Integrating Professional Coastal Study Techniques into School Fieldwork

Royal Geographical Society with IBG

Advancing geography and geographical learning

The enclosed information provides guidance on conducting coastal-based school fieldwork. Produced in partnership with ERM, a leading global provider of environmental, health, safety, risk and social consulting services, the *Professional Support for Fieldwork* project directly addresses issues surrounding geography fieldwork provision in schools. The project aims to highlight how the skills and knowledge developed through school fieldwork are directly relevant to 'real-world' professional industries, career paths and activities.

This document provides a series of fieldwork activities for the study of coastal systems, the application of which is demonstrated through an example study area (Point of Ayr & Prestatyn, North Wales). For each set of activities, this document also provides generic requirements for fieldwork site selection (with an emphasis on site types that can be found within proximity to most schools and at a low cost), critical health & safety considerations. the tools and techniques for data collection, pre- and post-fieldwork activities and relevance to GCSE and A Level curricula.

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1. Summary of exam board coastal studies curricula (2016)

These resources have been developed with reference to the GCSE and A Level curricula provided by the Department of Education and by the main exam boards (i.e., AQA, Edexcel, OCR, Eduqas).

1.1. GCSE

The study of physical landscapes is a prominent feature of all GCSE geography curricula, with 'Coastal landscapes, landforms and processes' one of three focus areas. Within this focus area, students are required to consider the roles of geology, climate, human impact, human management, weathering, mass movement, erosion, transport and deposition.

Coastal studies could also be relevant to other modules, including ecosystems, the restoration of habitats damaged by humans and water resources and management (Eduqas); weather hazards, climate change and the development, use and management of energy sources (Edexcel, OCR).

1.2. A Level

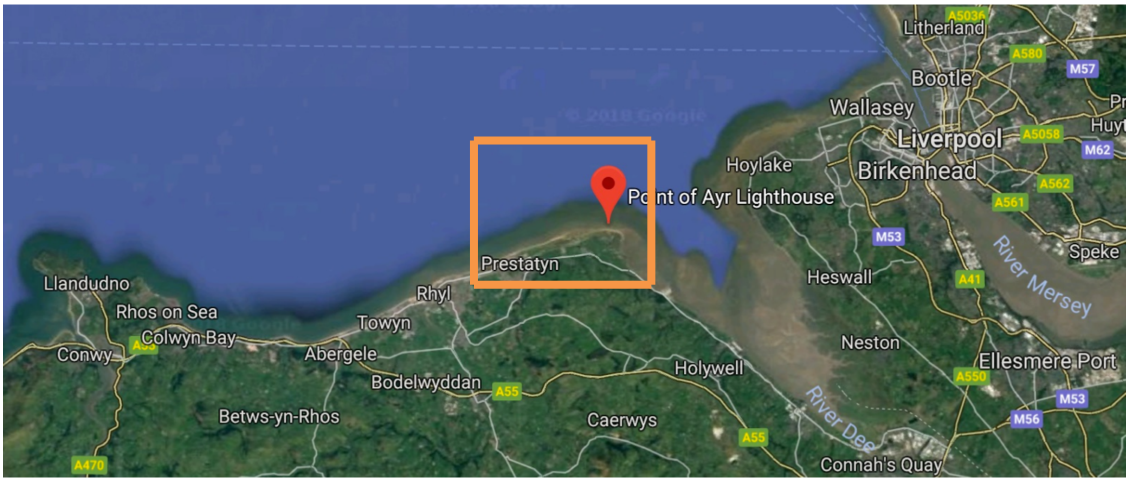
Coasts are one of two options specified by all exam boards (i.e., OCR, Edexcel, Eduqas) for the study of Systems and Landscapes. In this context, coast-based investigations should consider the following at a range of temporal and spatial scales:

- coastal landforms as a system, including energy and material inputs (e.g., sediment budgets), processes (e.g., waves, wind, currents) and outputs; students should consider both high and low energy coastal systems (e.g., sandy and rocky vs. estuarine);
- development of geomorphological features and the relationships between landforms;
- landform evolution with changing climate;
- humans and the landscape (e.g., management/impact).

