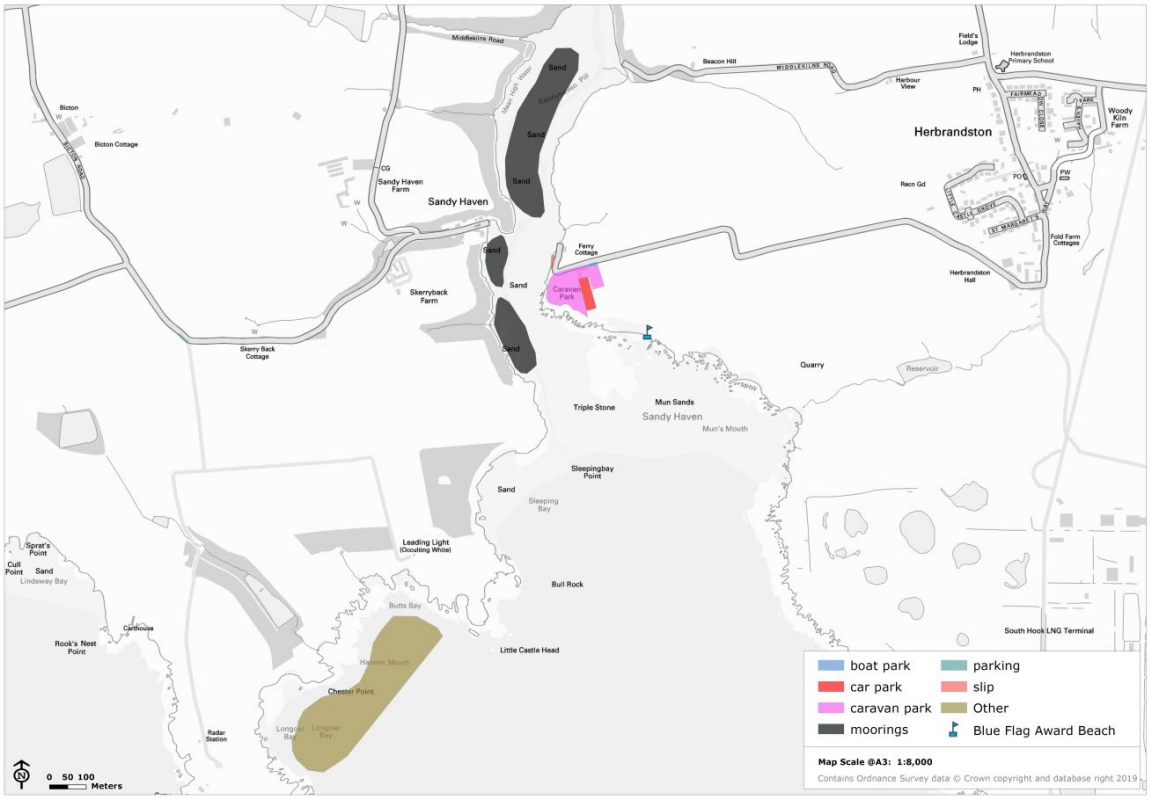


Figure 9: Coastal recreational infrastructure features for a rural coastal setting. Contains Ordnance Survey data © Crown copyright and database right 2019.

2.3.6 Mobile data

Datasets

- O2, EE mobile data

Ownership

- Telefonica, EE mobile networks

What is it?

- Mobile phones are continuously communicating with their mobile network providers. They can establish, at any given point in time, which cell in the network each phone is within and record this information. This location data is available to purchase from some mobile network providers.

- EE is the largest mobile network provider in the UK and offer a service called mData which provide up to date insights on customer behaviours, using anonymous and collated usage data from EE mobile customers. This includes the possibility to view population movement patterns and location footfall.

- Telefonica, trading as O2 in the UK, is the second-largest mobile network provider in the UK. They offer the purchase of anonymous locational mobile data of O2 customers.

Why was it collected?

- Mobile network data is a by-product of mobile phone network operations. It can be used to provide information on the number of individuals visiting a particular area including information on time of day and week. This would allow mapping of activity patterns based on mobile phones carried by people.

How it could be used?

- In theory, this data could allow mapping of visitor activity within the intertidal zone. However, it is based on recording a phone's presence within the 'cell' served by particular mobile phone masts or antennae. Cells tend to be largest in remote rural areas (such as large parts of the Welsh coastline), so the ability to locate an individual within the intertidal zone (as opposed to on a nearby path, road or settlement) is limited. As an indication, masts in dense urban areas can be less than 500m apart, in suburban areas they are commonly around 2km apart while in rural areas they can be anything up to 35km apart, depending on topography and the technology in question. Locational accuracy can be better where three or more masts allow a position to be triangulated, is limited by the low number of masts in more remote area and the absence of masts out to sea.

- While this kind of data would provide low spatial accuracy, it does have very high temporal accuracy and can be used to distinguish between local residents, workers and visitors to an area. The high temporal accuracy and frequency of data collection would allow this data to be used for detailed

analysis on time of day and/or week that people are within areas of the Welsh coastline.

- This data could also be used in conjunction with other datasets. For example, combining this with data from people counters to infer overall counts of people in the intertidal zone.

Strengths

- Can distinguish between local residents, workers and visitors to an area
- Very high temporal accuracy allowing for analysing across time scales

Weaknesses

- Phone signal may be poor or absent on the intertidal zone
- Low spatial accuracy due to limited signal
- Data limited to O2 and/or EE mobile network towers and customers

Table 6: Assessment of the suitability of Mobile data for determining foot access intensity in intertidal zones.

Component	Comment	Rating – O2	Rating – EE
Spatial Coverage	UK	High	High
Spatial Accuracy	O2: 1 to 5km spatial accuracy on coasts	Low	Low
Temporal Coverage	Time of day and week can be provided	Very High	Very High
Frequency of collection	Continuously	Very High	Very High
Availability	Good contact with O2, no contact with EE	Yes	Unknown
Cost	O2 - for 1 months data for a 5km strip of wales entire coastline.	Less than £30,000	High
Usefulness	Lacks spatial accuracy	Medium	Medium

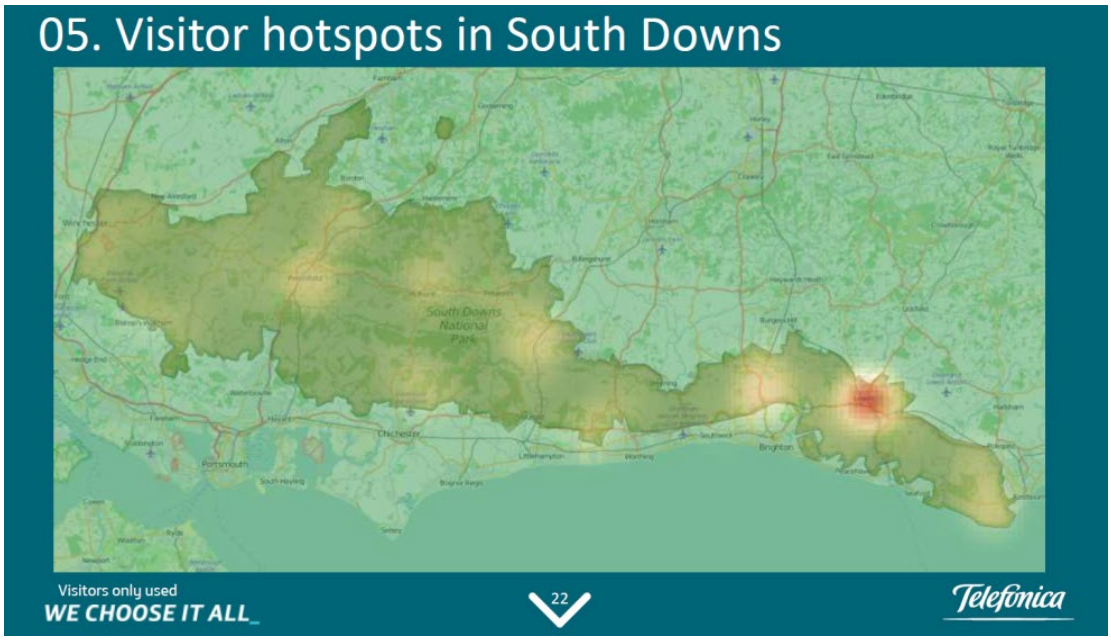


Figure 10: Example of how mobile phone data presence can be aggregated to show hotspots. Data from O2 Telefonica.

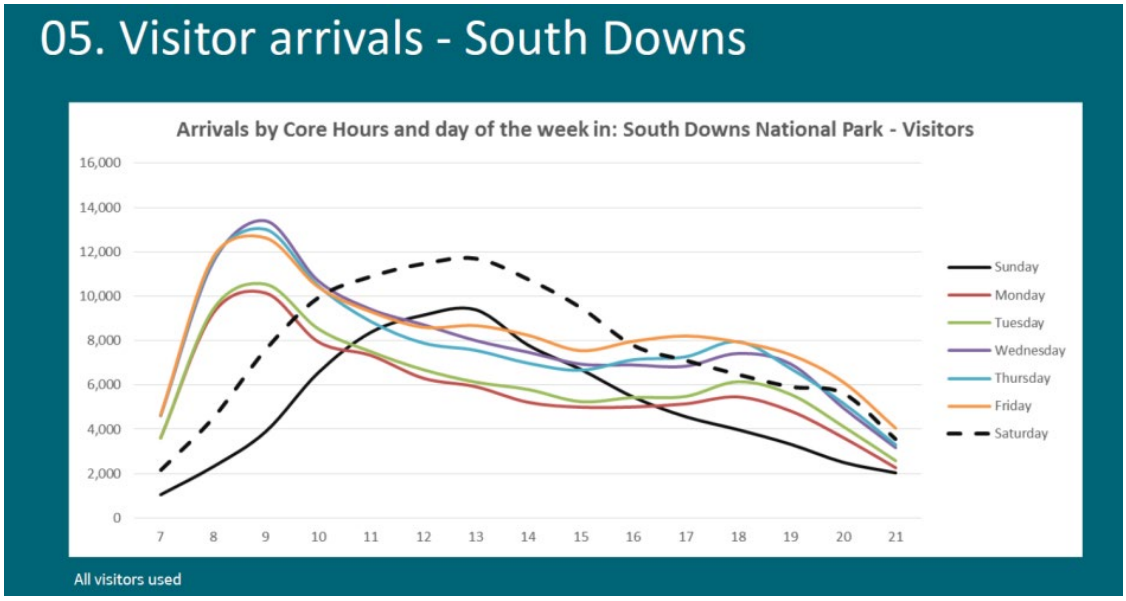


Figure 11: Visitors to the South Downs National Park between 7am and 9pm, separated by day of the week. Based on mobile phone network data. Data from O2 Telefonica.

2.3.7 Mobile app activity mapping

Datasets

- Strava data

Ownership

- Strava

What is it?

- Many training and activity apps record fairly accurate GPS tracks of your movement when using the app. Strava is the most popular and well known of these mobile apps, running on smart phones and smart watches. Other 'health' apps such as Google Fit, Moves and Samsung Health operate in the background, whenever a phone is on, and if gathering GPS data, may offer potential to gather spatial data. Further research is needed to test the suitability and availability of these data sources.

- Strava is used by people engaged in sport and active recreation to record and track their activity. The app uses GPS to record the route followed by runners, cyclists walkers and people undertaking water sports, for example. Subject to privacy settings, Strava aggregate individuals' data and publish composite activity maps. These maps are available to purchase but is also free to view online on Strava heat maps (https://www.strava.com/heatmap). The heat maps show combined data in the following categories: cycling, running, water and winter activities. Online heat maps are also continuously updated to reflect new activities and data.

Why was it collected?

- Strava maps are a by-product from use of the Strava activity app. They provide a very rich source of spatial information relating to the specified activities and the data are now marketed to city and transport planners and for other applications.

How it could be used?

- Strava data could be used to identify routes and paths used by runners and possibly cyclists on beaches. Although the activity categories are very general, there is some scope for further subdivision.

- Apps like Strava will, however, under-represent those undertaking less active, more informal or regular activities such as dog walking. It is likely to exclude those who do not use mobile apps, potentially under-representing older and less tech-savvy parts of the population. There are, however, likely to be similarities between users and non-users, particularly in terms of identifying key access points onto the intertidal zone (potentially complementing other, more partial sources of information).

- Purchase of Strava datasets relating to the Welsh coastline would provide a spatially and temporally accurate and up to date picture of some recreation activities. The maps could be of wider value (e.g. for terrestrial recreation planning) to NRW, the Welsh Government or local authorities, so a partnership based approach may help make purchase more affordable.

- Strava maps can also be viewed on-line, providing information which could be used to help analyse and benchmark activity patterns at key locations around the Welsh coast. This is a low cost option, though analysis would be limited to 'eye balling' data on-screen.

Strengths

- High spatial coverage and accuracy

- Can provide historical or current information and continuously being updated

Weaknesses

- Focused on active recreation and limited to those using mobile apps

- High cost to purchase the anonymous data

- Activity categories are fairly broad

Table 7: Assessment of the suitability of Mobile App Activity data for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Global although used in some areas more than others	High
Spatial Accuracy	Dependant on quality of GPS signal but usually accurate	Medium
Temporal Coverage	Can provide historical or current information	High
Frequency of collection	Continuously being updated	High
Availability	Blank	Yes
Cost	12 months intertidal zone + 500m buffer	Less than £25,000
Usefulness	Very useful to map active use of the coastal area. Less useful for general coastal use but could help measure overall visitor numbers to different areas.	High

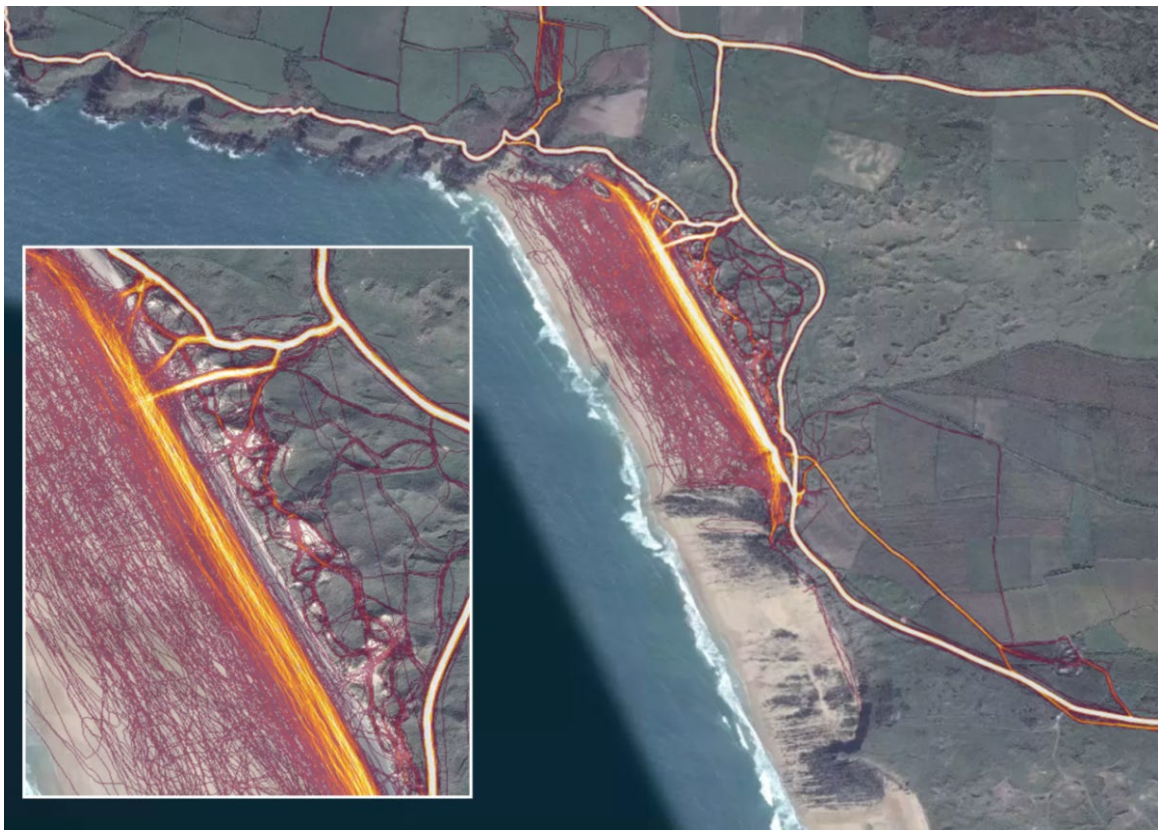


Figure 12: An example visualisation of walking or running data from Strava. The white areas indicate the highest density of user presence. © 2018 Strava | © Mapbox © OpenStreetMap

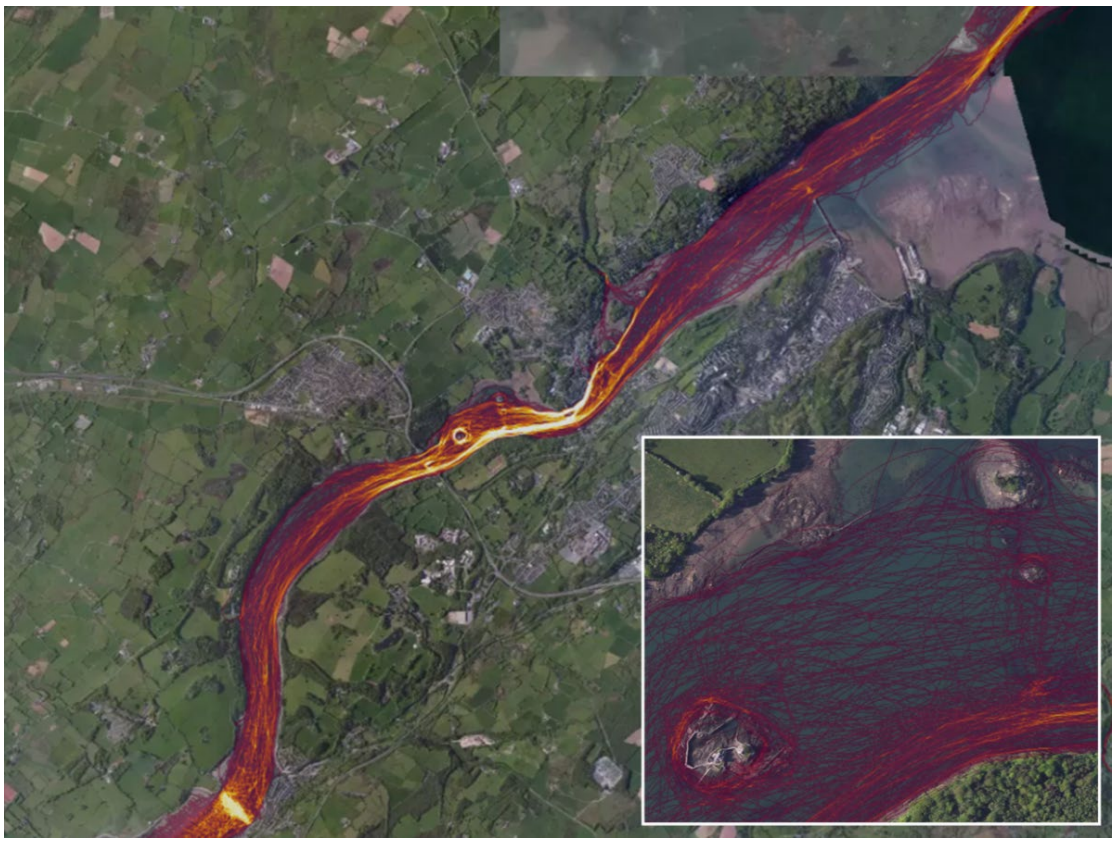


Figure 13: An example visualisation of water activity data from Strava. The white areas indicate the highest density of user presence. © 2018 Strava | © Mapbox © OpenStreetMap

2.3.8 Automatic people counters

Datasets

- Automatic outdoor people counter units

Ownership

- Chambers electronic, SensMax, Local Authorities

What is it?

- People counters can provide absolute counts of individuals in chosen areas. This can be combined with other datasets to build a picture of recreational activity in a particular area.

- Automatic people counters are individual units which can be placed outdoors at specified locations. There are multiple manufactures with a range of products and costs. Options include radio beam, physical step pads that are buried and versions that operate on gates as they open and close. Options are also there for simple versions that require data collection on a regular basis, to the versions with a GSM mobile network connection to provide automatic data collection.

- Chambers electronic and SensMax are two of these which have a range of different automatic people counters suitable for the outdoors using long life batteries. Once the units are in the field, data collection is available via an internal data logger for the download of time/date counts onto a PC. Some are uni-directional - does not detect any difference of people coming in and out of an access point. Others are bi-directional where people moving in both directions are recorded separately.

Why was it collected?

- Previously, NRW and local authorities have installed automatic people counters along the coastal path to identify counts of people in particular areas. However, the ownership and management of these units have now been passed onto local authorities.

- If possible, these existing units could be repurposed and used for this study if available alongside additional units to be purchased. However, it should be noted that 25% of these counters have failed to produce results due to removal, vandalism, lack of maintenance or theft.

How it could be used?

- Automatic people counters can be used to record everyone who passes the counter at a specific day and time. These can be placed at recreation sites along the coastline such as access points and coastal path gates. Counters are not suitable for deployment within the intertidal zone itself, so provide no detailed information on which parts of a beach are visited by people passing a counter.

- Due to large number of units potentially required, a targeted approach could be taken. This would focus on certain hotspots and putting multiple counters over a small area to measure movement. This information could then be used to weight model recreation activity in the intertidal zone, where intensity can be increased within popular, well visited sections of coastline in comparison to remote, less visited areas.