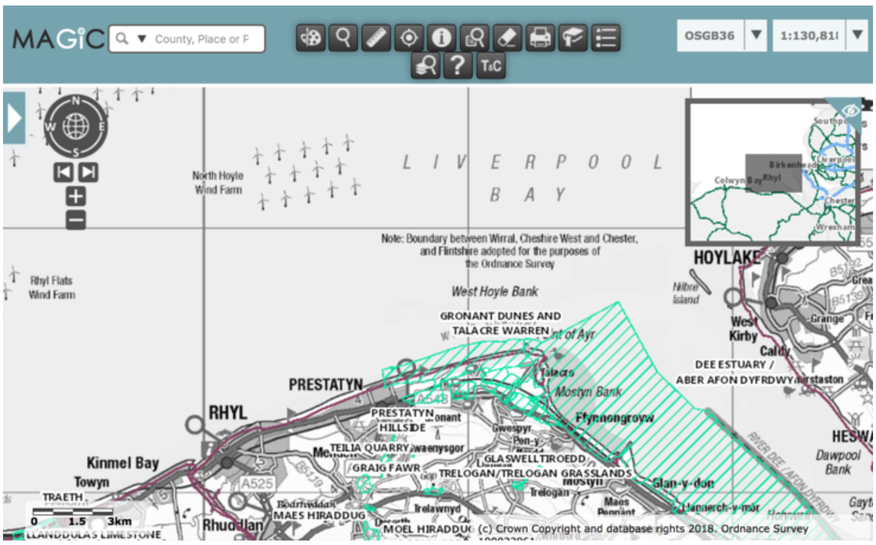
Coastal studies could also be relevant to modules on climate change (OCR), weather and climate (Educas) and non-tectonic hazards (AQA, Eduqas).

2. Case study background & practicalities (Point of Ayr, North Wales)

The example study sites used in this guide are based around Point of Ayr, the most north-easterly point of North Wales (see below a regional satellite image[1] covering the study area), where a high-energy sandy coastline meets the low-energy Dee Estuary. One site is located 5 miles west, along the beachfront of Prestatyn, Denbighshire. The field area is easily accessed from major transportation routes (road & rail).



The study area is focused around the Point of Ayr Gas Terminal (operated by Eni UK) and Talacre Beach. The land around this area is highly designated, with multiple Sites of Special Scientific Interest (SSSI)—see image below for screen grab of local MagicMap with SSSIs shown in green[2]—including Gronant Dunes & Talacre Warren SSSI and the Dee Estuary/Aber Afon Dyfrdwy SSSI. The area is actively managed to restore and create habitats for birds (including wildfowl, waders and overwintering species), protect the area from coastal flooding and shield local communities from the gas terminal.



[1] Annotated Google Maps image
[2] Screenshot from www.natureonthemap.naturalengland.org.uk/magicmap.aspx

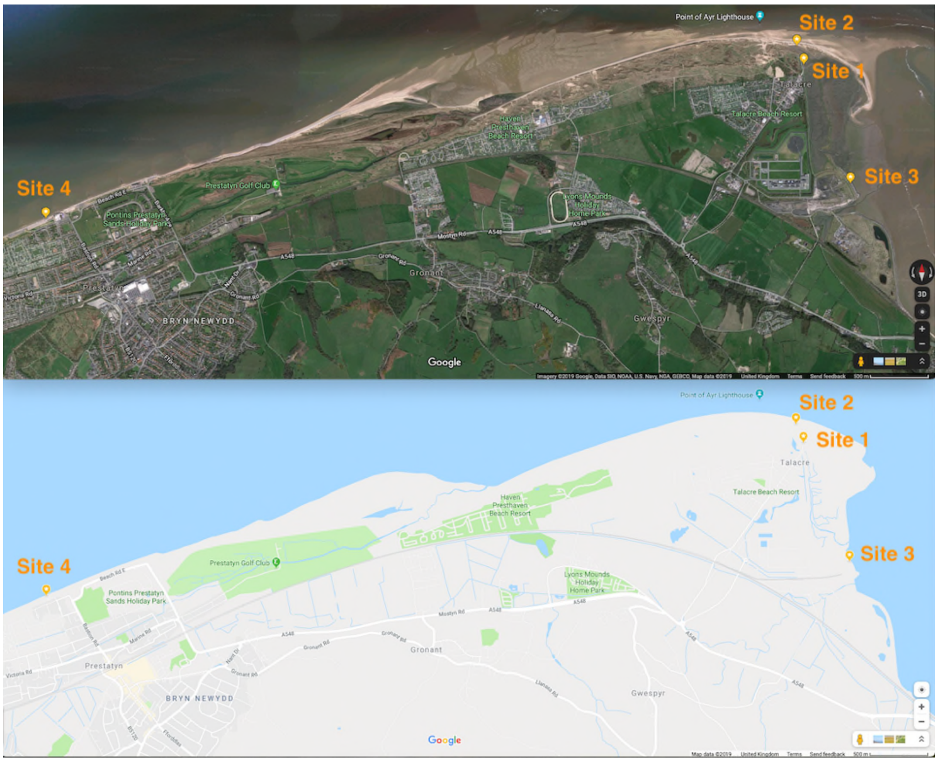
Talacre Beach is a popular tourist destination. During World War II, the dunes were the site of chalets and cottages used to house evacuees from Liverpool. Today, the village is the site of a large holiday park (see images below[3]).

Point of Ayr Gas Terminal (see image below[4]) is an onshore processing station for gas extracted in Liverpool Bay and transferred to shore via a pipeline. At this facility, gas is sweetened (i.e., sulphur is removed) before transfer via another pipeline to a power station at Connah's Quay. As a part of a planning agreement put in place when the facility was established, Eni UK purchased land around the site for the purpose of conservation and to mitigate for the loss of habitat where the Point of Ayr terminal was being built, create screening and segregate site traffic. It also supplies educational facilities at a field study centre and at the DangerPoint indoor learning centre.

[3] Images courtesy of RGS-IBG. Image licence: CC-BY-SA 4.0
[4] Image courtesy of Eni UK

2.1. *Example study sites*

The study area comprises four separate field sites (see study area map below[5]):



Site 1: Talacre Coastal Embankment (53°21'13.2"N 3°18'59.3"W; co-ordinates for public car park at the north end of Station Road).

The coastal embankment is a man-made earthen embankment with a crest height of approximately 6.5 m AOD, running for approximately 800 m along the northeast frontage of Talacre (see image below[6]). It runs from the north end of Station Road to the raised ground east of the Point of Ayr Gas Terminal.

[5] Annotated Google Maps images
[6] Google Maps street view image

Site 2: Gronant and Talacre Dunes (53°21'18.5"N 3°19'02.7"W)

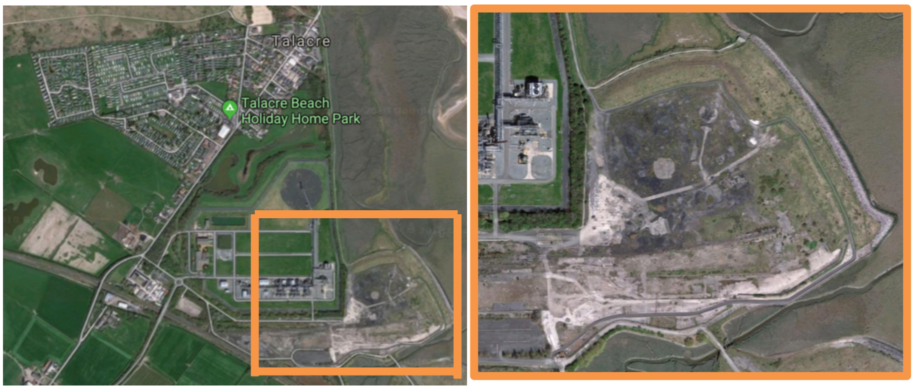
The Gronant and Talacre dunes (see image below left[7]) are part of a Site of Special Scientific Interest protected for its dune system habitats, flora and fauna (including natterjack toads [see image below[8]], sand lizards, little terns and sandhill rustic moths). The dune system is virtually the only natural coastline between the outer Dee Estuary and the Great Orme. It provides an important coastal protection function to the low-lying coastal hinterland of farmland, tourism facilities and residential areas of Talacre.

The dunes are subject to active management measures to control visitor pressure (see images below[9]), encourage sand accretion and perform species re-introductions, most notably the natterjack toad and sand lizard, both thought to have been previously extinct in North Wales. The dunes also accommodate a high-pressure gas pipeline that links the offshore gas fields to the Point of Ayr gas terminal and thence via a cross-country pipeline to a power station at the head of the Dee Estuary.

[7] Image courtesy of ERM
[8] Image by Bernard Dupont (https://www.flickr.com/photos/berniedup/40768303714). Image licence: CC-BY-SA 2.0
[9] Images courtesy of RGS-IBG. Image licence: CC-BY-SA 4.0

Site 3: Gas Colliery Quay Wall and Revetment (53°20'40.0"N 3°18'37.6"W)

The quay wall and revetment are located along the south and southeast edges of the former colliery site (see images below[10]); they protect both the industrial site and residential areas from flooding. They are actively managed as part of the environmental controls put in place during construction of the industrial site. The quay wall is approximately 220 m long and runs along the left bank of the Sluice House Gutter (watercourse). At its northeast end, it connects with the revetment, a 10 m wide coastal defence constructed from large blocks of rock armour. Similar rock armour is visible across the inlet, on the other side of the Sluice House Gutter.