Strengths

- Counts of people at exact geographic locations
- Time of activity also recorded
- Continuously recording data
- Uni-directional or bi-directional versions available

Weaknesses

- Can't guaranteed complete security of the boxes from theft/vandalism
- Very costly method due to the large number of units required
- Cannot provide any information on where individual go once within the intertidal zone

Table 8: Assessment of the suitability of Automatic people counters for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Limited to the number of sensors and their location	Low
Spatial Accuracy	Very high at the access point in question	High
Temporal Coverage	Time of counts are measured	Very High
Frequency of collection	Measures everything passing by	Very High
Availability	Blank	Yes
Cost	Substantial volume of units will be needed. Prices in the region of £500 - £1,000 (+/-) per unit (including posts)	Less than £100,000
Usefulness	Effective in counting people entering a coastal area	Medium

Figure 14: Examples of radio-beam based outdoor people counters manufactured by Chambers electronic.

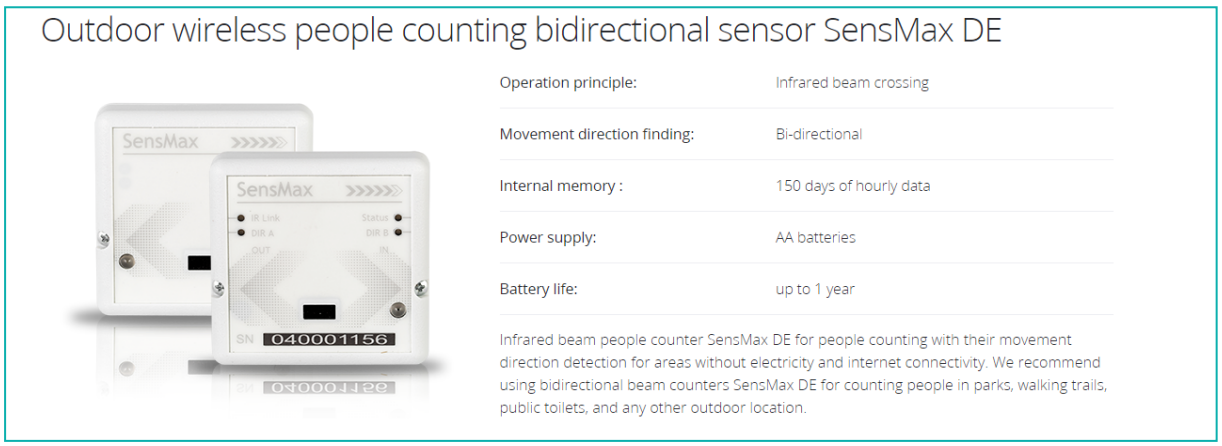


Figure 15: Example of infrared-beam based outdoor people counters manufactured by SenseMax.

2.3.9 Video counting

Datasets

- Camera and machine learning technology

Ownership

- Tracsis

What is it?

- Tracsis is one of a number of companies that offer a vision based survey which uses an intelligent camera solution and machine learning technology. This allows different objects to be identified and classified in a video feed, including people. The tracking software provides a live path (available as longitude/latitude coordinates) of an individual detected. If multiple camera sensors are located in an area, these operate individually and not together so there is a risk of double counting.

- The units require a connection to a power source to operate. Alternatively, smart poles are available which is an off grid power solution that provides secure reliable remote power. These cost <£10,000 each and have a 10 year guarantee.

Why was it collected?

- This technology has been developed to count and track the movements of individuals.

How it could be used?

- Vision based surveys could be undertaken on selected intertidal locations around the Welsh coast. Carefully located cameras could be used to record which parts of the intertidal zone are visited by beach users. Costs are high, however, so a targeted approach would be most appropriate, focusing on areas of highest sensitivity and or highest footfall, or locations where findings could be used to calibrate modelled activity patterns elsewhere.

Strengths

- Can count people on the intertidal zone rather than just those passing access points

- Can provide tracks which show where the person has gone (within a limited area)

Weaknesses

- Cannot identify people from beyond ~70m as camera loses visible features which distinguish a person

- Double counting of individuals is possible if picked up on multiple cameras
- Varying capability to differentiate between types of visitor / activity
- Equipment could be conspicuous in coastal setting and vulnerable to vandalism

Table 9: Assessment of the suitability of Video counting of people using machine learning and video for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Can locate people ~70m away from a ~20m high camera	Medium
Spatial Accuracy	Detection locations provided as latitude/longitude coordinates	High
Temporal Coverage	Blank	Very High
Frequency of collection	Blank	Very High
Availability	Blank	Yes
Cost	Initial cost per unit less than £5,000 (including sensor purchase, installation and data portal) Subsequent yearly cost less than £1,000 (maintenance of sensor, portal licence and data support)	Less than £100,000
Usefulness	As well as measuring counts it could measure where people go within a small area of the intertidal zone. Impractical for large areas.	Medium

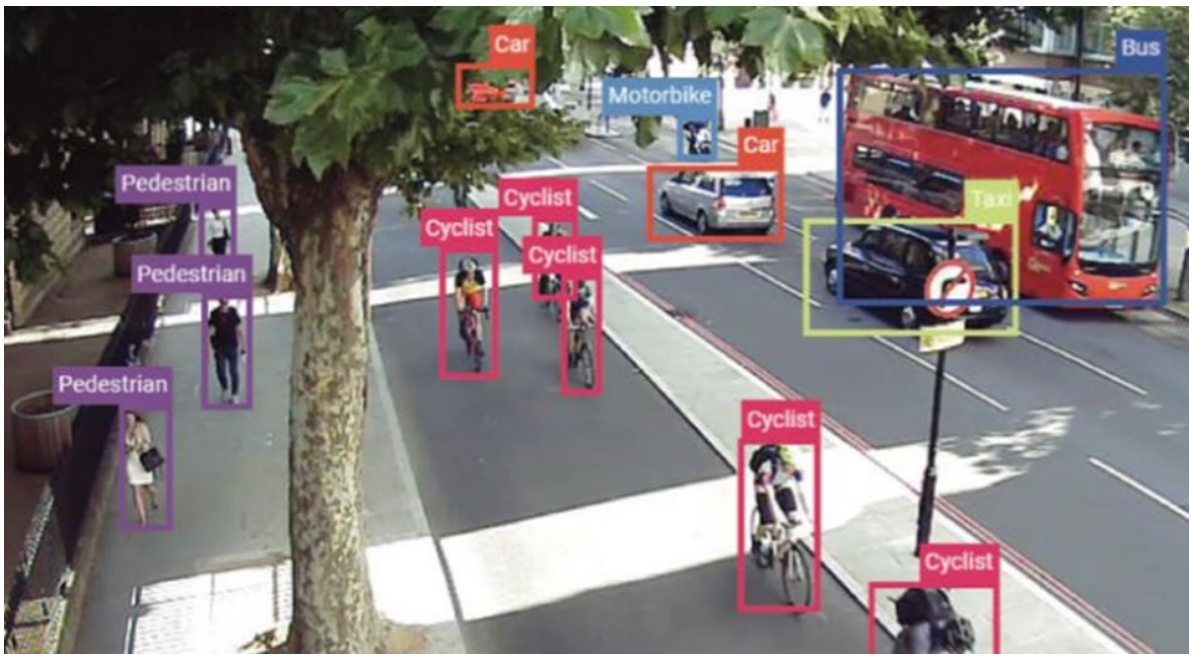


Figure 16: Example of how the machine learning system identifies pedestrians different road users on a busy urban street.

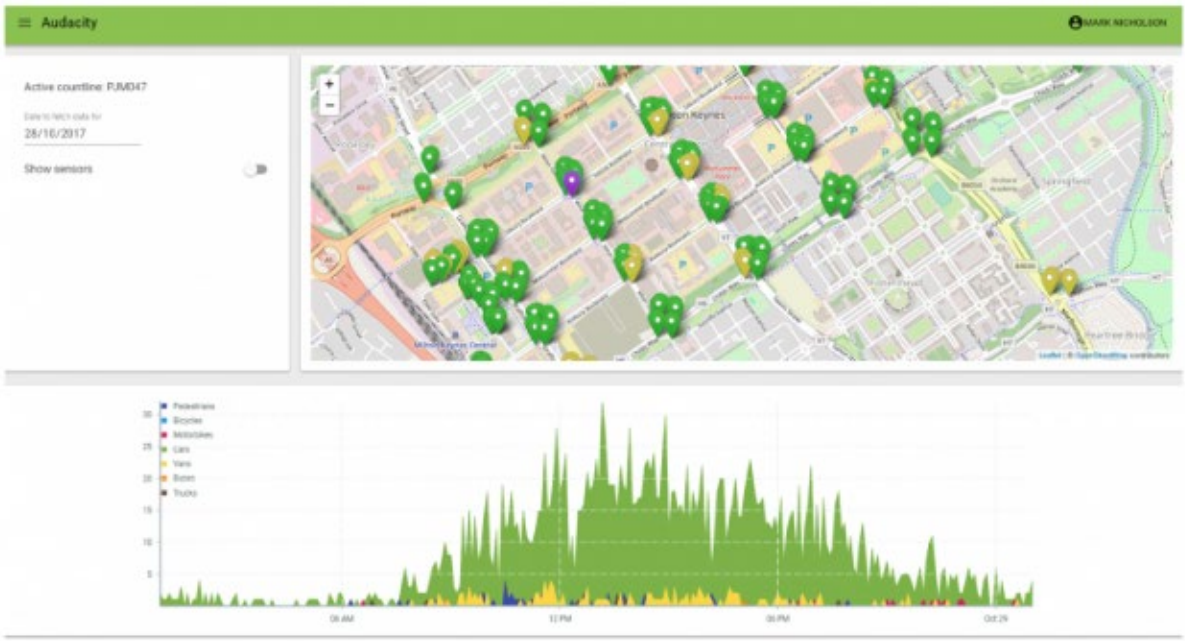


Figure 17: Example output of the video counting system from Tracsis, identifying relative position on a map as well as displaying data visualisations of types of road users.

2.3.10 Travel time catchments and Population Census data from National Statistics

Datasets

- Drive time catchments

Ownership

- iGeolise, National Statistics, ArcGIS network analyst

What is it?

- iGeolise own TravelTime platform, a travel and mapping software which draws time travel maps and produces drive time catchment data. These travel times can be calculated for roads, walking, cycling or public transport routes from a user specified location and time of day. The model takes into account average speeds and factors in common delays including traffic lights, roundabouts and switching platforms in a station.

- The travel time catchments can also be calculated with network analysis and display in GIS software for example ArcGIS Network Analyst.

- Section 2.3.15 Outdoor Recreation Valuation Tool (ORVal) describes a similar approach that uses travel times as a parameter to calculate visitor numbers. It is possible that if ORVal was used no further travel time data would be required.

Why was it collected?

- This kind of software has been developed to assist transport planning and to inform market appraisals for developments such as retailing.

How it could be used?

- Drive time and Walking time data could be combined with Population Census data from National Statistics to indicate populations within drive/walk time to a beach.

- Drive time analysis could be used at a strategic scale to assess the likely level of recreation activity based on the number of people living within a given distance. This reflects the likelihood that activity levels on beaches are likely to be higher in areas accessible to larger population centres (e.g. Cardiff, Swansea or the conurbations of north west England).

- Walk time analysis could be used at a local scale to model the influence of proximity to a settlement on the level of activity on a given beach. This reflects the likelihood that activity levels will be higher closer to settlements – whether for visitors or residents.

Strengths

- Calculate journey times from many origins at specified times of day
- Accurate travel times based on road, public transport and footpath routes rather than the ‘as the crow flies’ method
- Possible using travel time areas to calculate roughly resident populations using free National Statistics data

Weaknesses

- Smallest areas of National Statistics units (LSOA) can cover broad rural areas and might result in overestimations of population within walk times. Less of an issue for drive times.

Table 10: Assessment of the suitability of travel time maps and census data for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Blank	High
Spatial Accuracy	Blank	Medium
Temporal Coverage	Blank	High
Frequency of collection	Analysis as required	Blank
Availability	Blank	Yes
Cost	**iGeolise** – Less than £500 setup fee; plus a cost per travel time area for over 100 + VAT (see website for details)	Less than £10,000
Usefulness	Could help estimate overall visitor numbers	High

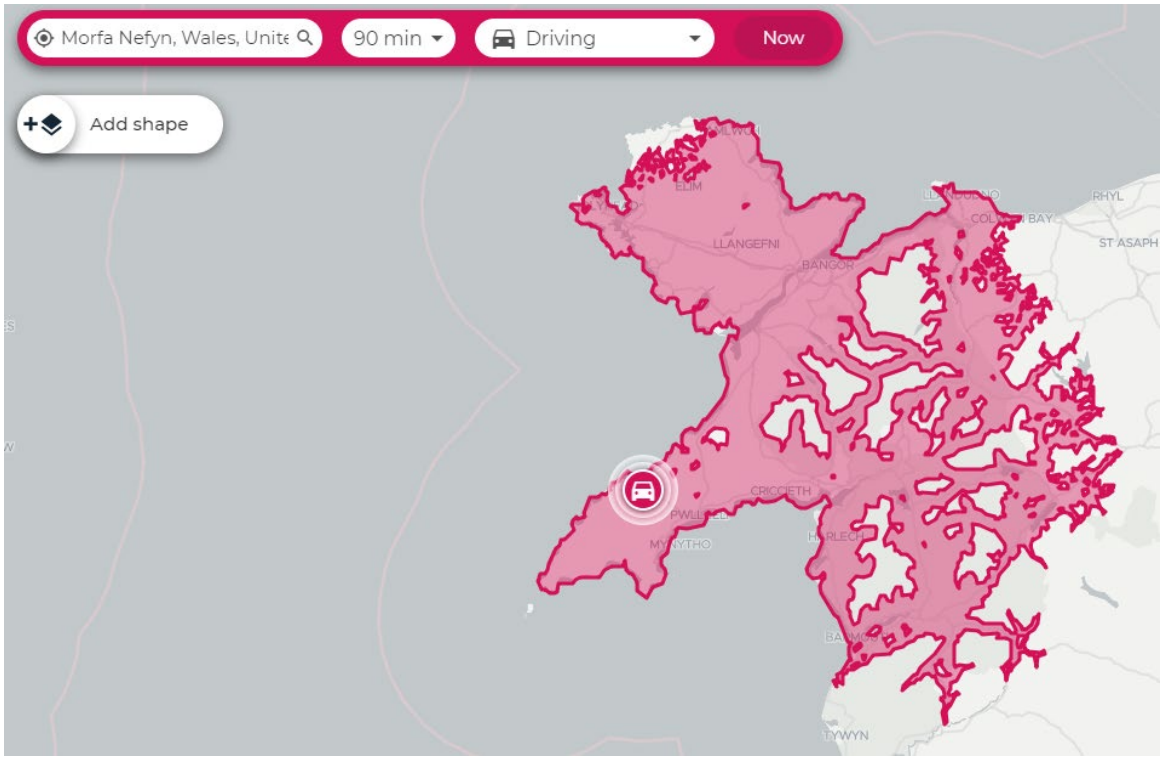


Figure 18: Example of 1.5 hour drive time from Morfa Nefyn. © iGeolise

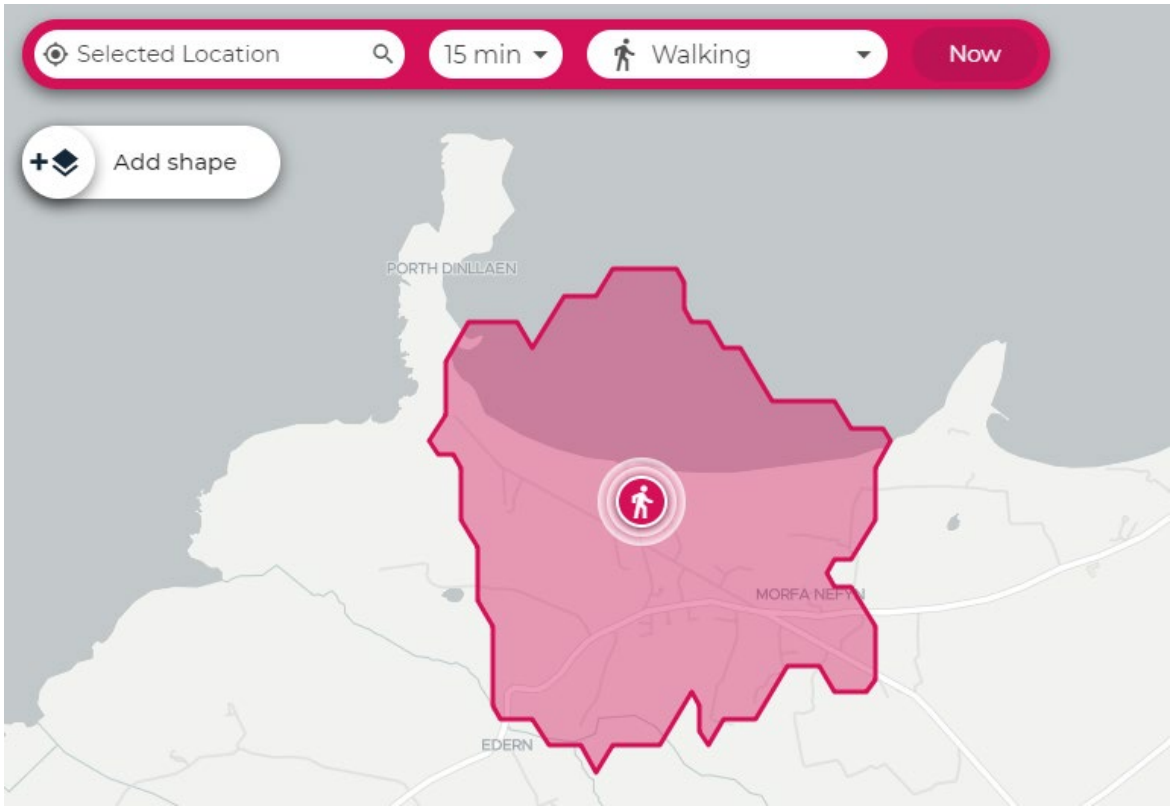


Figure 19: Example of 15 minute walk time from Morfa Nefyn beach. © iGeolise

2.3.11 Survey – online questionnaire with interactive mapping

Dataset

- Online spatial survey from Survey 123

Ownership

- ESRI

What is it?

- Some online spatial surveys have the capability to use interactive web maps to collect spatial information from online respondents. An example of this is using Survey123 for ArcGIS - a form-centric data collection app which allows web map questions to be embedded into a larger survey.

Why was it collected?

- The team drew on their inspiration from designing and analysing the 2015 Scottish Marine Recreation and Tourism Survey. This survey allowed over 50,000 items of spatial information to be collected on where they had undertaken different activities around the Scottish coastline.

- This highlighted the vast amount of spatial information which can be obtained from surveys of this nature which can then be analysed and used to inform decision making.

How it could be used?

- An online interactive web map survey has the potential to gather new spatial information from recreation users. Having selected a beach they had visited in the past year (or other period), respondents would be presented with a zoomable map onto which they could plot the routes they had followed and the activities they had undertaken. Composite maps can be generated showing all the routes followed by respondents, or heatmaps representing the locations where activity is most intense.

- Key challenges include ensuring that people are able to input locations accurately (which can be difficult where people rely on memory and there is a lack of features on the base map) and achieving a sufficiently large sample to provide good information for remoter or less visited beaches.

- Piloting the approach to compare actual data with input data could help test the first of these issues.

- Achieving a good sample could be made easier by piggy-backing onto existing surveys, by an extensive publicity / social media campaign and by using incentives such as prize draws to encourage participation.

- Given the potential to embed this spatial mapping within a larger recreation survey, there would be potential to develop a partnership approach involving

other parts of NRW, Welsh Government, local authorities and sector representatives.

Strengths

- New spatial information from a large area can be captured
- A range of recreational activities can be added
- More detailed information can be obtained on why people are in particular areas

Weaknesses

- Requires input from public where response rates can't be guaranteed
- Limited by mapping ability of respondents which could reduce spatial accuracy
- Limited by the type of user who engage with these crowd sourcing questionnaires

Table 11: Assessment of the suitability of online questionnaires with interactive mapping for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Blank	High
Spatial Accuracy	Subject to design of the interactive mapping tool and piloting to compare 'actual' with respondents' entered data	Medium
Temporal Coverage	Blank	Low
Frequency of collection	Blank	Low
Availability	Blank	Yes
Cost	Blank	Medium Less than £100,000
Usefulness	Blank	Medium

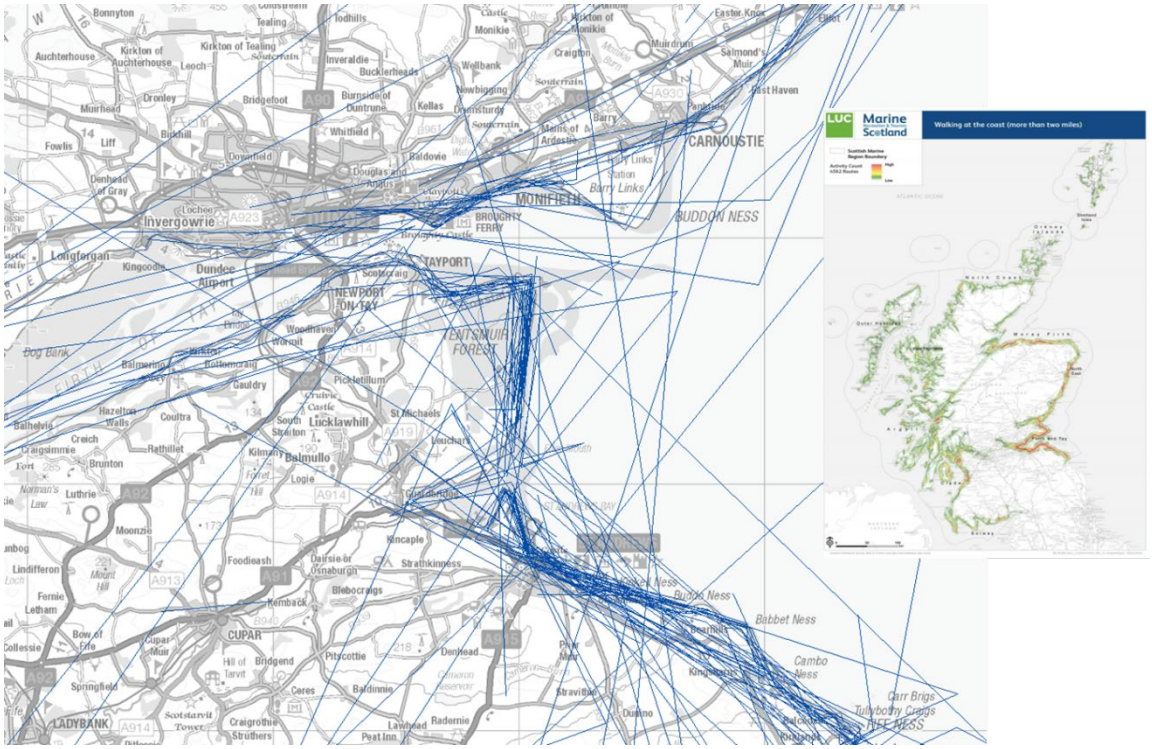


Figure 20: Example of an interactive web map generated form online surveys. Shown is the Scottish Marine Tourism and Recreation Survey. Contains Ordnance Survey data © Crown copyright and database right 2017.