The top of the revetment (see images below[11]) is a pedestrian path frequented by local residents, bird-watchers and tourists. Areas on the seaward side of the revetment are managed by the RSPB, who maintain bird watching infrastructure. Pumping stations used to manage floodwaters are visible along the path.

Site 4: Prestatyn Sea Defences (53°20'30.3"N 3°24'54.5"W)

Prestatyn is located on the Denbighshire Coast between Talacre and Rhyl. Along this stretch of coast, three beaches join to form a 5-mile stretch of sand, interspersed with groynes (wooden groynes from the 1950s/1960s and breakwater groynes constructed since 1991). Coastal flood risk affects much of the town, which sits within a low-lying coastal plain. Most of the coastal frontage is defended by raised defences, including natural sand dunes that have undergone stabilization and hard engineering comprised of sea walls,

[10] Annotated Google Maps images
[11] Images courtesy of RGS-IBG. Image licence: CC-BY-SA 4.0

groynes, rock armour and flood gates (see images below[12]); in addition, over the years a large volume of beach material has been introduced to replenish the beach.


With future climate change, rising sea levels and increases in extreme weather, both residential and economic assets in the town will be at increasing risk of overtopping or breaching of defences. Furthermore, Prestatyn has a history of pluvial flooding caused by heavy rain and surface water runoff.

Using combinations of these four sites, three coastal study fieldwork projects have been developed. These projects are designed as standalone units; however, the data from each could be used together to form a larger study of the coastal environment in the study area. Repeat visits to the field area (or any field area) over a number of years and/or seasons would allow a school to develop a comprehensive record of change, which itself could become a valuable teaching tool.

2.2. Proximity to key localities and facilities

	Locality/Facility	**Distance (based on Google Maps estimates)**
Major settlements	Manchester	60 miles / 1 hour 30 min drive
	Liverpool	40 miles / 1 hour drive
	Birmingham	113 miles / 2 hour 15 min drive
	Aberystwyth	90 miles / 2 hour 30 min drive
Major road routes	A55	< 9 miles / 20 min drive
Train station	Prestatyn[13]	< 4 miles / 10 min drive
A&E Dept.	Glan Clwyd Hospital	11 miles / 25 min drive
Bus parking	Eni UK field study centre[14]	1 mile / 15 min walk
Food outlets	Limited shops and cafes (may be seasonal)	Talacre village & holiday park
Picnic facilities	Eni UK field study centre[14]	1 mile / 15 min walk
Toilet facilities	Eni UK field study centre[14]	1 mile / 15 min walk
	Talacre Beach public toilets	Adjacent to field area
Field centres	Eni UK field study centre[14]	1 mile / 15 min walk

[12] Images courtesy of RGS-IBG. Image licence: CC-BY-SA 4.0
[13] Trains to/from London Euston (via Crewe) and Holyhead, Anglesey
[14] Situated alongside the DangerPoint indoor education centre (http://dangerpoint.org.uk/). Contact Eni UK for access (cerys.percival@Eni.com / kim.norman@external.Eni.com). Facility has an indoor classroom for use by schools

2.3. Accessibility

Most field sites are accessible on established footpaths (with a mixture of paved and unpaved walkways) within walking distance (0–15 minutes) of Talacre village and the Eni UK field study centre. However, beach and dune access require walking over sandy areas that may pose an issue for those with mobility restrictions.

Parking and visitor facilities are available at Danger Point (CH8 9RL), by prior arrangement with Eni UK, and along the Prestatyn sea-front (LL19 7EY).

2.4. Notable health & safety considerations

Wherever possible, students (particularly at A Level) should be involved in pre-fieldwork planning, including the development of health and safety risk assessments.

Guidance for fieldwork safety and planning, including the preparation of risk assessments, has been published by the Field Studies Council and can be found on the RGS-IBG website[15]. Here we detail only the main hazards associated with the case study field area.