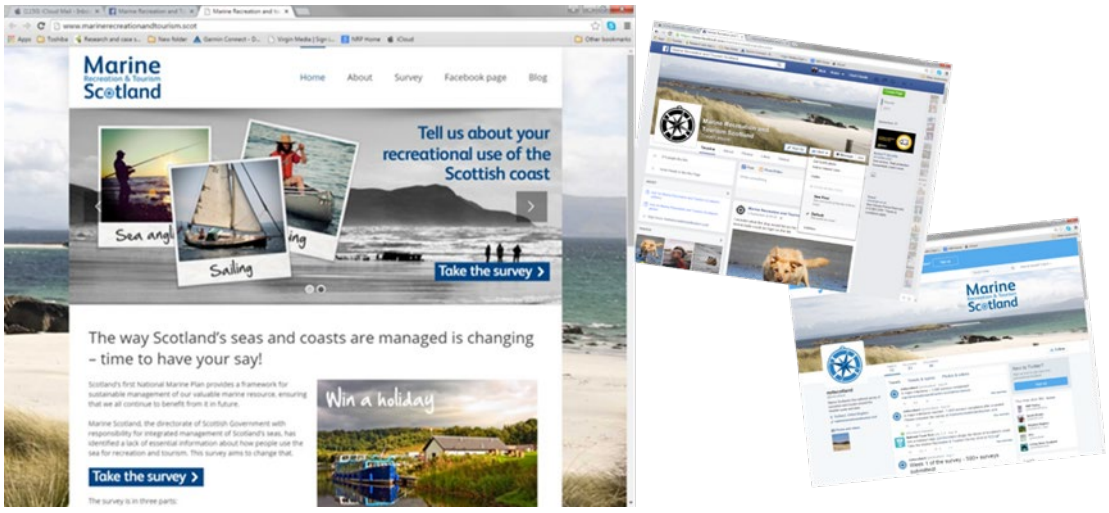


Figure 21: Screenshots of the main web page of Marine Scotland and the associated social media pages where the public can find links to the survey shown in Figure 20.

2.3.12 Wales Activity mapping

Datasets

- Wales Activity Mapping (WAM) project

Ownership

- Pembrokeshire Coastal Forum

What is it?

- The Wales Activity mapping project is focused on the south west Wales coastline and aims to study the type, amount and distribution of activities there.
- They use a GIS mapping system to display the data collected which covers a large variety of spatial data. This includes land, water and boat based activities alongside site infrastructure and conservation layers amongst others.
- Although the project is currently confined to the south west coastline, there is great scope for the project to be extended beyond here and display a wider range of information.

Why was it collected?

- The Wales Activity Mapping project provides an understanding of key coastal recreation activities along the south-west Welsh coast. This data source is a useful indication of the scale and distribution of recreation activities.

How it could be used?

- This source can aid in the identification of locations where particular recreation activities are undertaken and the frequency of these.

Strengths

- Wide range of spatial information displayed
- Information on the distribution of activities

Weaknesses

- Only covers south-west Wales

Table 12: Assessment of the suitability of Wales Activity Mapping Project data for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Blank	Medium
Spatial Accuracy	Blank	High
Temporal Coverage	Blank	n/a
Frequency of collection	Currently undergoing an update and the gap between data collection points has been 10 years.	Low
Availability	Blank	Yes
Cost	Blank	£0
Usefulness	Blank	Medium

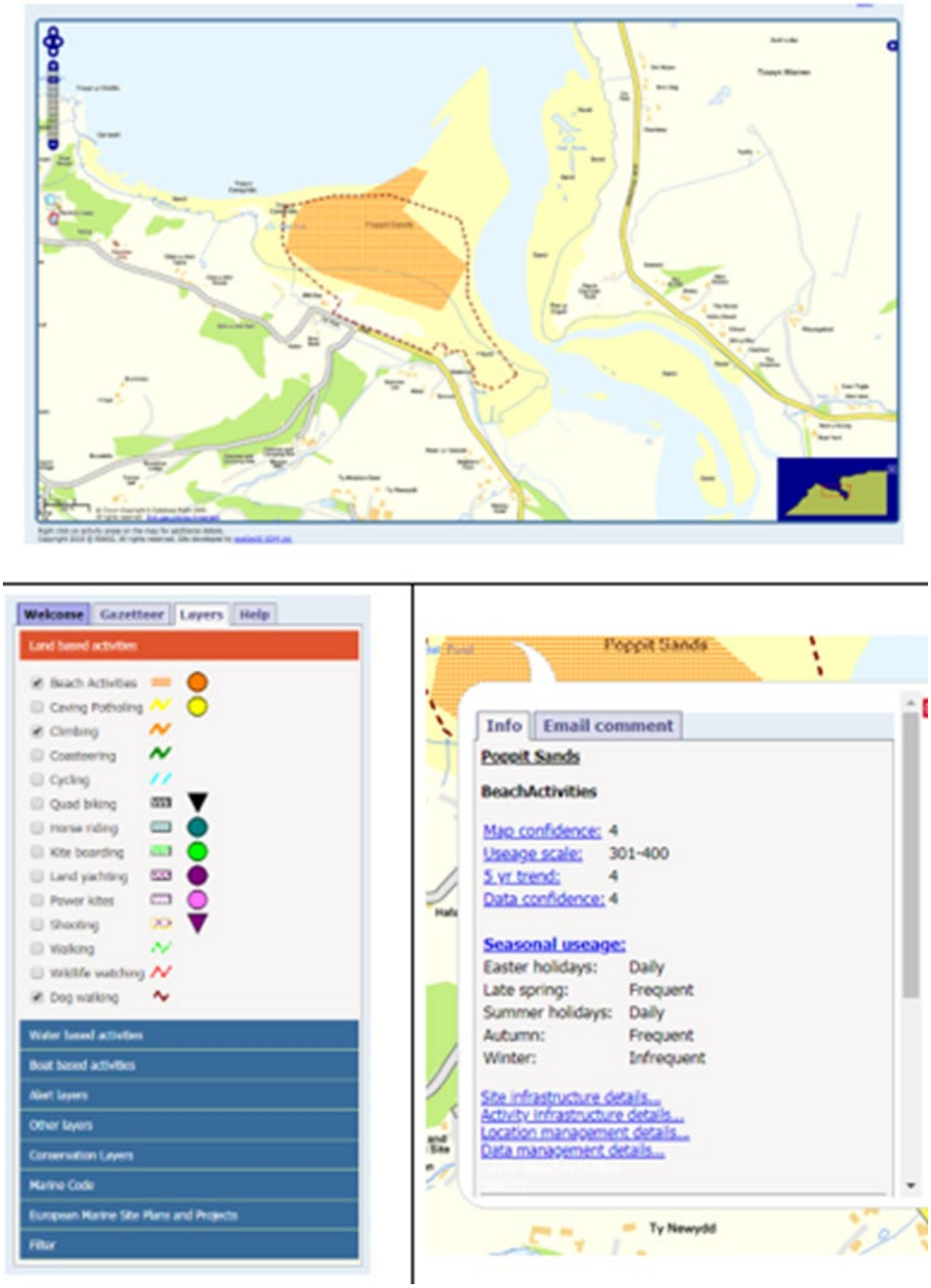


Figure 22: Screenshots of the Wales Activity Mapping GIS web tool. Copyright 2010 © RAWG

2.3.13 Georeferenced photos

Datasets

- Photographs

Ownership

- Geograph, Google

What is it?

- Geograph is a web-based project with an abundance of freely available georeferenced photos across the UK & Ireland. This Ordnance Survey sponsored project encourages the public to upload photos and in doing so, contributing to covering every grid square of the country with photos.
- Google Earth photos is a layer available to view in Google Earth software. This displays geotagged photos submitted by Google account users.
- It is possible that photos published on social media platforms such as Facebook, Twitter, Flickr and Instagram could provide a further indication of the relative importance of different beaches, though there are likely to be privacy issues while the specific location of photographs may be difficult to ascertain accurately.

Why was it collected?

- Due to the volume of freely accessible georeferenced photos online, it may be possible to use these as a source for activity levels on different intertidal zones. Alongside this, popularity of different areas could be inferred based on the number of photos in an area.

How it could be used?

- The relatively small numbers of georeferenced photographs uploaded to Geograph and Google Earth, this data source is unlikely to provide sufficient information to map or predict activity within the intertidal zone.
- There is potential, however, to use the density of photos to identify the relative importance of different parts of the coastline for recreation, informing the weighting of predictions for different locations.

Strengths

- Free source of photographs
- Spatial coverage is good

Weaknesses

- Content is not always relevant to the location

- Insufficient numbers of photos to accurately record activity across the intertidal zone.

Table 13: Assessment of the suitability of georeferenced photos for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Blank	High
Spatial Accuracy	Blank	Low
Temporal Coverage	Blank	Low
Frequency of collection	Blank	Medium
Availability	Blank	Yes
Cost	Blank	£0
Usefulness	Blank	Low

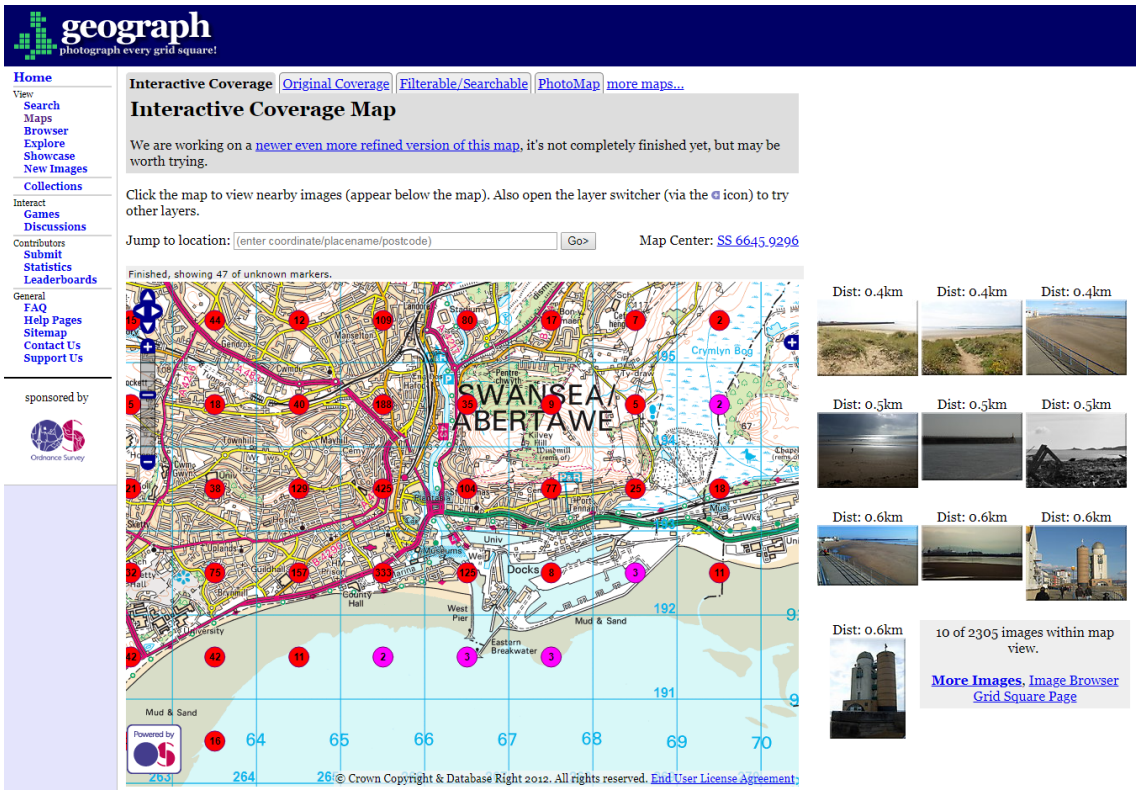


Figure 23: A screenshot from the Geograph website.

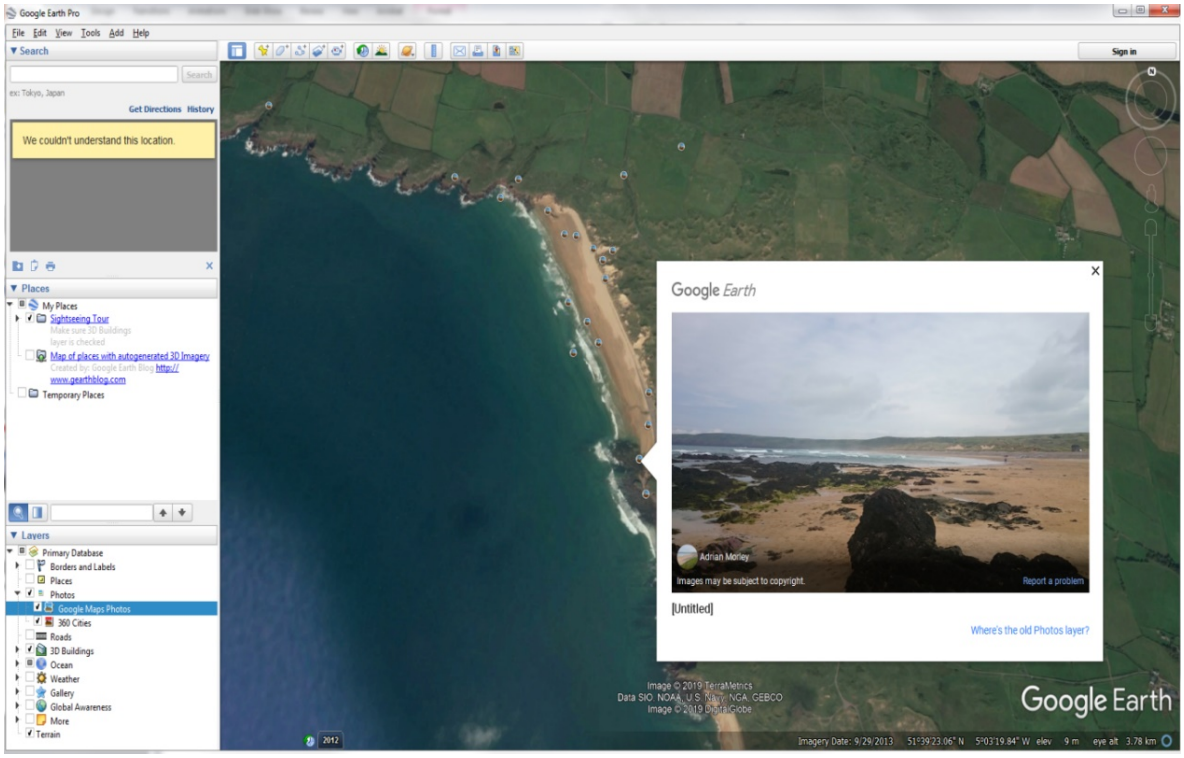


Figure 24: An example of a georeferenced photo on the Google Earth platform. © Google Earth. Image © Digital Globe

2.3.14 Activity logbook data

Dataset(s)

- Capturing our Coast; UK climbing website

Ownership

- Capturing our Coast; UK climbing

What is it?

- Capturing our Coast is a nationwide project which allows individuals to get involved in marine biodiversity and record where they have completed fieldwork. The project aims to recruit volunteers to collect data across the UK coasts and in doing so contribute to the knowledge and protection of our marine areas. This in turn, can build a more accurate picture of marine life all around the UK.

- Climbers can note where they have been climbing around the Welsh Coast using UK climbing's (UKC) spatial logbook. Within this, they are able to record locations, photographs, and details of climbs including the date.

- Other activity systems exist, such as the Mountain Training online logbook system

Why was it collected?

- Web-based activity logbooks provide the opportunity to view spatially accurate data, recorded by niche users who are passionate about their hobbies.

How it could be used?

- As these examples show, online activity log books are biased towards specific activities and therefore don't reflect the wider pattern of activity on intertidal zones. They can be used however, to help build a picture of activity along the coastline.

Strengths

- Ongoing projects so new data anticipated

- Almost all climbing venues in Wales in recorded on UKC

- As well as climbing locations the popularity of locations can be found by number of logbook entries

Weaknesses

- Biased towards niche areas

- Can’t rely on volume of data along the Welsh coast specifically

Table 14: Assessment of the suitability of activity logbook data for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	Blank	Medium
Spatial Accuracy	Blank	High
Temporal Coverage	Blank	Medium
Frequency of collection	Blank	Medium
Availability	Blank	Yes
Cost	Annual logbooks and entire climbing sites along the Welsh coastline	Less than £500
Usefulness	Blank	Medium

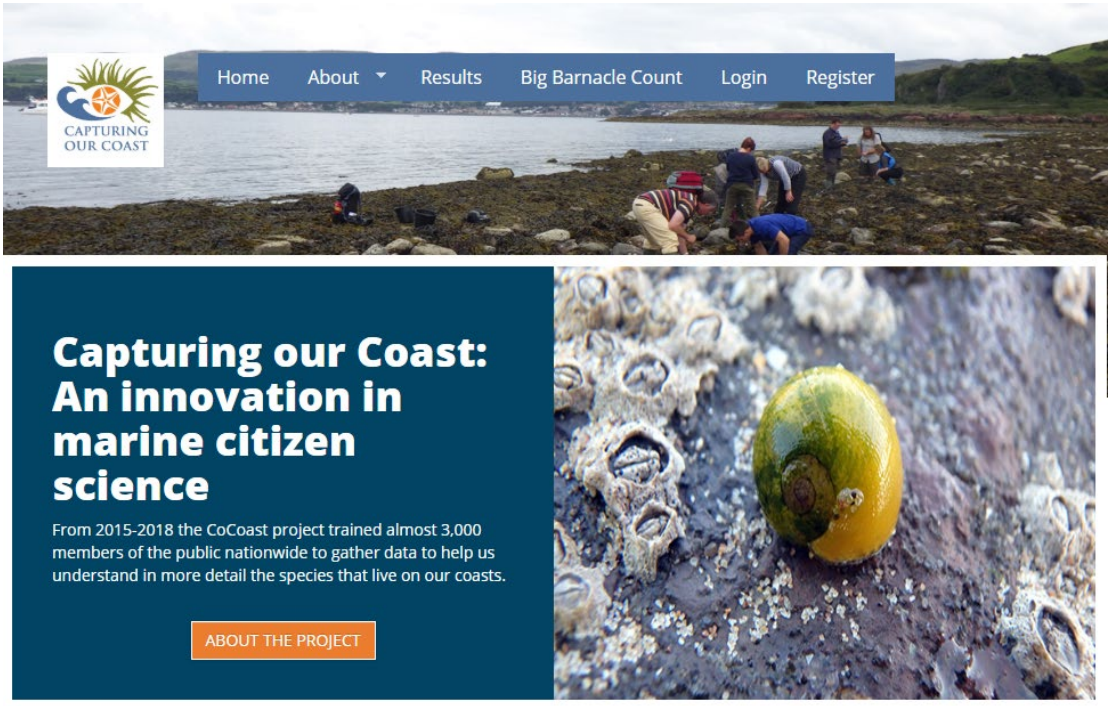


Figure 25: The homepage of the ‘Capturing our Coast’ website.