Potential Hazard	Control Measures	Level of Residual Risk
Working near waterways[16]	Waterways will not be entered. Cross waterways by way of bridges. All attendees will have fully charged mobile phones.	LOW
Working in tidal areas	Access to beach areas will depend on tidal conditions. Tide schedules should be consulted before travel to the study site. All participants should maintain vigilance and continue to monitor changing tidal conditions.	MEDIUM
Uneven/unstable ground & slippery surfaces	Potential for slips, trips and falls. Keep to flat and level areas where possible and stay a suitable distance from steep banks. Remain aware of ground around you and move with care at all times.	LOW
Biological hazards	Potential for insect bites, particularly in areas close to standing water. Insect repellent to be used where required. The field area is popular with local dog walkers. Take necessary precautions around unknown animals (i.e., do not pet dogs without owners' permission).	LOW

Adequate clothing for outdoor fieldwork should be worn or carried, including: long sleeved tops, trousers, sturdy shoes and wet weather gear.

The example study area includes sites of scientific interest and habitat sensitivity. Always consider the impacts of activities on the local environment. To mitigate negative impacts,

[15] https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/risk-assessments/
[16] The RGS-IBG has produced a series of videos on safety when working around water. These can be accessed at *https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/safety-around-water/*

please keep to established footpaths wherever possible. When accessing sand dunes, move as a group and walk directly through (i.e., do not spread out over the dunes).

2.5. Other resources for coastal fieldwork planning

The RGS-IBG guide to A Level independent investigation[17] covers a range of topics, including guidance on data collection, analysis and presentation techniques; this information could also be used to guide GCSE level investigations. Specific ideas for coast-based fieldwork[18] and for classroom activities to address relevant theoretical concepts and data skills[19] have also been produced by the RGS-IBG and by the Field Studies Council[20] and are available online. The Internet provides an excellent source of materials to help with fieldwork planning and execution.

[17] https://www.rgs.org/schools/teaching-resources/a-student-guide-to-the-a-level-independent-investi/
[18] https://www.rgs.org/schools/teaching-resources/coasts-(1)/
[19] https://www.rgs.org/schools/teaching-resources/coasts/ and https://www.rgs.org/schools/teaching-resources/coastal-processes-and-management/ and https://www.rgs.org/schools/teaching-resources/coasts/planning-coastal-fieldwork/
[20] https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/

3. Fieldwork project 1: contrasting approaches to coastal defence

3.1. Introduction

Coastal defences are an area of critical concern for residents, businesses and local & regional governments along coastal margins. Coastal areas are of very high value for numerous (often competing) sectors and services, including environmental services (e.g., natural features, habitats), tourism and recreation, residential development, transportation infrastructure, the military, industrial development and infrastructure.

Approaches to protecting and defending highly valuable coastal assets have been considered and employed for millennia[21]; despite this, they remain hotly debated. For many, the protection of economic and social assets (e.g., urban areas, industrial sites, beaches with high tourism footfall) warrants the use of hard engineering approaches (e.g., seawalls, groynes), despite potential long-term impacts on shoreline evolution, particularly for coastal areas down-coast. Others advocate the use of soft engineering approaches that require greater investment and longer-term management strategies, but that offer greater sustainability and environmental protection. Some advocate no intervention at all. In practice, the choice of coastal defences is controlled by many factors, including the social, economic and political climate; local, regional and national stakeholders; and technological advancements.

In the example study area, the Talacre coastline is very dynamic and coastal defences are being used, albeit in different ways, to protect heavy industry, tourism, local populations and natural habitats. The scale of change over time has been significant. For example, aerial images[22] of the beach and Talacre Lighthouse in 1992 show the dunes some distance away (below left) and in 1955 show the dunes close by (below right).

[21] https://www.telegraph.co.uk/science/2017/07/03/secret-roman-concrete-survived-tidal-battering-2000-years-revealed/
[22] Images courtesy of ERM

Furthermore, an 1815 William Daniel painting of the lighthouse shows the dunes directly adjacent, while in an image of the lighthouse from 2018, the dunes are out of shot behind the photographer[23].


This activity asks students to characterise and compare coastal processes and features along beaches using different coastal defences. Students should use their data to assess the pros and cons of each management strategy, including environmental, social and economic considerations. They should also consider the future of coastal defence strategies, with particular reference to the pressures of changing climate.

3.1.1. Links to curricula

At GCSE, this activity directly contributes to the study of physical landscapes in the UK, a core module for all of the exam boards. In each case, coastal landscapes are given as one of the three study options. Students will consider coastal landforms and processes, and the role of climate change, human impact and management.