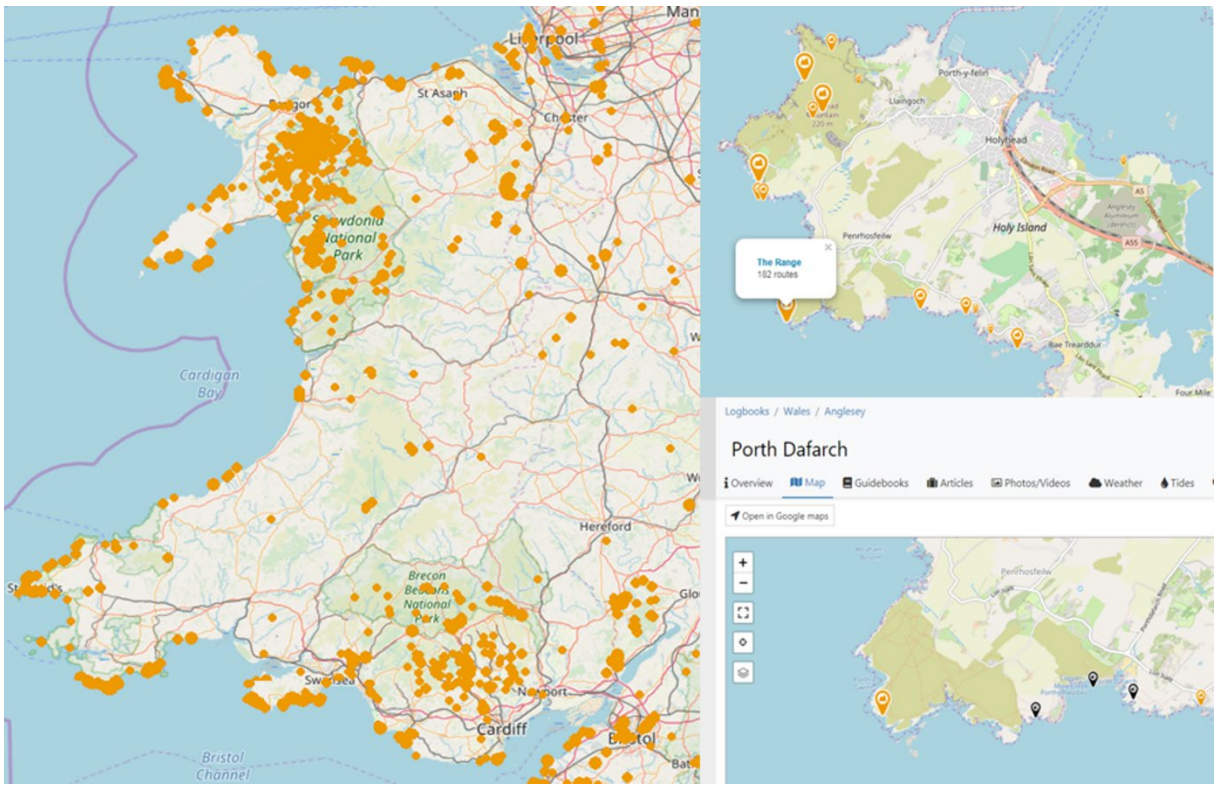


Figure 26: Data from UK Climbing's online Spatial Activity logbook and web tool.

2.3.15 Outdoor Recreation Valuation Tool (ORVal)

Datasets

- Online model used to make estimates of visitor numbers (and welfare values) of sites for England and Wales

Ownership

- Land, Environment, Economics and Policy Institute (LEEP) at The University of Exeter

What is it?

- Rule based model to estimate visitor numbers for new and existing greenspaces for England and Wales. It has an online webmap interface (and accompanying documentation) enabling users to either draw an area on the online map or to select existing AONBs, National Parks and other existing green spaces as the area to get estimates from. It uses data such as paths and road network which are used to calculate travel times, landcover, POI and designations to calculate the output figures.

Why was it collected?

- ORVal was set up to provide a full working model that could predict recreational welfare values that functioned at the scale of England and Wales.

How it could be used?

- It has the potential to be used as the rule based model. To do so it would involve contact and further work alongside the developers of this model.

Strengths

- An existing, rules based model that would be able to make estimates on numbers of visitors.

Weaknesses

- Not designed specifically for coastal regions so does not include features such as Biotopes or coastal environment sensitivity

- An online tool that is useful for a small number of sites but would require development to work with this project

Table 15: Assessment of the suitability of Outdoor Recreation Valuation Tool (ORVal) for determining foot access intensity in intertidal zones.

Component	Comment	Rating
Spatial Coverage	England and Wales coverage	High
Spatial Accuracy	Possible to create small areas for study	High
Temporal Coverage	Blank	n/a
Frequency of collection	Blank	n/a
Availability	Feely available to use existing version online	n/a
Cost	Free if no further development is required	£0
Usefulness	Would require further development to become very useful	n/a

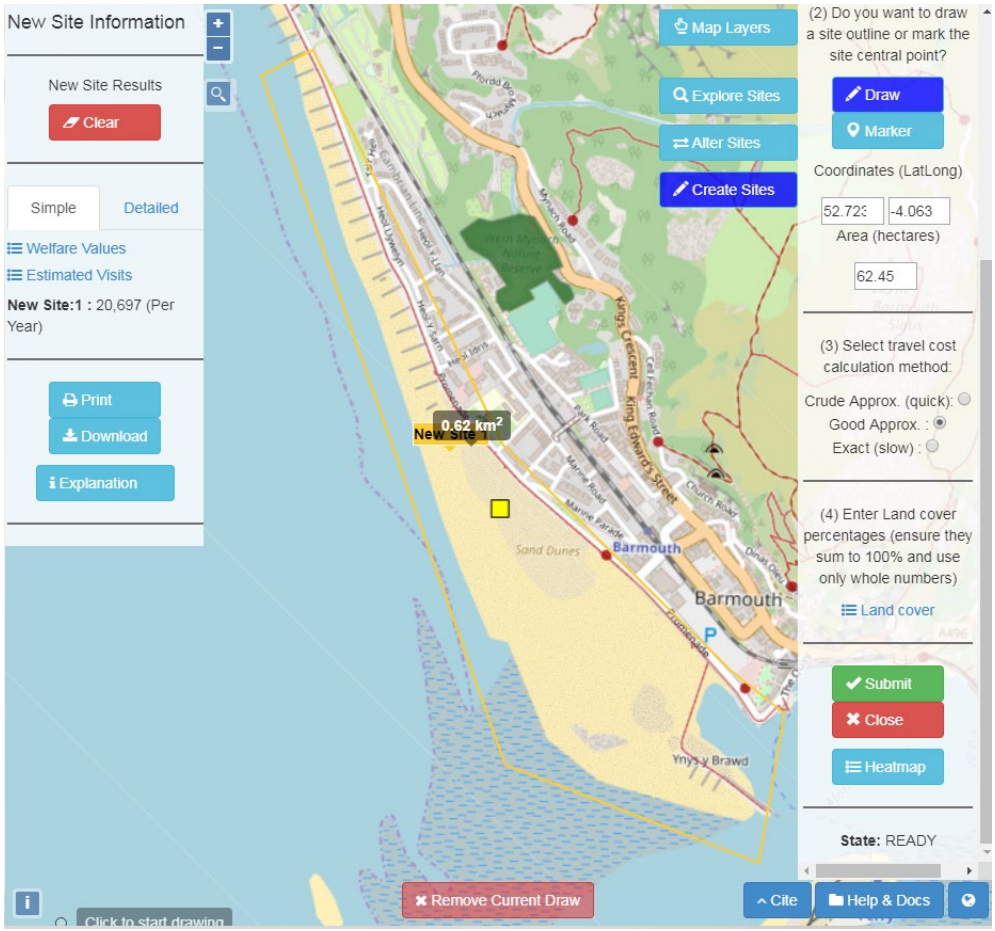


Figure 27: Screenshot of the ORVal dashboard, showing estimated visits based on site drawn at Barmouth beach. © OpenStreetMap

3. Literature Review

3.1. Introduction

This part of the report sets out the findings from a literature review that was undertaken in parallel with the review of spatial data reported in the previous section. The literature review was broad in scope, including published national and regional recreation surveys, studies of recreation activity in ecologically sensitive locations, academic research into visitor behaviour at the coast and visitor information on Welsh beaches.

3.2. Aims

The aim was to identify published information which could be used to develop an approach to mapping or predicting the intensity of recreation activity within the Welsh intertidal zone. This could include information to identify or predict the relative levels of activity on different beaches, information to profile visitors using intertidal areas (e.g. visitors or locals, with or without dogs, distance walked etc.) or behavioural information which could be used to predict where activity within the intertidal zone is likely to be most intense.

3.3. Overview of Findings

3.3.1. National Surveys

Welsh Outdoor Recreation Survey / National Survey for Wales

The Welsh Outdoor Recreation Survey was carried out every three years up until 2015 after which date it was subsumed within the wider National Survey for Wales.

The Outdoor Recreation Survey was based on a telephone survey of around 6000 people from across Wales. The survey explored aspects such as the type and frequency of recreation activity, the types of places visited and the characteristics of the respondent. The results are presented at a national level and provide an overall indication of the levels of participation in recreation activity, the split between coastal and non-coastal destinations and the types of recreation activity undertaken. It is not possible to undertake more detailed cross tabulation for example to focus in on only those activities undertaken in a coastal setting. It is understood that participants were also asked to name the place they had last visited. This may provide an indication of the relative importance of different coastal destinations, though the proportion of the 6000 that were at the coast is unknown.

The outdoor recreation survey has been incorporated into the National Survey for Wales. This is based on a survey of 11,000 people and is run throughout the year across the whole of Wales. It provides information on the types of places visits, the frequency of visit and the types of activity undertaken. Some limited cross-tabulation is possible (e.g. reasons for visiting the outdoors × type of place last visited). More detailed spatial information on places visited is not collected.

It is concluded that, unless spatial information can be extracted from the 2014 findings, these surveys, whilst providing contextual information, are of limited use in developing a better understanding of recreation within the Welsh intertidal zone.

Example outputs from the National Survey for Wales

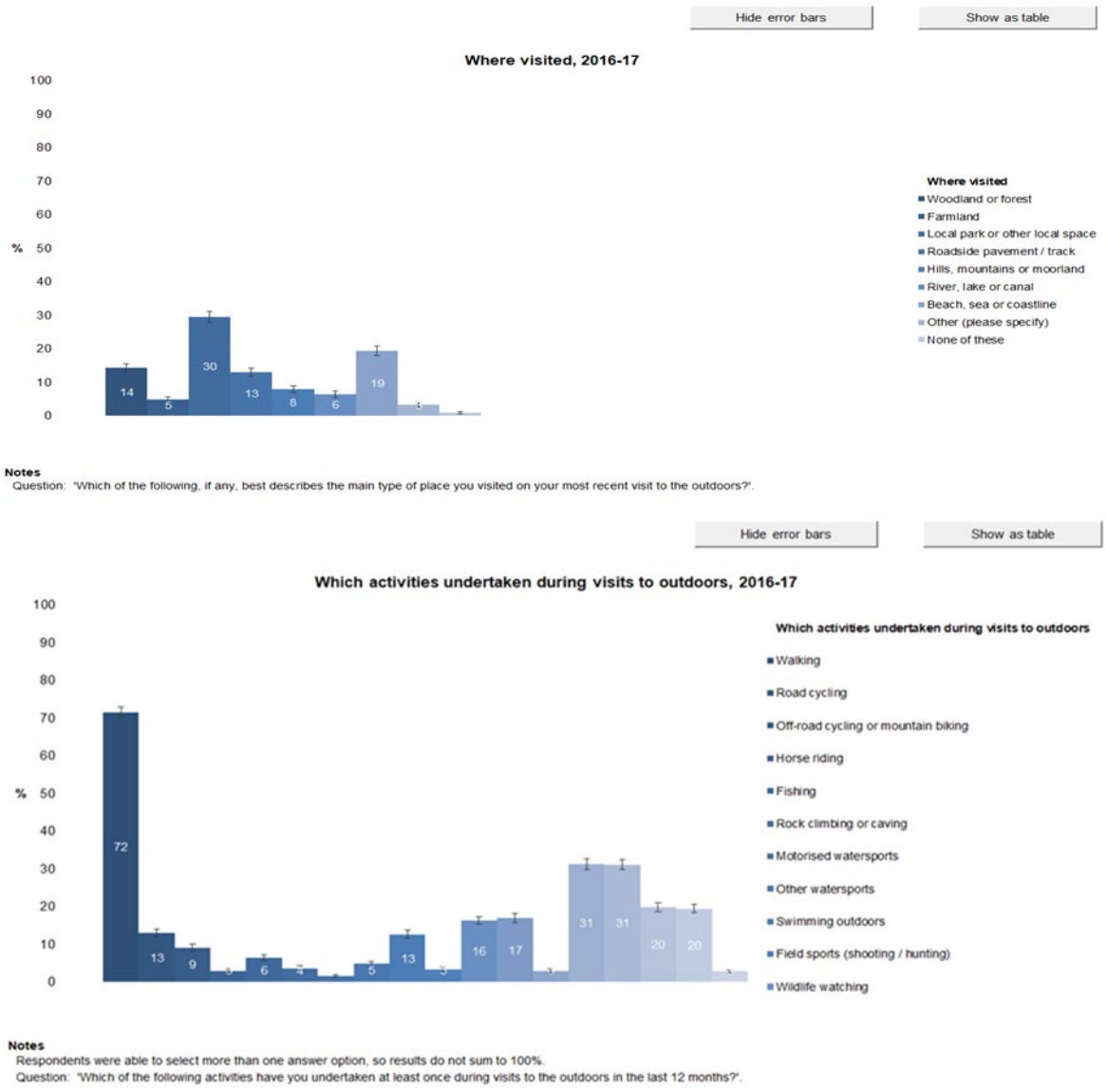


Figure 28: Example outputs from the National Survey for Wales, showing (top) which outdoor area types respondents most visited and (below) which activites were undertaken by visitors to the outdoors.

Natural England – Monitor of Engagement with the Natural Environment

A similar survey of recreation in England provides slightly more granular information, recording for example, the types of activity undertaken in different environmental settings, including at the coast.

The monitor also includes information on the split of visitors between resorts and other coastline, allowing some consideration of the relative intensity of activity in coastal towns compared with sections of undeveloped coast. It provides some data on variations in visits and activities between different types of coastline, between weekdays and weekends and distinguishing between visitors and local people. It provides information on the duration of visit and the type of activity being undertaken.

The survey asked people the location of their most recent recreation and found that around 10% of respondents visited either a 'beach' or other coastline. Around 44% of those visiting a beach were also dog owners. Around half of visits to the beach or coastline were made alone, around a quarter in groups of two, and the remaining 25% in larger groups.

Activities undertaken during visits to the coast (NE Monitor of engagement with the natural environment)

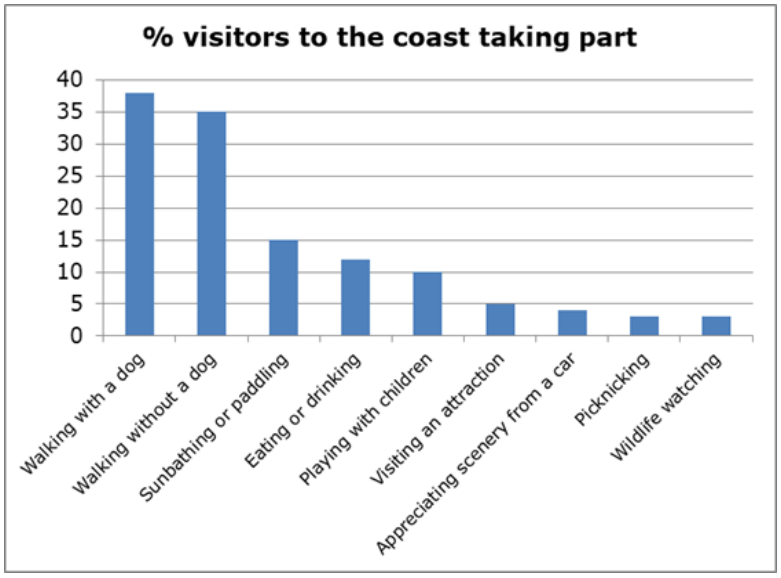


Figure 29: Activities undertaken during visits to the coast as a percentage of visitors. Data from Natural England's Monitor of Engagement with the Natural Environment.

Duration of visits to the coast (NE Monitor of engagement with the natural environment)

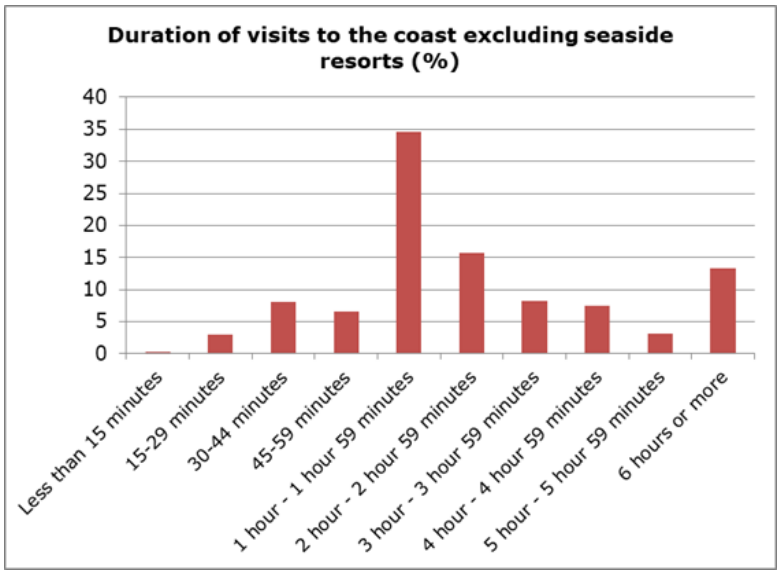


Figure 30: Duration of visits to the coast (excluding seaside resorts). Data from Natural England's Monitor of Engagement with the Natural Environment.

Similar to the Welsh national surveys, while some of this information is valuable in profiling visitors to the coast, it is of limited use in developing a better understanding of recreation within the Welsh intertidal zone itself.

3.3.2. Great Britain Day Visits Survey 2017

GBDVS 2017 was undertaken using an online methodology with a total of 35,118 interviews conducted with adults aged 16 and over who were resident in England, Scotland and Wales during 52 weekly survey waves.

The survey found that a larger proportion of tourism day visits in Wales are to the coast (17%) compared with England (8% and Scotland 2%). The survey provides a breakdown suggesting that the proportion of visits to the coast is highest in North Wales and lowest in South East Wales.

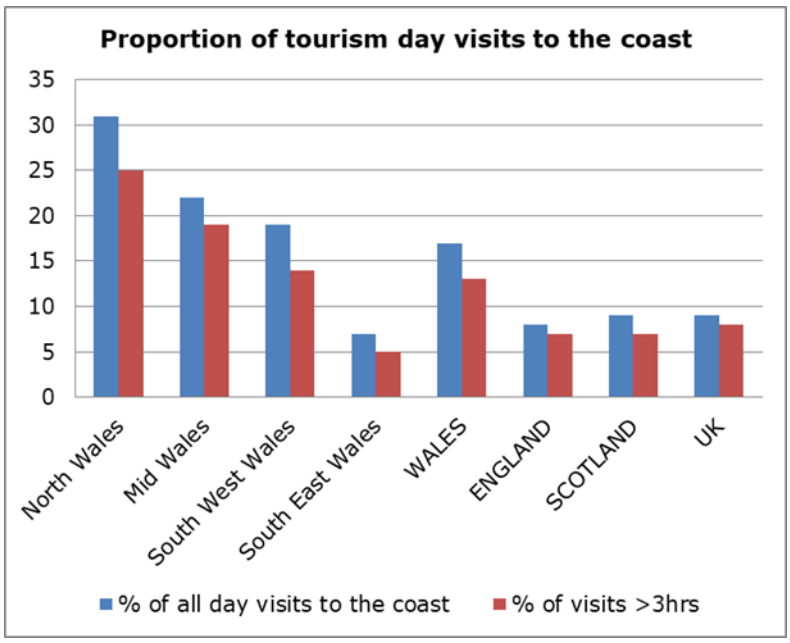


Figure 31: Proportion of tourism day visits to the coast as a percentage, broken down by area of Wales and nation of the United Kingdom.

The survey found that, for visits of three hours or longer, 13% of tourism day visits in Wales are to the coast. Again, this is higher than for other parts of the UK, but suggests that longer visits are more likely to be to the countryside or to small towns.

3.3.3. Wales Coast Path Visitor Survey 2015

Between December 2014 and January 2016 a total of 1483 people using the 870 mile Welsh Coastal Path were interviewed at 56 individual survey locations. The survey found that path users tended to be older than the population at large, with a larger proportion of people drawn from socio-economic groups ABC1 (National Readership Survey grades, now used extensively in market research; ABC1 social groups comprise people from one of the three higher social and economic groups, generally made up of people who have higher levels of education and income). The average number of people in a party was 1.9, and around 1 in 6 groups included children. Around 60% of people were day visitors and around two thirds used the path once a month or more often.

The mean length of the section of path covered by respondents was 2.9 miles (including return leg). Highest mileage covered was recorded amongst respondents using the Path along the North Coast (mean 4.3 miles), while the lowest mileage covered was recorded amongst respondents using the Path on Anglesey (mean 1.9 miles).

3.3.4. Promoted Beaches

Websites (e.g. Wales Online, Visit Wales) and guidebooks (e.g. Rough Guides, National Trust) could be used at a national or regional level to help identify those beaches where the intensity of visitor activity is likely to be most intense. This could

be used to weight any predictive model, or to focus early development and testing of the model.

"The 35 best beaches you'll find in Wales" (from Wales Online):

Aberdovey, Gwynedd; Aberporth, Ceredigion; Barafundle Bay, Pembrokeshire Barmouth; Bracelet Bay Beach, Mumbles; Broad Haven South, Pembrokeshire; Caswell Bay, Gower; Cefn Sidan, Carmarthenshire; Freshwater East, Pembrokeshire; Freshwater West, Pembrokeshire; Langland Bay, Gower; Manorbier, Pembrokeshire; Marloes Sands, Pembrokeshire; Mwnt, Ceredigion; Newgale Sands; Ogmore, Bridgend; Penbryn, Ceredigion; Poppit Sands Beach, Pembrokeshire; Port Eynon Bay, Gower; Porth Iago, Aberdaron, Gwynedd; Porthselau Beach, Pembrokeshire; Presipe, Pembrokeshire; Rest Bay, Porthcawl; Rhossili Bay, Rhossili; Saundersfoot; Skrinkle Haven, Pembrokeshire; Southerndown, Bridgend; Tenby South Beach; Three Cliffs Bay, Gower; Traeth yr Ora, Anglesey; Tresaith, Ceredigion; Tywyn, Gwynedd; Watwick Bay, Pembrokeshire; Whitesands, Pembrokeshire; Whitmore Bay, Barry Island

"Ten Brilliant beaches for families" (from Visit Wales):

Abersoch, Llyn Peninsula; Barmouth, Snowdonia Coast; Benllech, Isle of Anglesey; Broad Haven, Pembrokeshire; Caswell, Gower Peninsula; Cefn Sidan, Carmarthenshire; Llangrannog, Ceredigion; Port Eynon, Gower Peninsula; Tenby, Pembrokeshire; West Dale, Pembrokeshire

"Sand easy: 10 beaches for kids" (from Visit Wales):

Aberdaron, Llŷn Peninsula; Aberdyfi, Gwynedd; Caswell Bay, Gower; Newport, Pembrokeshire; Pendine Sands, Carmarthenshire; Porth Dafarch, Anglesey; Southerndown, Dunraven Bay; Tenby, Pembrokeshire; Tresaith, Ceredigion; Whitesands, Pembrokeshire

"21 most beautiful beaches in Wales" (from Rough Guides):

Aberdyfi (Aberdovey), Gwynedd; Aberffraw Bay, Anglesey; Barafundle Bay, Pembrokeshire; Broad Haven (St Brides Bay), Pembrokeshire; Cefn Sidan, Carmarthenshire; Dale, Pembrokeshire; Llanbedrog Beach, Gwynedd; Llanddwyn Beach, Anglesey; Llangrannog Beach, Ceredigion; Marloes Sands, Pembrokeshire; Mwnt Beach, Ceredigion; Pendine Sands, Carmarthenshire; Porthdinllaen, Gwynedd; Porthor (Oer), Gwynedd; Rest Bay, Bridgend; Rhosneigr Beach, Anglesey; Rhossili Beach; Tenby North, Pembrokeshire; Three Cliffs Bay, Swansea; Tywyn Beach, Gwynedd; Whitesands Bay, Pembrokeshire

"Best beaches in Wales" (from National Trust):

Barafundle Bay, Pembrokeshire; Broad Haven South, Pembrokeshire; Freshwater West, Pembrokeshire; Llanbedrog, Llŷn Peninsula; Marloes Sands, Pembrokeshire; Mwnt, Ceredigion; Penbryn, Ceredigion; Porth Ceiriad, Llŷn Peninsula; Porthdinllaen, Llŷn Peninsula; Porthor, Llŷn Peninsula; Rhossili Bay, Gower

3.3.5. Wales Activity Mapping

The Wales Activity Mapping project is focused on the South West Wales coastline, comprising Pembrokeshire, Carmarthenshire, Swansea, Neath Port-Talbot and Bridgend. The project is a study into the type, amount and distribution of activities carried out on the South West Wales Coastline. The project uses GIS based mapping to compile information about coastal recreation activity. Datasets include:

- Locations for 14 land based recreation activities;
- Locations for 8 water based recreation activities;
- Locations for 8 boat based recreation activities;
- Locations of ‘supply side’ infrastructure such as rights of way, slipways, moorings, car parks and areas with dog or climbing restrictions;
- Conservation designations applying along the coastline together with sensitive ecological areas.

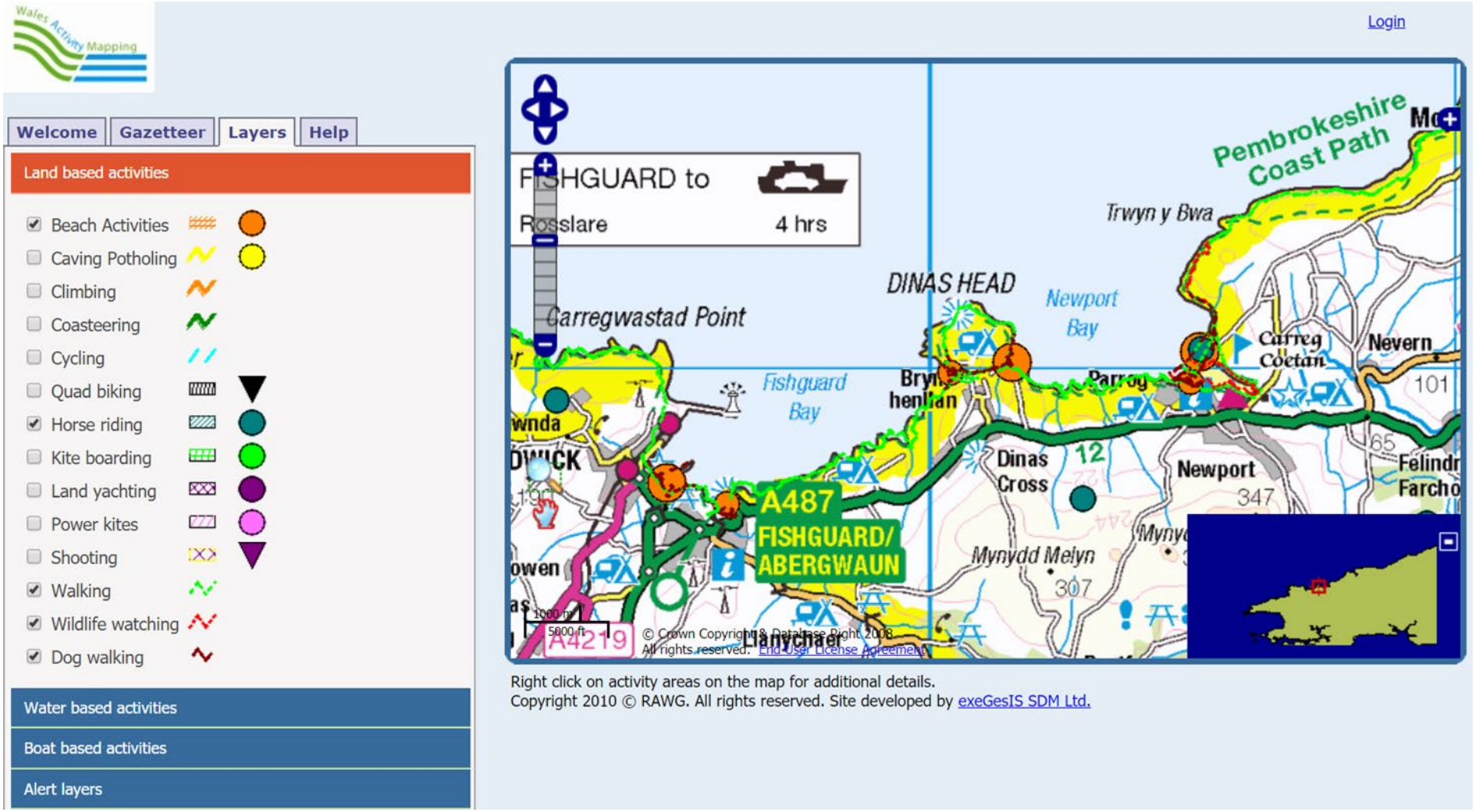


Figure 32: Wales Activity Map of land based activities – strategic view.

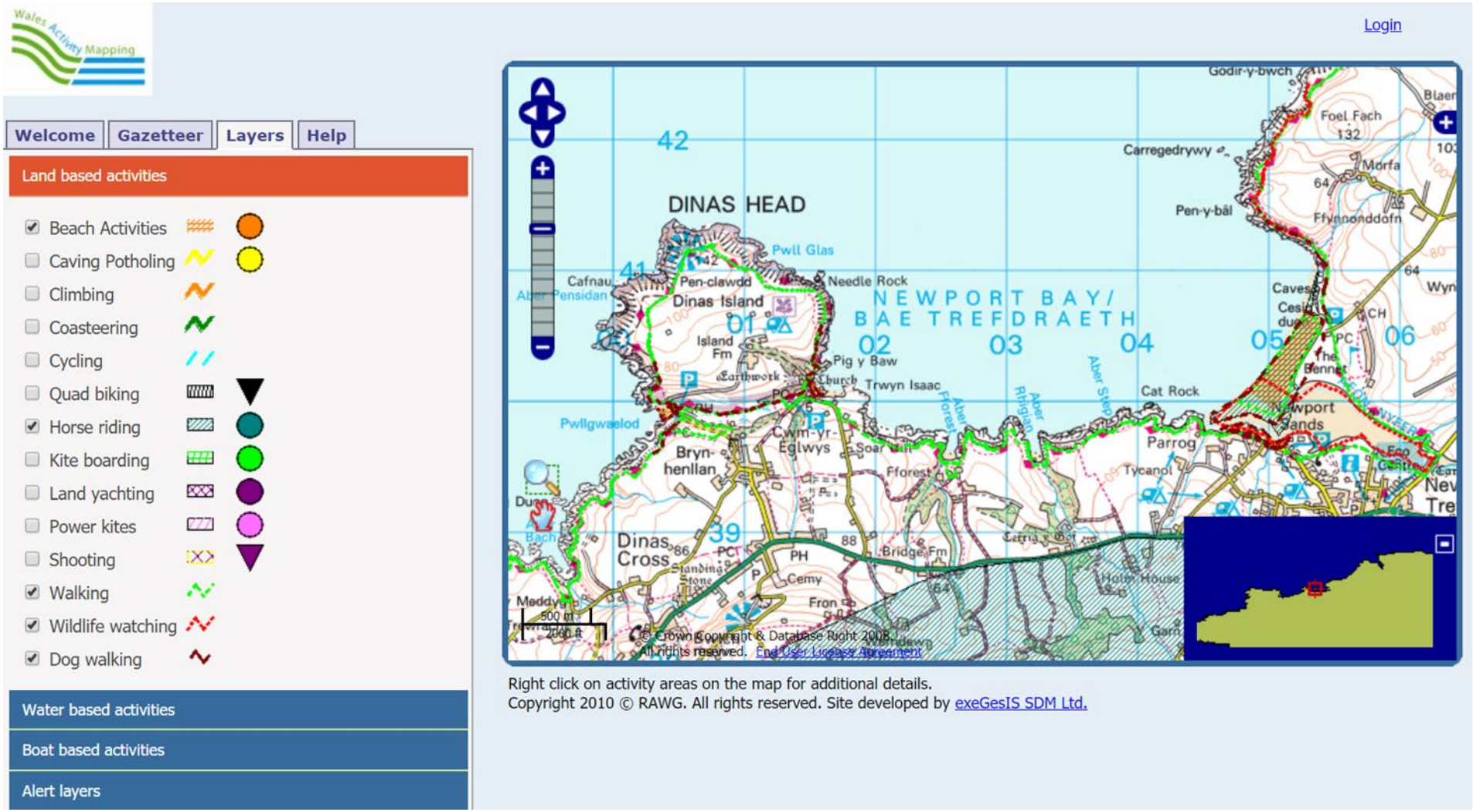


Figure 33: Wales Activity Map of land based activities – more detailed view.

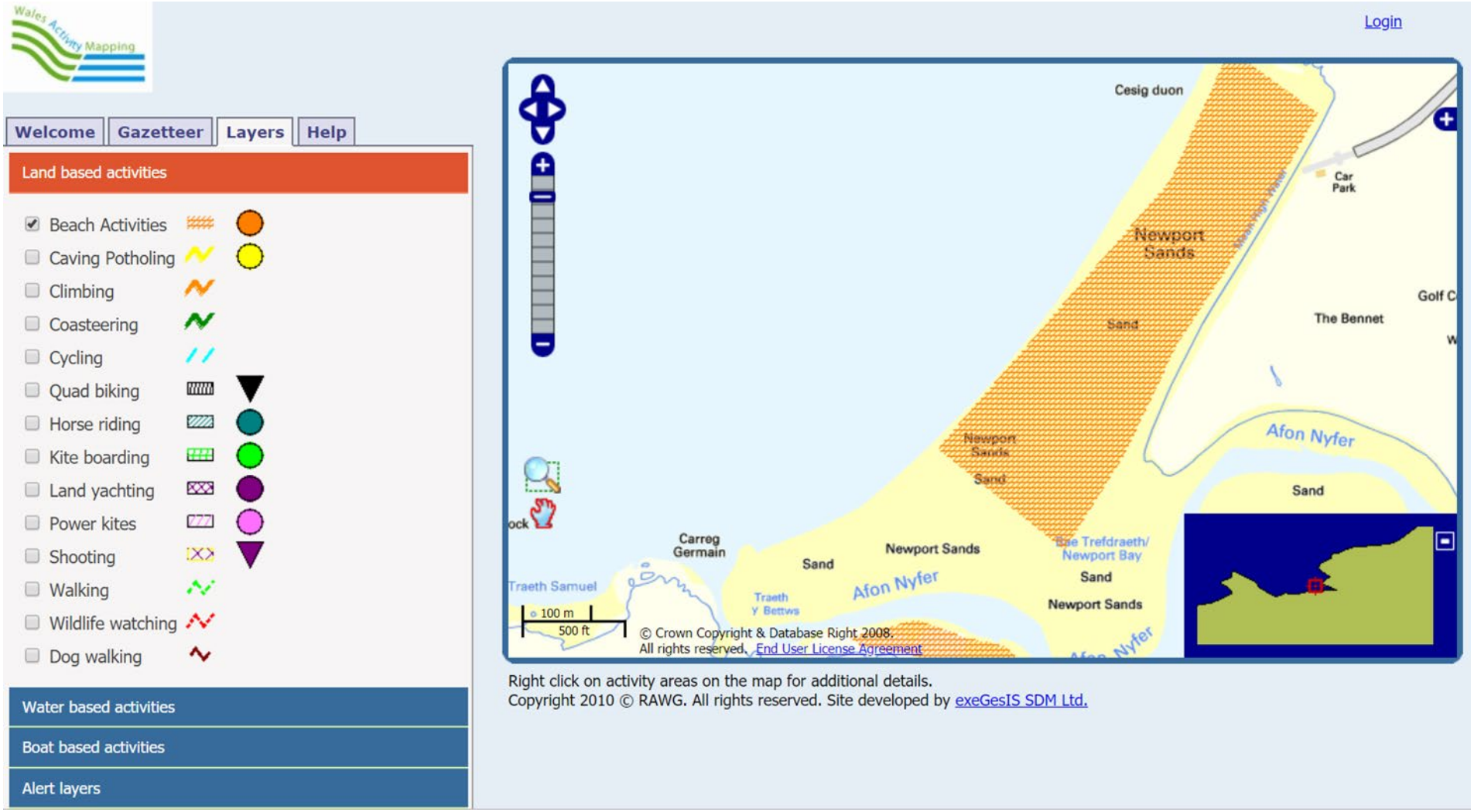


Figure 34: Wales Activity Map of land based activities – site view.

Data on the location and rates of participation for the listed activities is gathered using face to face interviews carried out with land-mangers, activity providers and other 'experts'. This data is then aggregated and combined with other site information to populate the mapping layers. It is, however, a broad scale assessment and while it locates beaches that are of recreation importance, and provides an indication of seasonal variation in use, there is little information on spatial variations in the intensity of activity within the intertidal zone. Survey data provides estimated numbers of participants at different beaches, seasonality, repeat visits, participant profile and activity trend.

The Wales Activity Mapping project could therefore provide a coarse indication of the relative levels of use of different beaches, and the locations of different activities around the coastline, but would need additional survey or modelling work to indicate those areas where recreation activity is likely to be most intense.

3.3.6. Recreation surveys at European protected sites

Surveys of recreation activity have been undertaken at several European designated wildlife sites – Special Protection Areas and Special Areas of Conservation and a number of these are in coastal locations. The aim of these surveys has been to determine baseline patterns of recreation and wildlife disturbance and to assess whether land use planning policies in the wider area could have an adverse effect on the sites' conservation interest. These studies tend to focus on coastal wetland sites rather than more popular sandy beaches. They have also been undertaken in locations which are not representative of the Welsh coastline (e.g. East Anglia, the Solent, the Wash). The surveys provide good profiling of visitors to the coast and some limited information on coastal areas where activity is concentrated.

An example, from Norfolk coastal and inland sites (Panter *et al*, 2016) illustrates the kind of information that is available. The survey here was based on observations and interviews at 40 survey points. A total of around 14,000 people were observed. Of these there were around 6,000 groups, around half of which included children and 3500 of which included one or more dogs.

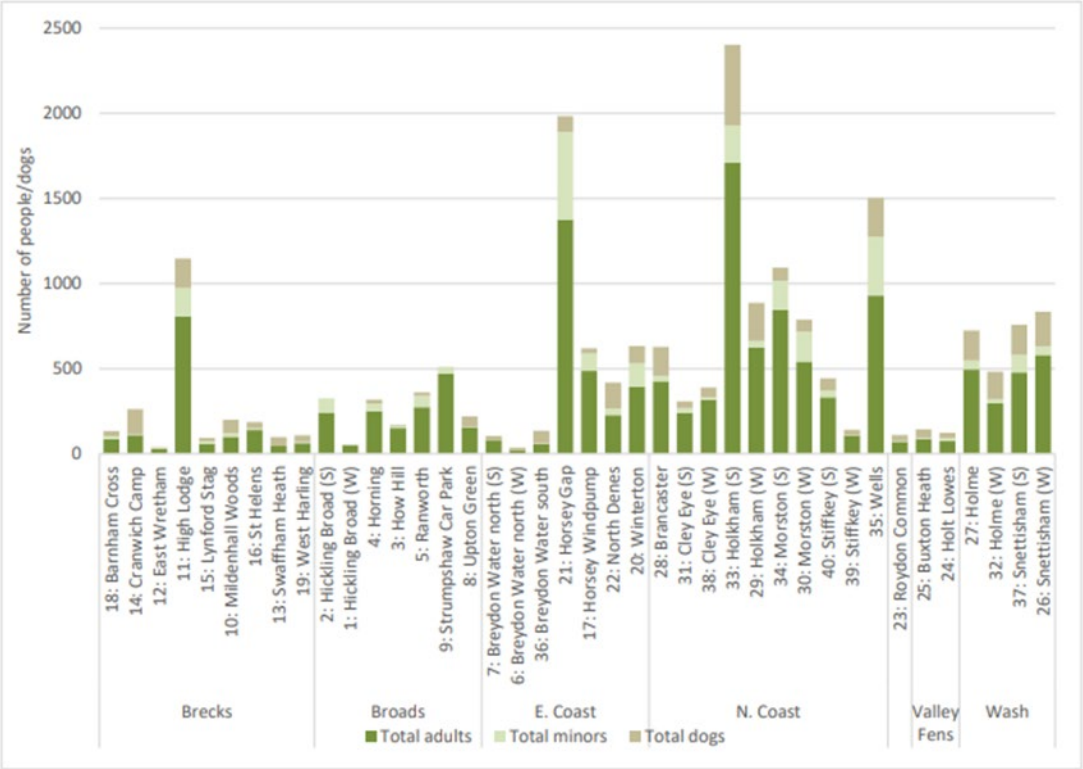


Figure 35: Figure from Panter *et al* (2016) showing total number of adults, minors and dogs recorded passing survey point locations at each survey point in Norfolk. Totals are all for 16 hours of surveying over a weekend and weekday (Note: for sessions with missing data these values are estimated).

The surveys provide information on the breakdown of activities undertaken and frequency of visit for different locations:

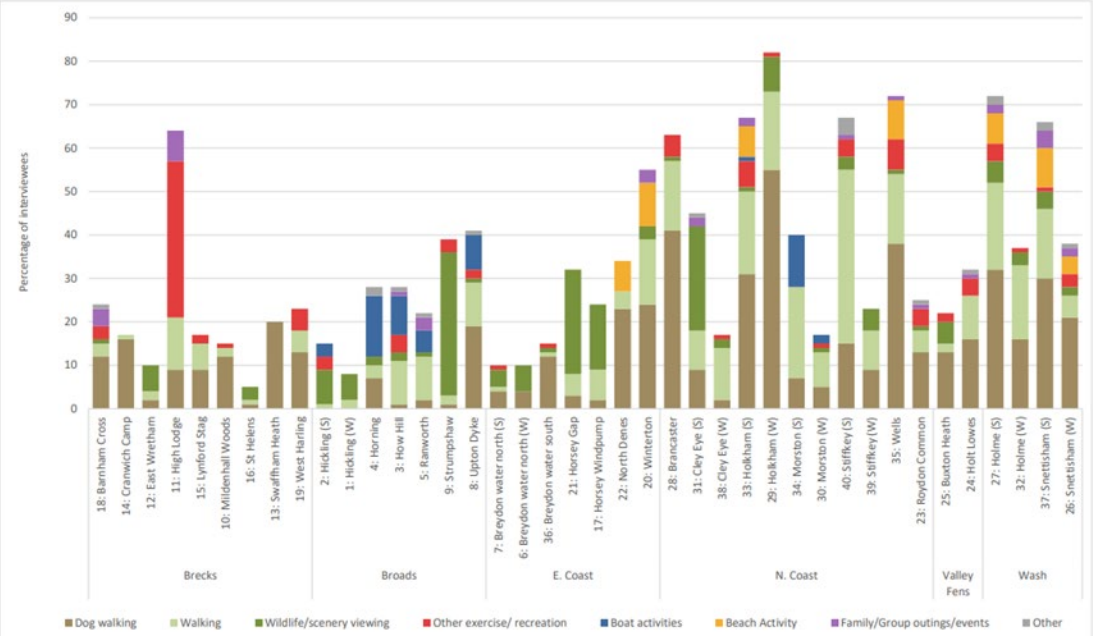


Figure 36: Figure from data presented in Panter et al (2016) showing type of outdoor activity conducted by interviewees for each survey point in Norfolk.

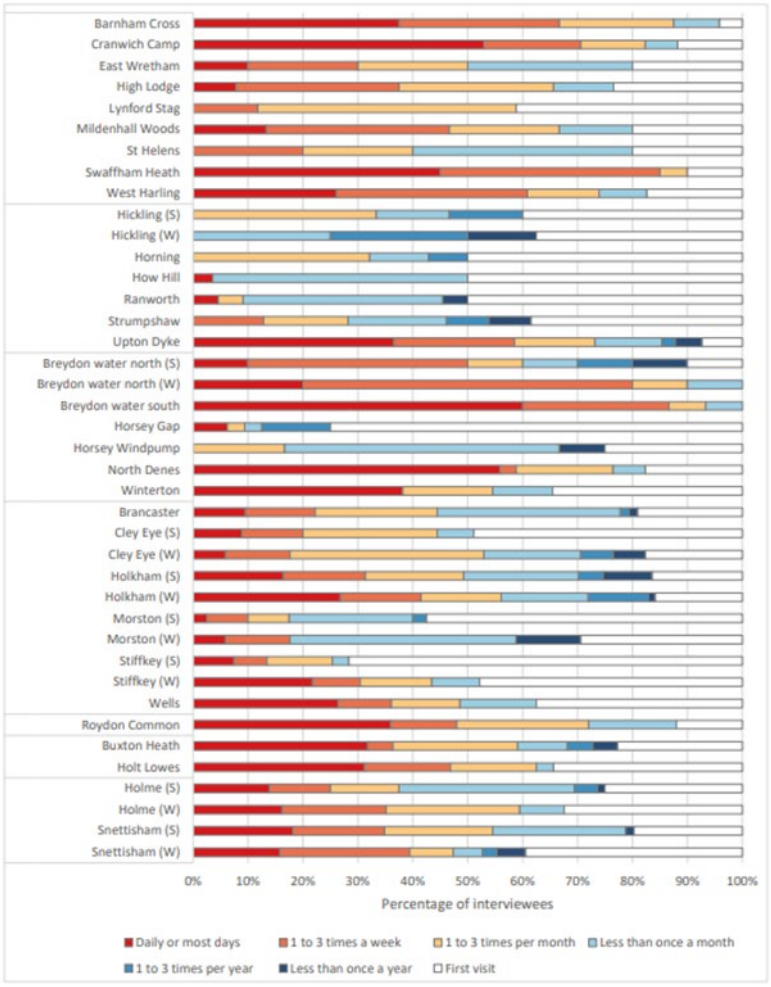


Figure 37: Figure from data presented in Panter *et al* (2016) showing frequency of visits by interviewees to the site they were interviewed at.

The Norfolk survey provides information on the length of routes walked by respondents in different survey locations and according to the activity undertaken.

Table 16: Reproduced table from Panter *et al* (2016), showing route length (km) walked by survey repsondents in different areas of Norfolk.

Area	Number of routes	Average route length	Median route length	Maximum route length
Brecks	194	6.44	4.07	8.55
Broads	180	3.71	2.69	20.46
E.Coast	180	3.07	2.03	23.35
Roydon & Dersingham	25	3.61	3.40	12.93
Valley Fens	53	2.72	2.59	9.78
Wash	202	3.01	2.53	28.41
N. Coast	480	4.91	3.87	25.70
Total	**1314**	**4.32**	**3.18**	**16.42**

Table presented in Panter and Lilley (2016) on route length walked by survey respondents in different areas of Norfolk.

Table 17: Reproduced table from Panter and Lilley (2016), showing route length (km) of interviewees at all sites, separated by activity.

Activity	**Number of routes**	**Average route length**	**Median route length**	**Maximum route length**
Beach activity	53	2.11	1.7	28.41
Boat activities	53	8.19	7.64	20.46
Dog walking	536	3.31	2.93	14.91
Family/group outings/events	33	2.07	1.45	8.00
Other	18	2.24	0.9	5.91
Other exercise/recreation	103	8.72	6.08	14.54
Walking	338	5.14	3.76	24.48
Wilidlife/scenery viewing	180	3.37	3.1	28.41
Total	**1,314**	**4.32**	**3.18**	**28.41**

This information could be used to inform the definition of a series of ‘rules’ to model how far visitors typically walk from a given access point. This would help define areas where the intensity of activity is likely to be greatest.

A smaller number of surveys as (Fearnley & Liley, 2011; Panter & Liley, 2016) collected spatial data, mapping the routes taken by people interviewed in each location. While the sample size is limited and the findings strongly reflective of the point at which the surveys were undertaken, the results do give an impression of typical visitor activity, underlining the fact that most people walk relatively short distances.

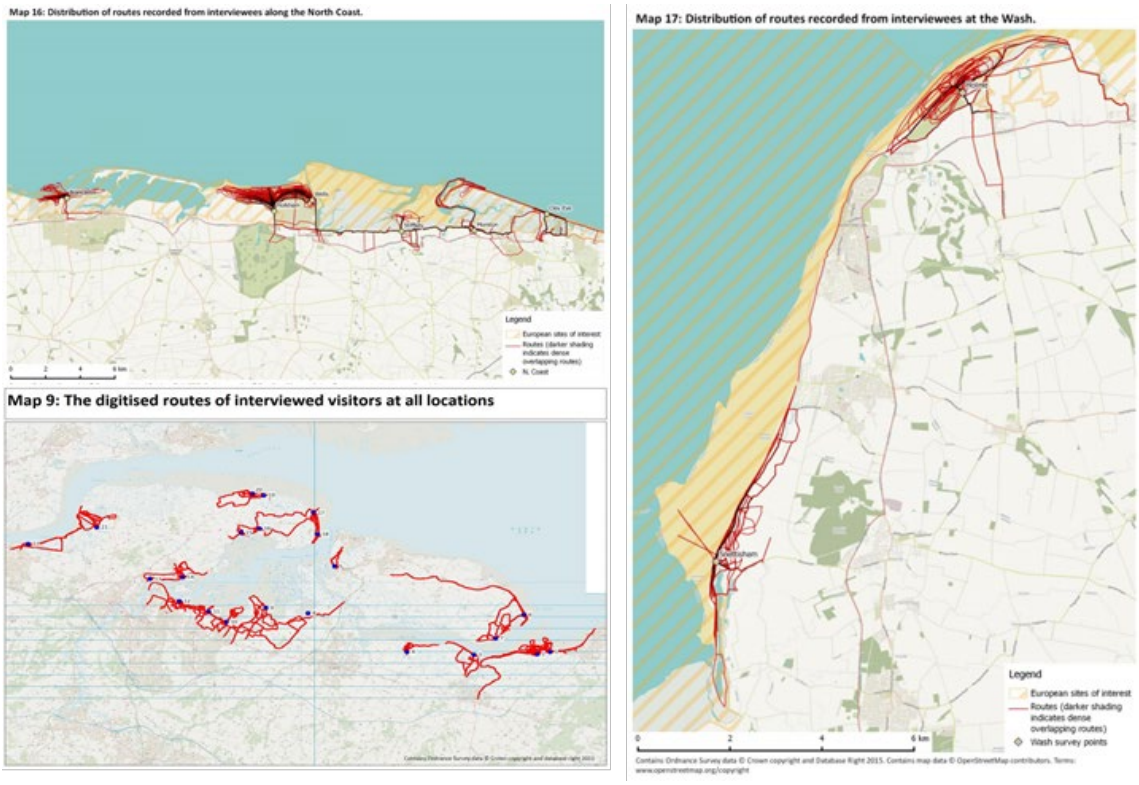


Figure 38: Maps from Panter and Lilley (2016).

Some surveys provide specific spatial analysis. The work in the Solent[3] included analysis of visitors use of different parts of the intertidal zone according to the activity they were undertaking. Though not applicable everywhere (for example because of the depth of intertidal zone), this nevertheless offers further potential for the generation of spatial 'rules' to help predict those parts of a beach most likely to experience heaviest use.

Table 18: Reproduced table from Panter and Lilley (2016), comparing the routes taken by visitors undertaking different activities. The values represent the number of visitors present in each intertidal zone by activity. It is assumed that the dogs were on a lead and followed an identical route to the dog walker.

Buffers around mean high water mark (m)	**Dog walking**	**Number of dogs**	**Walking**	**Bait digging**	**Cycling**	**Kite surfing**	**Jogging**	**Family Outing**	**Boating**	**Bird/wildlife watching**	**Other**	**Total number of visitors and dogs per intertidal zone**
No intertidal cross over non beach route	55	45	75	1	2	0	1	5	7	14	1	206
-25 to 25m no intertidal cross over but beach route	544	505	554	4	18	3	7	20	5	13	11	1684
>25 and <50	95	83	118	5	1	3	2	13	1	3	2	326
>50 and <75	20	11	32	4	1	3	2	9	1	Blank	Blank	83
>75 and <100	10	3	20	4	1	3	2	Blank	Blank	Blank	Blank	Blank
>100 and <150	4	1	12	3	1	3	Blank	Blank	Blank	Blank	Blank	Blank
>150 and <200	4	1	5	1	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
>200 and <250	4	1	2	1	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
>250 and <500	4	1	2	1	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
Total intertidal routes (>25m and 500m)	**141**	**101**	**191**	**19**	**4**	**12**	**6**	**22**	**2**	**3**	**2**	**503**

3.3.7. Research into beach use and behaviour

There has been a limited amount of academic research into visitor activity and preferences at the coast. Coombes *et al* (2008) published research into visitor activity along the East Anglian coastline. Up to 200km of coastline was filmed on three occasions (April, June and August) to represent different seasons. The beach was classified according to its morphology (e.g. sand, shingle, rock) and status (e.g. Blue Flag). Distances to car parks, toilets, campsites, pubs and hotels and local communities were calculated. The beach was divided into 200m sections and the number of visitors in each counted (totalling over 43,000 across the three surveys). The research found that the distance a beach section is from an entrance, car park, and toilet are the characteristics with the greatest influence on the intensity of visitor activity. It also found that the best temporal predictor of visitor activity is the prevailing morning weather, with a sunny morning generally associated with more visitors than a wet or cloudy morning.

As a further phase of this research, Coombes *et al* (2010) undertook visitor surveys at three locations along the East Anglian coastline. This analysed the split of activities (dog walking, walking, bird watching, relaxing/sunbathing and playing / paddling) and, for each of these activities, the mean number of visits per year, the mean number of people in the group, the number of dogs in the group, the length of the visit (hours) and mean distance walked.

Table 19: Reproduced from Coombes *et al* (2010). Percentage of people engaging in different activities in Holkham and Cley beaches, East Anglia, based on the number of visitors within groups interviewed and the number of visits they make annually.

Location	Dog walking (%)	Walking (%)	Bird watching (%)	Relaxing or sunbathing (%)	Playing or paddling (%)
Holkham	65	27	4	3	1
Cley	42	16	31	10	1
Overall	57	22	14	6	1
Total sample size (*n*)	319	735	197	185	73

Table 20: Adapted from Coombes *et al* (2010). Visitor behaviour and composition separated by activity, based on the combined data for Holkham and Cley beaches, East Anglia. Kruskall-Wallis *p*-value for all columns was <0.001%.

Activity	Mean visits per year	Mean visitors in group	Mean dogs in group	Mean visit length (hours)	Mean distance walked (km)
Dog walking	45.5	2.1	1.5	1.5	1.9
Walking	8.8	2.6	0.0	1.8	1.6
Bird watching	15.8	2.0	0.0	2.2	1.9
Relaxing or sunbathing	7.1	2.9	0.1	3.1	1.3
Playing or paddling	5.3	3.5	0.2	2.2	0.9

Patterns of activity across the beach were recorded in each location, allowing the location and relative intensity of different activities to be considered.

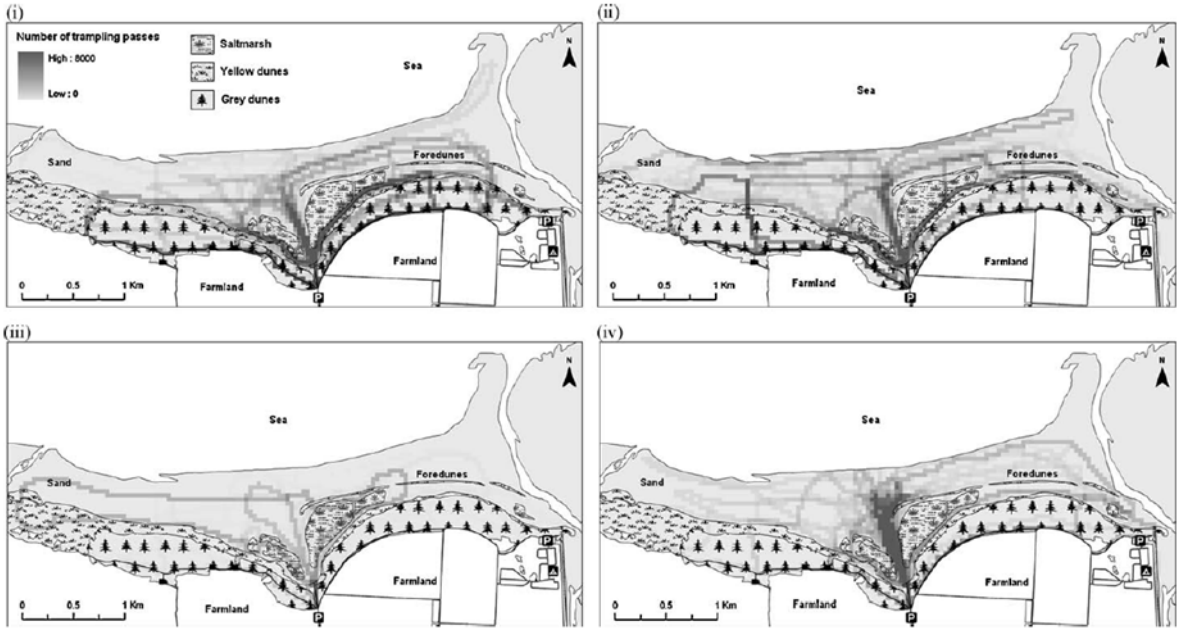


Figure 39: From Coombes *et al* (2010). Intensity of visitor use across Holkham beach, East Anglia, based on visitor routes recorded during surveys: (i) dog walkers, (ii) walkers, (iii) bird watchers, and (iv) visitors sunbathing or paddling. The area over whjich visitor impact was evaluated is shown in grey.

The findings of this research are valuable in providing data to inform the development of 'rules' which can be used to guide the modelling or prediction of visitor intensity within the coastal zone. It may also be possible to obtain and re-interpret the observational data to consider, for example, differences in patterns of activity by beach type, and use of different parts of the intertidal zone. It has not been possible to undertake this analysis as part of this commission.

Morgan (1999) undertook research into the preferences and priorities of recreational beach users in Wales. A survey was undertaken in 23 coastal locations around Wales, with a total of over 850 completed questionnaires. The research found that most people prefer beaches with an intertidal zone between 50 and 200m from the high water to low water mark. There is an overwhelming preference for sandy beaches, and significant preference for sheltered and more gently sloping beaches.

3.3.8. Walking distance thresholds

Although in more of an urban or developed context, a number of 'standards' have been defined to indicate how far people should be expected to walk for different purposes (Wakenshaw and Bunn, 2015). This information could be used, alongside data from the coastal recreation surveys described above, to define rules for distance decay in foot based activity from key access points. The Royal Town Planning Institute and the Institute for Highways and Transport have published guidance for a number of activities.

Journey Purpose	Sample Size	% Split	Median (m)	Mean (m)	85th Percentile (m)
Commuting	2166	7.1%	1000	1250	2100
Business	290	1.0%			
Education/ Escort	5609	18.5%	800	1000	1600
Shopping	5958	19.6%	800	1000	1600
Other Escort	1392	4.6%	800	1100	1600
Personal Business	2730	9.0%	800	1000	1600
Leisure	5539	18.2%	800	1150	1950
Other (including just walk)	6698	22.0%	1200	1450	2400
All	30382	100%	800	1150	1950

Figure 40: Table from Wakenshaw and Bunn (2015) showing survey data in response to the question: *"how far is acceptable to walk?"* (excluding London).

IHT (2000)	Town Centres	Commuting/ school Sight-seeing	Elsewhere
Desirable	200	500	400
Acceptable	400	1000	800
Preferred Maximum	800	2000	1200

Figure 41: Table from Wakenshaw and Bunn (2015) of IHT walking standards in different contexts.

4. Options for assessing the intensity of foot activity in the intertidal zone

4.1. Introduction

This part of the report draws on the findings of the literature review and the data review to map out ways in which information about the intensity of recreation activity within the Welsh intertidal zone could be improved. It covers three main options:

- The purchase and analysis of 'big data';
- New survey and data collection; and
- An initial 'rules based model' based on information from data and literature review.

4.2. 'Big Data'

Google Location Data

Google has the potential to collect locational data where anyone with an android phone has been (and has not turned off their location services and tracking). Google uses this type of data to generate traffic information, based on the numbers of people travelling along particular sections of road. Feedback from onigroup a google cloud partner indicated that at this stage Google has not released footfall data. As a result despite the data being recorded it is not available to private or public.

Mobile Network Data

Using mobile network data has one main issue in the spatial accuracy of the locations, particularly where phone signal is poorest. This would prevent it being able to detect the difference between people on a beach, people on a coastal path or people at a resort, town or campsite near the intertidal zone. This could however be used to relatively accurately identify numbers of people visiting beach resorts, popular locations around the coast. It could also distinguish visitors, residents and workers based on mobile information. Therefore it could be used alongside other data to try and calculate where beaches are likely to be busier due the fact that more visitors are in the area. It could also be used for more strategic surveys over bigger areas than the intertidal zone. However due to costs it is probably not the best option for detecting where people go on a beach.

As previously discussed, Strava mapping has great potential for a range of recreation management uses because it gathers spatially and temporally accurate data from a large number of users via their use of smart phone and smart watch applications (Strava does not publish how many people use its app globally or in the UK. However, in 2017 it stated that it was gaining 1 million new users every 45 days and that around 8 million new activities are uploaded every week). It is, however, focused on the sporting end of the recreation spectrum, with most users being runners, cyclists and those involved in water activities. As a result the data collected is likely to underrepresent more informal 'every day' recreation and information about people less inclined to use mobile apps. However, the data provided still helps define popular walking routes though as these are often similar to those used by runners. Information is constantly updated. Data are already being collected for more specific activity types (e.g. hiking, kayaking etc.) and it is possible that future iterations of

Strava maps will allow greater differentiation of activity types. Data should be available as raw GIS formats as well as end-use web visualisation heat maps.

This is considered to be the most promising option based on the use of big data. However, costs are likely to be high but given the wide application of the data there could be benefit in a collaborative approach within NRW and with the Welsh Government.

It should be noted that the Strava heat map can still be viewed for free and could be used to identify access points and key recreation hotspots in what would be a fairly manual procedure. It would not be able to attribute a count to each access point though.

4.3. Survey

A second group of options for improving understanding of recreation intensity within the Welsh intertidal zone focuses on new survey work.

4.3.1. People counters

Automatic counters provide a means of recording how many people pass a specific point. New technology allows different types of user to be counted (e.g. pedestrian, cyclist, horse-rider etc.) and it is likely that technology will continue to evolve allowing for improved differentiation.

While relying solely on the use of people counters would be unrealistic, requiring purchase, deployment and maintenance of equipment for a very large number of locations (and the analysis of an equally large volume of data), there is potential for a more targeted deployment which could, for example:

- gather information on numbers of visitors at a selection of sample locations which could be used to calibrate and refine predictions of recreation activity made, for example, by a ‘rules based model’ (see below);
- identify locations where there could be value in site specific surveys of recreation activity within the intertidal zone, with the results being used to inform refinement of a rules based model;
- gather information for locations where there are high levels of ecological sensitivity and where a rules based model suggests there are likely to be higher levels of recreation activity.

The cost of this option could be relatively modest, though clearly the more locations where people counters are installed, the higher the costs. There is likely to be some loss of equipment due to theft, vandalism or accidental damage, and there will be costs associated with installation, data collection and analysis. Past experience suggests an attrition rate of around 25%.

It would be sensible to allow £2-3k per location for the purchase and installation of equipment. The costs could be reduced if NRW was able to work in partnership with local authorities who manage existing people-counters, with the potential for redeployment of existing equipment or sharing of costs and data.

4.3.2. Video counting

Representing a further development of people counting technology, video counting technology can gather information on the number of people across a wider area (for example, part of the intertidal zone), though accuracy is limited to around 70m. This is a potentially expensive solution (<£5,000), particularly where installation in remote, off-grid locations is required. Widespread deployment is therefore unlikely to be a viable option, so a focus on gathering information in a very small number of locations with high ecological sensitivity and higher levels of recreation activity may be more appropriate.

Again, this is unlikely to be a stand-alone solution and would need to form part of a wider package of monitoring or predictive tools. It is possible that the cost of this technology will fall in the future and that its accuracy over longer distances will improve.

4.3.3. Video survey

While people counters and video counters would gather information over an extended period, an alternative would be to fly the coastline (light plane or UAV) and to film the intertidal zone during the busiest or most sensitive times (e.g. summer bank holidays, or bird migration periods). This is an approach which has been used in previous academic studies. Given the need to analyse the resulting footage, it is a potentially time consuming exercise, particularly if applied to the whole coastline. A more proportionate approach would be to deploy a UAV mounted camera at a selection of beaches – again selected to provide a representative sample or examples of particularly busy and/or ecologically sensitive beaches. Filming from a sufficient elevation and distance off-shore would help ensure that issues of privacy were avoided.

The costs of this option vary, but we estimate that professional UAV mounted filming a 10km section of coast (e.g. between Tenby and Saundersfoot) could cost could be between £10,000 and £25,000, with analysis on top of this.

4.3.4. Questionnaire survey

The final option in this group is to undertake a survey of visitors to the Welsh coastline and to use on-line mapping to gather spatial information about the places people visit and where within the intertidal zone they go, and what they do there. This is an approach that was used for the 2015 Scottish Marine Recreation and Tourism Survey (c2500 responses gathering more than 52,000 items of spatial information across 23 activity types) and is similar to the more spatially focused Welsh Activity Mapping project.

The technology to undertake such a survey is now widely available, with a web-based questionnaire which includes zoomable maps onto which people can plot places they have visited and the routes they have walked or cycled. The spatial information provided by respondents can be combined into a single map using heat mapping to indicate areas where activity is most concentrated.

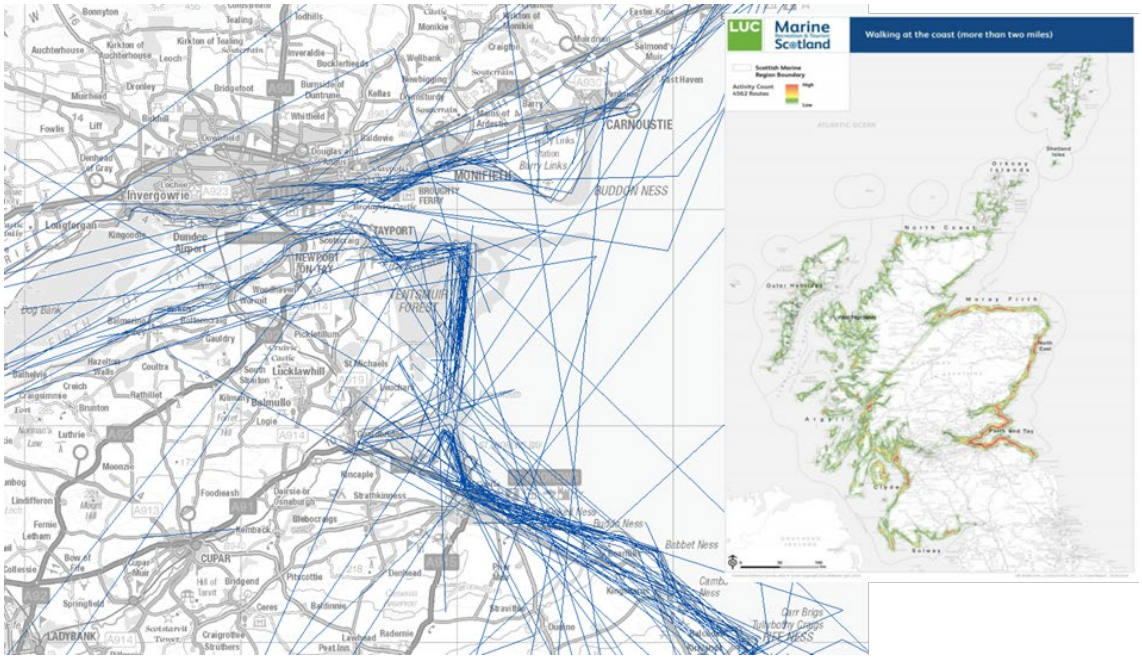


Figure 42: Data from the 2015 Scottish Marine Recreation and Tourism Survey, where users plot their routes using an online questionnaire.

Additional questions can be included, gathering, for example, information on trip origin, use of accommodation, spending, reasons for visiting identified locations, awareness of environmental issues and socio-economic / group information.

One of the drawbacks of this kind of survey, however, is that the spatial information depends on people's memory of where they went. While they may reasonably accurately indicate that they visited Pendine Sands, for example, their recollection of where on the beach they were, may be less reliable, or less easily recorded on a map which shows a relatively featureless extent of beach.

A further challenge may be achieving a sufficiently large response rate to provide reliable results, particularly for remoter or less often visited beaches (which may be ecologically sensitive, nonetheless). In the case of the Scottish survey referred to above, the focus was on specialist recreation activities and the study made extensive use of the network of clubs and associations, and their social media channels to reach potential respondents. A prize draw was used as a further incentive. Potential solutions could include piggy-backing on other surveys and incentivising the survey.

Based on the requirements to design a survey, build a survey website, publicise the survey, monitor response rates and analyse the results, this kind of approach could cost in the region of £60k. It could however yield a range of other information of interest to a wider range of public sector organisations, including the Welsh Government and Visit Wales, suggesting that a collaborative approach, with cost sharing, could be beneficial.

It would be possible to combine an on-line survey with engagement with expert stakeholders to add to the evidence base and sense check the findings from interactive mapping, particularly for less visited locations.

4.3.5. Observation and site based survey

An alternative approach would be to undertake observational surveys at a number of key locations, using methods similar to those used for a number of English coastal (and inland) Natura Sites. This could place a greater emphasis on recording where within the intertidal zone visitors walk, details of their party (including presence of dogs) and the activities they are observed undertaking. The results are likely to be more spatially accurate than a self-completion, on line survey, but the geographic coverage of beaches is likely to be much more limited. Locations could be selected to provide a representative sample or examples of particularly busy and/or ecologically sensitive beaches. Ideally, these surveys would be undertaken during the summer months, on weekdays and weekends and at different times of day. Questionnaire surveys could be added to these surveys but the main emphasis would be on observation.

Allowing for five survey days and five analysis days, it would be sensible to allow around £5-10k per location.

4.3.6. Questionnaire and site based survey

It would also be possible to develop a combined approach based on a questionnaire survey (run on-line and administered at key coastal locations), observations at key locations and engagement with expert stakeholders. This would build a robust approach providing spatial breadth (covering all coastal locations in Wales) and depth at locations known to be popular for recreation and / or of higher ecological sensitivity.

Elements of the approach could be standardised and applied to all surveys of coastal recreation (e.g. to inform Habitats Regulations Assessments).

4.4. Rules based model

A rules based model would involve a desktop GIS study to attempt to model how people behave and where people go on a beach environment. The approach uses existing or freely available datasets and would help identify locations where more intense visitor activity would be expected.

Rule based models have been developed previously, with a good example being the online Outdoor Recreation Valuation Tool (ORVal). ORVal estimates visitor numbers for new and existing greenspaces for England and Wales based on standardised algorithms. One option would be to adapt and develop this tool to focus on the intertidal zone. Alternatively, a bespoke approach based on tailored layers of information, as described below, could be developed.

4.4.1. Data improvement

Initially a rules based model approach will require improvement of a number of datasets currently held by NRW.

- Access points should be defined as access adjacent to the intertidal zone. Currently there is a mixture of locations of access points that sit some way away (for example at a car park) from the intertidal zone, with others that

are adjacent to it. It might be helpful to have both access from car parks/roads, and access to the intertidal zone points.

- Increase number of access points based on ones visibly used on apps like Strava for example, or desire lines visible over grassland on aerial imagery.
    - ‘Desire lines’ describe the linear routes that people take that are not on paths or public rights of way. They may be visible as paths worn across grass or dune systems.
- Identify differences between official/non-official access points. Done as desktop study, then ground truthing.
- Define estuarine/non-estuarine areas of the intertidal zone.
- Define areas of the intertidal zone that are cliffs and have no beach at high tide.
- Obtain road and railway data from Ordnance Survey.
- Obtain Settlement data from Local Authorities.
- Blue flag needs to define the entire area of the beach that is given to blue flag. It will be difficult to use this as point data in a GIS.
- Improve caravan/camping park data with counts of caravan spaces or overall area – use OpenStreetMap (OSM) data for overall area.
- Improve car park data with numbers of spaces – use OSM data. For example none of the car parks shown on the following map extract are in the current dataset, though several are known to be used by groups such as climbers and coasteering groups.

Figure 43: Open Street Map example of Car Park data (© OpenStreetMap contributors)

4.4.2. Use of a gridded version of the Intertidal Zone

To allow for measurements and to apply scores it would be sensible to use a raster or gridded version of the Intertidal Zone, using typical grid size e.g. a 10 x 10 metre grid. This would allow for scoring dominant land-cover, recreational features and proximity to transport and population which could be applied to each cell. These scoring features are described in following sections.

4.4.3. Relative importance of beach for recreation

The first stage of a rules based model will be to predict the likely relative levels of recreation activity on different beaches around the Welsh coast, based on their character, facilities, proximity to settlements and transport provision. The approach set out below is a first step and would be subject to testing and refinement to more accurately reflect the influence of different factors.

Type of beach

The type of beach is likely to have influence on the numbers of people visiting it. There is some evidence that sandy beaches are most preferred by users (Morgan, 1999). It is therefore proposed that the intertidal Biotopes dataset is classified as follows:

Table 21: Beach material scoring

Beach material	Score
Sand; Sand / Shingle	4
Shingle	3
Rock	2
Mud / Salt Marsh	1
No beach (cliff)	0

Further analysis could be carried out to reflect Morgan's other findings that people prefer gently sloping beaches (using slope analysis) and more sheltered beaches (using exposure to prevailing winds as a measure). Both of these would be available using freely available LiDAR data to calculate slope angles of beaches, and freely available prevailing wind speed and direction however this additional analysis may be too detailed at this broad scale.

Proximity to settlement

Evidence from coastal recreation surveys suggests that activity levels are highest on beaches closest to cities and larger towns and lower in more remote locations. This reflects the function of coastal resorts, where beaches form part of the visitor 'experience', and the finding that a significant proportion of beach visits are frequent and locally generated.

It is proposed that beach locations should be classified as follows:

Table 22: Beach proximity to settlement scoring.

Proximity to settlement	Score
0-1 km	4
1-5 km	3
5 – 10 km	2
10 km+	1

Proximity to caravan or campsite

It is likely that proximity to caravan sites or campsites is an important influence on the level of beach use, particularly during the Easter to October period. Beach use is likely to be greatest where access on foot is easy.

It is proposed that beach locations should be classified as follows:

Table 23: Beach proximity to caravan sites and campsites scoring

Proximity to caravan site or campsite	Score
0-100 m	3
100 – 1000 m	2
1000 m +	1

The figure below shows the access points and caravan parks/campsites and indicates the closest access points to a caravan park.

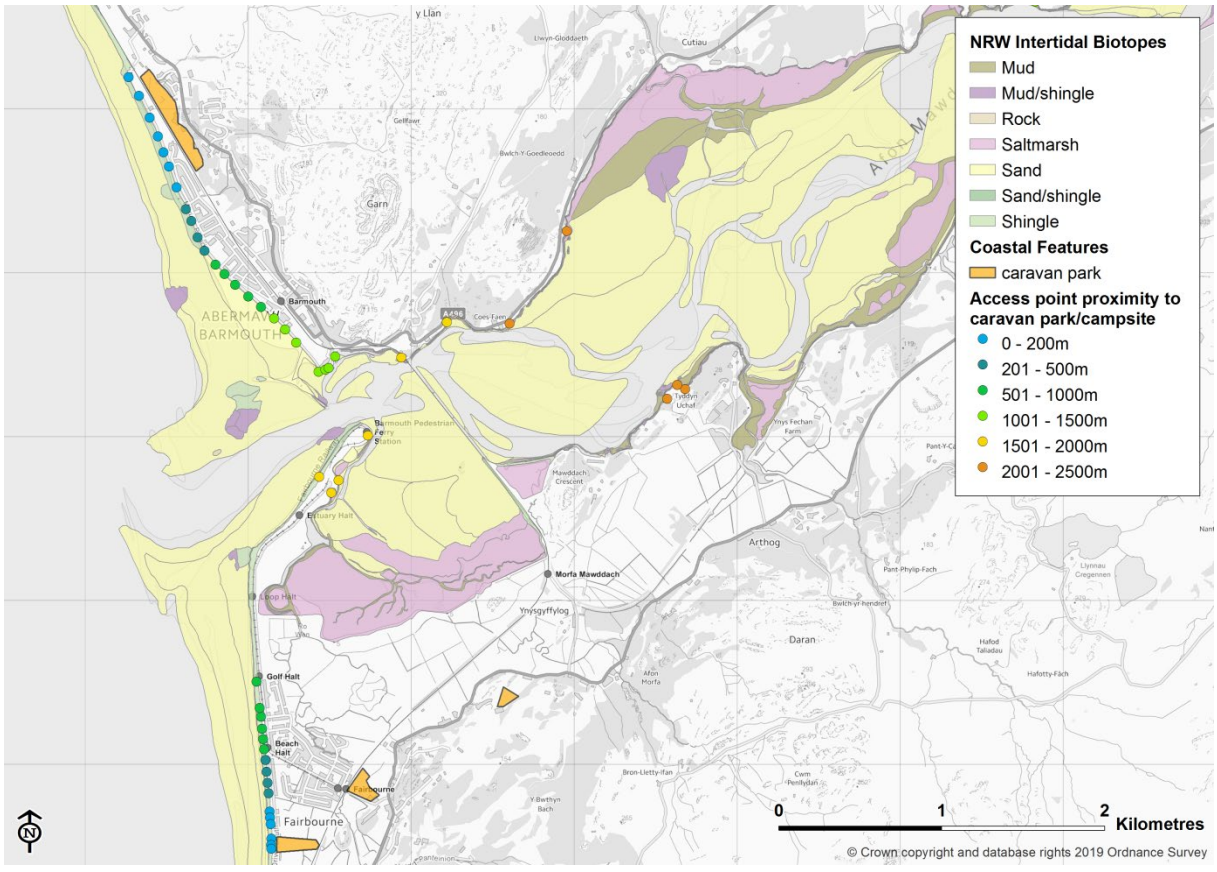


Figure 44: Access point distance to caravan parks/campsites

Beach accessibility from public road

Similarly, it is likely that easy access from the public road is an important influence on the level of beach use. Beach use is likely to be greatest where access on foot is easy.

It is proposed that beach locations should be classified as follows:

Table 24: beach proximity to public road scoring

Proximity to public road	Score
0-100 m	3
100 – 1000 m	2
1000 m +	1

Beach accessibility from railway station

Similarly, it is likely that easy access from a railway station is an influence on the level of beach use. Beach use is likely to be greatest where access on foot is easy.

It is proposed that beach locations should be classified as follows:

Table 25: beach proximity to railway station scoring

Proximity to railway station	Score
0-500 m	3
500 – 1000 m	2
1000 m +	1

The figure below shows the access points and railway stations and indicates the closest access points to a railway station (note the accuracy used for the railway locations was not ideal):

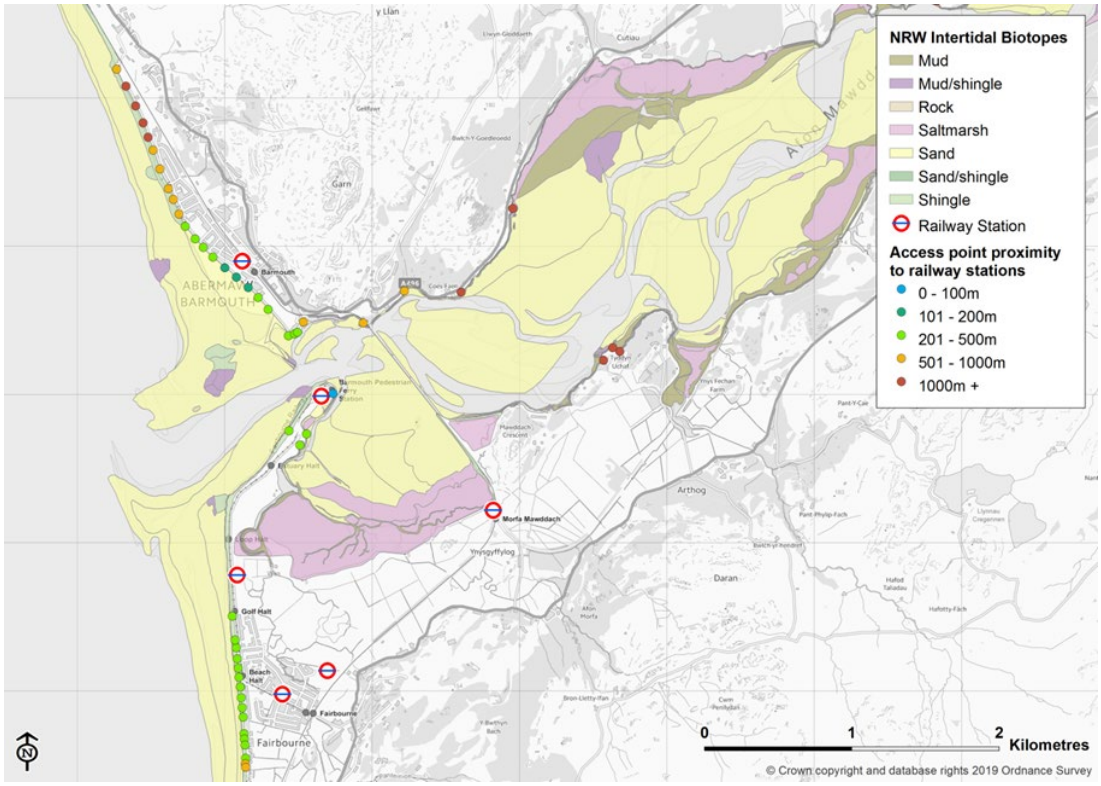


Figure 45: Access point distance to railway stations

Proximity to population

Proximity to large populations is likely to increase numbers despite having lower scores due to other factors. It is possible to obtain Travel Time areas (both drive time and public transport times), which define the area within a certain time. With this data combined with freely available National Statistics population data it would be possible to get a count of populations within a set travel time from a beach. In addition this could provide further information by indicating population within 15 minute walk from an access point, so could be used as a means to indicate proximity to a village or town. A suggested approach is outlined below of the scoring given to travel time within 2 hours and walking distance within 15 minutes.

Table 26: Drive time analysis scoring.

Population within 2 hours travel time	Score
+2,000,000	4
1,000,000 – 2,000,000	3
100,000 – 1,000,000	2
0 -100,000	1

Table 27: Walk time analysis scoring

Population within 15 minutes walking time	Score
+1000	4
500 - 1000	3
100 - 500	2
0 -100	1

Presence of facilities

While many people prefer beaches without formal facilities, it is likely that certain features reflect or result in higher levels of beach activity.

It is proposed that beach locations should be classified as follows:

Table 28: Beach facilities scoring

Facility	Score
Car park adjacent to beach	2
No car park	1
Café	2
No café	1
Harbour, jetty or slipway	2
No harbour, jetty or slipway	1

The figure below shows the access points and car parks and on road parking and indicates the closest access points to a car park:

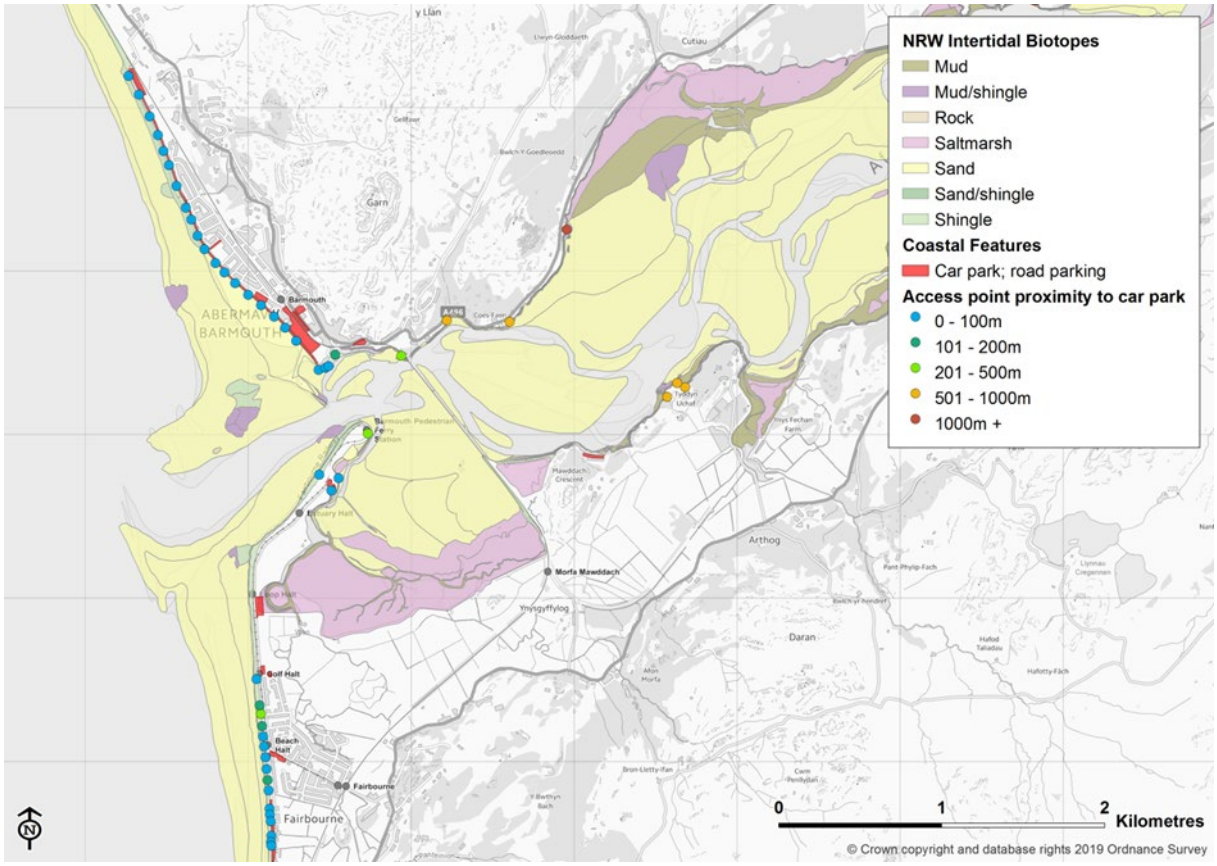


Figure 46: Access point distance to car parks and on-road parking

Environmental status

All things being equal, people are more likely to visit a beach with high scenic quality, where water quality is high. It is proposed to use a series of proxies as measures of environmental quality.

It is proposed that beach locations should be classified as follows:

Table 29: Beach environmental status scoring

Measure of environmental quality	Score
Blue Flag Status	2
No Blue Flag Status	1
Location within a National Park or AONB	2
Location outside a National Park and AONB	1
National Trust site	2
Not a National Trust site	1
Other relevant environmental designation	2
No other relevant environmental designation	1

Other activities

Activity on beaches may reflect special interest activities for which spatial data exist. An example is the climbing dataset that is maintained by UK Climbing (UKC). Another could be surfing locations from Magic Seaweed. Both of these are quite specific whereas activities such as sea-kayaking and sailing could occur anywhere along the Welsh coastline, although some areas are preferred to others.

Other zoning

Some beaches are used (intermittently or continuously) for military live firing or other training purposes. It is proposed that beach locations should be classified as follows:

Table 30: Beach military use scoring

Zoned for military activity	Score
Not zoned for military activity	1
Zoned for military activity	0

4.4.4. Activity zoning

The above analysis will help compare the likely level of activity between different beaches, but will not indicate where on a given beach activity is likely to be most intense. Published literature provides information on the distances that people typically walk while visiting beaches around the UK. There is some variation in the average distances walked between different studies, reflecting the nature of the coastline, the profile of visitors and the time of year that the survey was undertaken. We have, however, used this information to define a series of buffer distances that can be applied to provide an indication of the likely pattern of beach activity. Further survey and observation would allow this information to be refined in the context of the Welsh coastline. This could, for example, identify differences in distances walked by people on different types of coast.

Beach zoning

Drawing on research carried out in the Solent region we propose zoning the beach from the high water mark, reflecting the finding that most people walk along the top of the beach which is exposed for longer and generally drier for walking. The Solent study found that around 74% of beach users are concentrated in the top 50m of the beach, 13% between 50 and 75m and the remaining 13% spread across the remainder of the beach (up to 500m from high water mark). People with dogs are more likely to use the full extent of the beach.

While beaches come in all shapes and sizes, this could provide an initial indication of those parts of the beach where most activity is likely to be concentrated.

Table 31: Concentration of activity from high water mark to low water mark

Beach zone	% of all walkers	% of walkers without a dog	% of walkers with a dog
High water mark to 50m	74	82	67
50 – 75m	13	11	14
75m+	13	7	19

The figure below shows the beach zones as described in table 31:

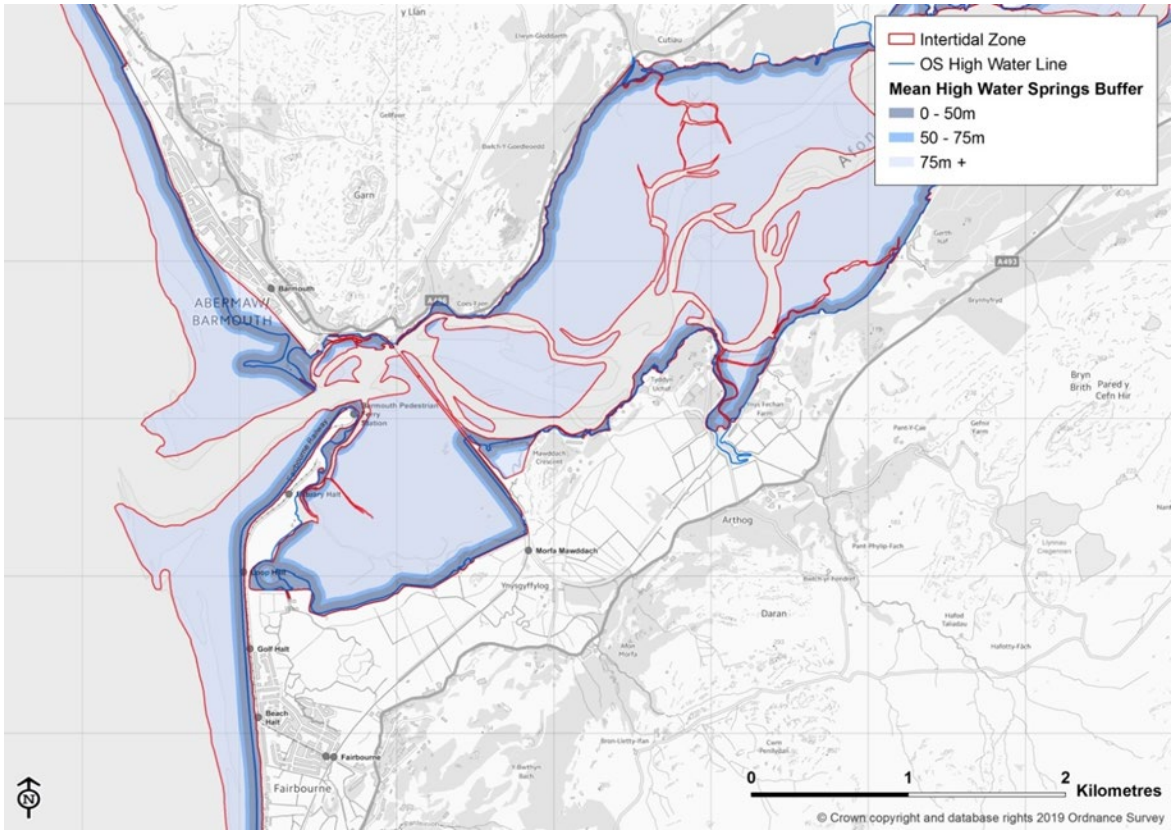


Figure 47: Intertidal Zone split into beach zones

Distance from access points

Surveys also provide information on the average distance that visitors to beaches tend to walk, again differentiating between walkers with and without dogs. More limited information is available for other kinds of beach activity such as general relaxation and playing / paddling, though the sample numbers tend to be less. Again there is variation between studies, reflecting the time of the survey and the nature of the coastline, with several of the surveys having been carried out in areas characterised by coastal wetlands rather than classic sandy beaches. Nevertheless the information provides a good starting point for refinement through additional survey over time.

Drawing on surveys carried out around the Norfolk coast, the Wash, North Kent, Sandlings, Breckland, the Solent and the Exe, we propose using the following distances for different user groups. These are total distances, so mapping would half

them to represent circular walks. A proportion of people will not undertake circular walks, but review of published information suggests that most people return to the starting point. These distances can then be applied to identified access points to indicate those parts of the beach most likely to be used by visitors.

Table 32: Typical distances walked while visiting the beach

Walking distances (m)	Mean distance walked	Median distance walked	85th percentile
Walkers with dogs	3100	2400	5100
Walkers without dogs	3800	2850	6200
All walkers	3450	2600	5650

The figure below shows the access points and indicates the distance to access point in the intertidal zone. It gives an indication of where people are likely to be based solely on proximity to an access point:

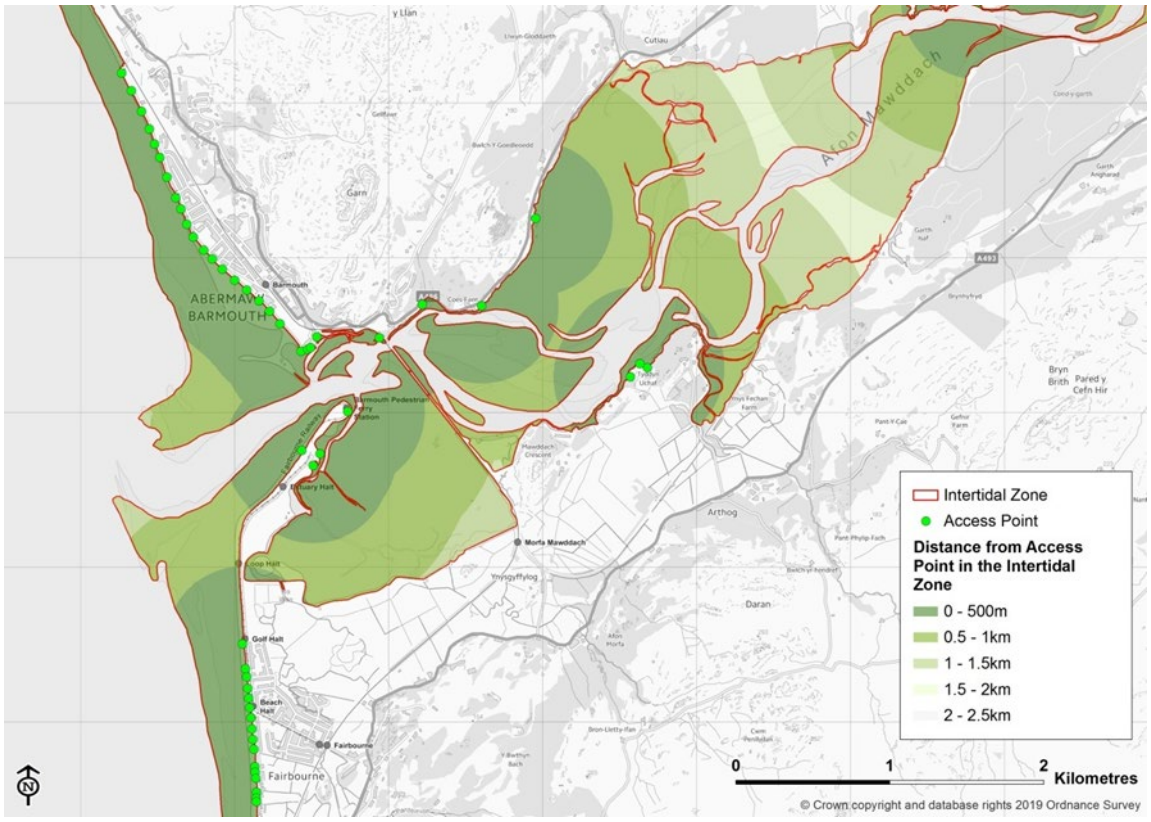


Figure 48: Intertidal zone split by distance from access point

Activity foci

It is also sensible to identify other foci for beach activity and to draw buffers around them to highlight areas where activity is likely to be concentrated. From existing

information it would be appropriate to define 50m buffers around climbing locations, slipways and other key features.

Combining results of outputs

Once the measurements above from each access point have been created it is possible to make a single scoring field that takes into account all the results. Initially this could be done in a simple addition of the results for each ‘rule’. It would be possible subsequently test the results in the field and to weight those factors judged to have a greater influence on where people go within the intertidal zone.

The figure below shows 1km proximity to access points and grades these areas according to whether an access point is within 200m of a railway station, 100m from a public road, 100m from a campsite/caravan park and 100m from a car park/on-road parking. If the access point is within the estuarine area it is given a minus one value to the score. It also includes a grey shading showing proximity to the MHWS. This reflects the tendency for most activity to be concentrated at the top of the beach:

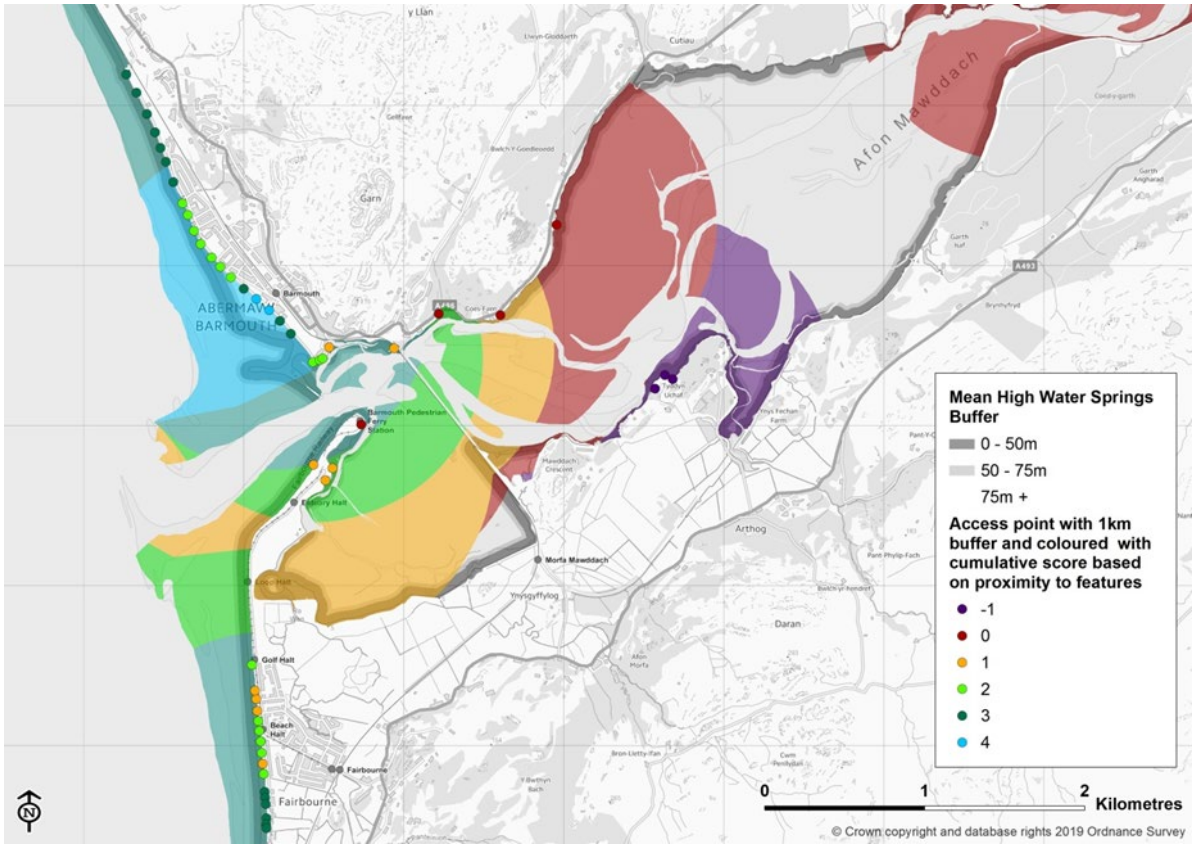


Figure 49: Intertidal zone split by distance from access point and overall scores.

The figures shown in this report only give a few examples and further analysis is possible using other datasets for example the biotopes data has not yet been displayed and could also be added to this fairly easily by giving scores based on the sub-strata. For example, there could be a further subdivision to reflect the likelihood that people are more likely to visit open coastal beaches than those within estuaries.

Regarding the figure above it would benefit from ensuring scores are not applied over estuaries if walking access is much less likely.

Apply people counts to overall scoring values.

Once an overall score has been made it the next step would involve applying estimated people counts to these scores. To get an idea of how the datasets and processes are linked see a suggested diagram in *Appendix I: Rule Based Model Diagram*

4.4.5. Rules based model – costs

Application of an approach similar to that outlined above could be achieved at relatively low cost (though the precise cost would depend on the level of development and refinement and the degree to which additional survey work is undertaken or data purchased), with the largest requirement being GIS based mapping analysis. However, it is likely that this standardised approach will require considerable testing and refinement at a national scale, and at the level of individual beaches where local circumstances are likely to have a bearing on patterns of activity and the accuracy of the model's predictions. Key ways in which the model could be improved include:

- Comprehensive mapping of beach access points and car parks, for example by adding open source mapping to existing coastal infrastructure dataset (low cost);
- Calibration at national or regional levels data from automatic people counters or video survey (medium to high cost depending on the number of sites and technology used);
- Site level calibration using published information (e.g. Strava maps) to confirm access points (including relative importance) and concentration of activity within the inter-tidal zone (low to medium cost depending on number of sites examined – assumes no data purchase);
- Site level observation based mapping (most popular beaches, most sensitive locations) (medium cost depending on number of sites);
- Continuous improvement based on recorded experience and evidence;
- Standard methodology for all activity-based surveys, bringing together questionnaire surveys, observation surveys, data from people counters and use of spatial data from sources such as activity apps.

5. Conclusions and next steps

Natural Resources Wales (NRW) is leading a project which aims to investigate the possible impacts of non-licensable activities on the Welsh marine environment. A key component of this activity is foot access to the intertidal area, with or without a dog, since this can be a source of disturbance and damage to sensitive habitats and species.

This study was commissioned in order to identify the best approach to estimate intensity of access to the intertidal area using data that is currently available. It represents a first step towards achieving NRW's aim of creating a way of assessing the relative intensity of foot access within the intertidal area.

The study comprised three main components:

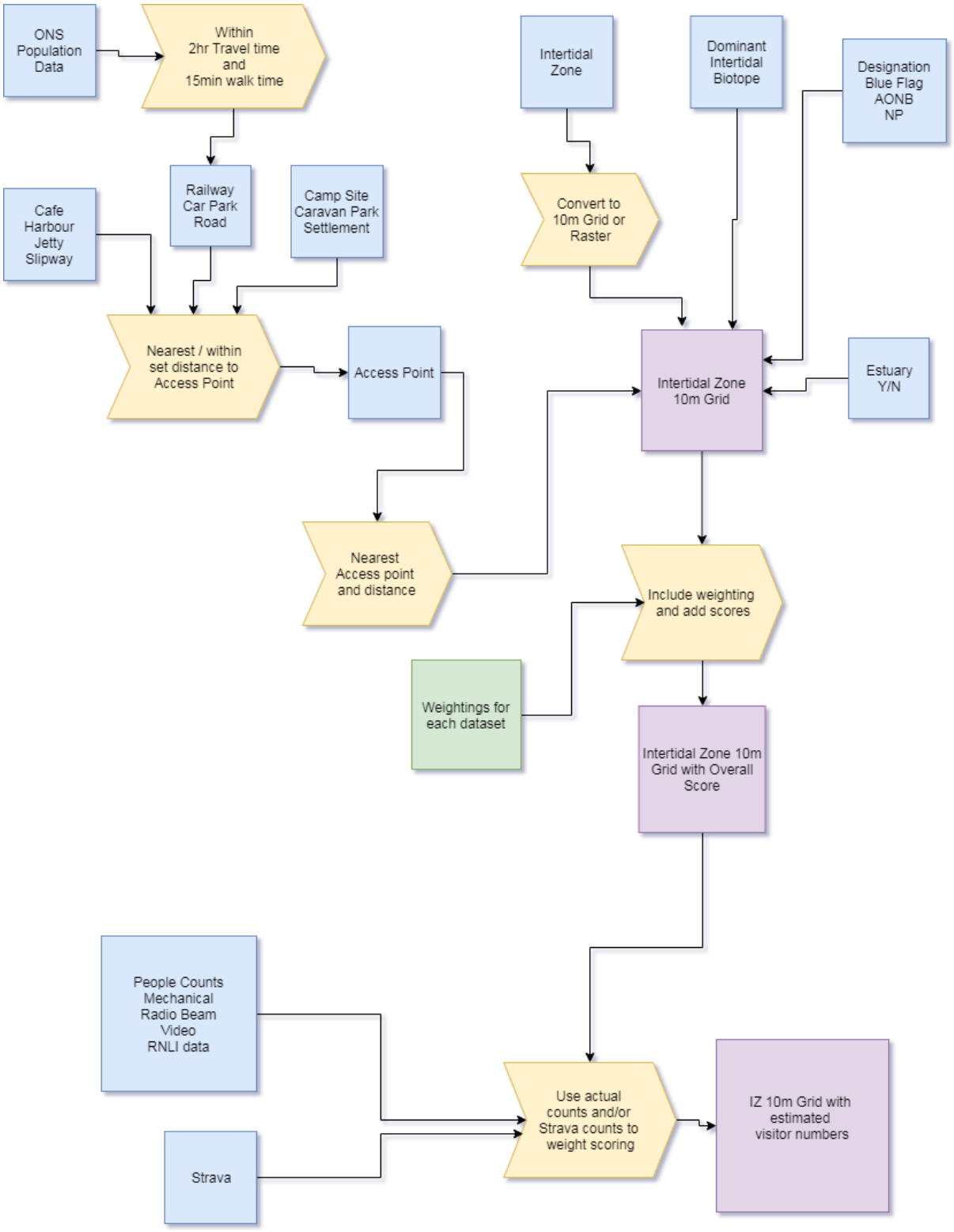
- The identification and review of existing sources of spatial data which could be used to measure or predict the intensity of foot access within the intertidal area;
- A review of literature relating to coastal recreation with the aim of identifying evidence that could be used to develop a better understanding of the intensity of foot access within the intertidal area;
- Drawing on the findings from the previous two stages, an assessment of options for ways of estimating the intensity of access to the intertidal area.

The study found that no single existing source of data provides a complete picture of foot access within the intertidal area. Future options fell into three main groups:

- The use of existing 'big data' sources such as those generated by activity trackers and other GPS enabled apps on people's smartphones and smart watches. This would provide accurate and up to date information, but would not be fully representative and would be costly. There may be scope for sharing the costs with NRW and with other parts of local and national government in Wales;
- The use of a range of survey techniques to gather information about the intensity of recreation activity in the intertidal zone. This could include interactive mapping as part of questionnaire survey, the use of people counter technology, and engagement with expert stakeholders. This could build on the Welsh Activity Mapping project in South West Wales; and
- The development and use of a rules based, predictive model, analogous to approaches such as the online Outdoor Recreation Valuation Tool (ORVal). Operation would be based on factors such as beach characteristics, proximity to access points and behaviour patterns informed by the literature review. It is likely this would require a reasonable amount of testing, refinement and calibration. It could potentially draw on information generated by the previous two options, if available.

NRW will draw on these findings and options in developing its approach to the mapping of recreation intensity within the Welsh intertidal area.

6. Appendix I: Rule Based Model Diagram



Data Archive Appendix

No data outputs were produced as part of this project.

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