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can address each of the skills areas specified for GCSE geography by the Department of Education.

- Cartographic skills: use different types of maps (e.g., topographical, aerial, hazard) at a range of scales (e.g., national, regional, local) to extract information about a study area (e.g., latitude, longitude, geological setting, topographical setting, local infrastructure, landforms); students should also be able to produce sketch maps and interpret cross-sections and transects.
- Graphical skills: students should be able to use and apply appropriate graphs and charts (e.g., line charts, bar charts, etc.); they should also be able to produce hand-drawn images to present and record information.
- Numerical skills: students should appreciate the concepts of number, area and scale and the relationships between units; they should collect fieldwork data and understand its limitations (e.g., accuracy, sample size, etc.).
- Statistical skills: select and use statistical techniques appropriate to the data type.
- Consider techniques that measure flow (e.g., longshore drift), scale (e.g., grain size), spatial patterns (e.g., sediment deposition along a beach) and temporal change.

[23] Images courtesy of (left) ERM and (right) Tornillo Scientific (Image licence: CC-BY-SA 4.0)

- Develop research and fieldwork planning skills, including the development of hypotheses, the planning of appropriate fieldwork procedures and consideration of health and safety.
- Present findings with a text report that should be descriptive, analytical and critical.

At A Level, this activity falls within the study of Systems and Landscapes. Students will investigate coastal processes and landforms and the relationships between then. They will also consider the role of humans in the landscape (e.g., management/impact) and future coastal change as a result of climate change.

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can develop many of the skills required by the Department of Education for A Level geography students.

- Understand, collect and use different types of geographical information (e.g., qualitative vs. quantitative, primary vs. secondary).
- Collect and analyse information, and critically assess data sources, methodologies and data outputs/reporting, including the ability to identify data misuse and sources of error.
- This module has a particular focus on the use of quantitative data, for which students should be able to: collect, analyse and present geo-referenced data; apply appropriate statistical and data plotting techniques; perform simple calculations.

3.1.2. 'Real-world' examples

Although professional coastal surveys may use more stringent methodological protocols and expensive, high-tech equipment, the basic analysis approaches available to GCSE and A Level students are directly comparable to those used by 'real-world' practitioners. Example of 'real-world' projects and studies related to coastal defences include:

- a 2003 report on the Cromer Coastal Defence Strategy Study[24]. Cromer is a coastal town with competing interests from residents, tourism and industry. The area has a history of coastal erosion and coastal defence projects. In this study, the area's environmental value (e.g., designated areas, geology, flora and fauna, historic sites, tourism & recreation), hydrodynamic conditions (e.g., waves, tidal currents), shoreline processes and evolution (e.g., sediment transport, beach changes, longshore drift, etc.) were all considered. The study used a variety of techniques, of which computer modelling of future change for different management options was an important component;
- a 2009 report from the OSPAR Commission, a co-operative group consisting of 15 European countries with an aim to protect the marine environment of the Northeast Atlantic[25]. This report considers in detail the impacts of coastal defence structures. The report contains a number of excellent case studies of different coastal management approaches (e.g., the soft approaches used along the low-lying Netherland's coast, where hard engineering is only permitted in exceptional cases;

[24] https://www.north-norfolk.gov.uk/media/3084/cromer-coastal-strategy-study.pdf
[25] https://qsr2010.ospar.org/media/assessments/p00435_Coastal_defence.pdf

- a 2002 EU funded report on coastal erosion indicators at the European level[26]. These indicators cover changes in coastal erosion, the identification of erosion hot spots and the impacts of climate change (storm surges and sea level rise). Technical sheets are provided to allow practitioners to implement the suggested indicators.

With the advent of new technologies, the professional study of coastal change is increasingly employing complex computer modelling and remote analysis techniques, including aerial and satellite remote sensing data, which allow for rapid analysis over large areas. For example:

- in a 2017 study[27], scientists and engineers in India used analytical modelling and remote sensing to assess the impacts of seawall construction on adjacent beaches and on coastal dynamics. Using this approach, the investigators were able to estimate longshore material transport and landward erosion up to a kilometre down-coast of a seawall over a multi-year period.

Students should be encouraged to think about possible sources of publicly available remote sensing or modelling data for their field site (e.g., Google Earth, Google Maps, Met Office satellite imagery, earth[28]).

[26] https://www.eea.europa.eu/data-and-maps/data/hydrodynamics-and-sea-level-rise/coastal-erosion-indicators-study/coastal-erosion-indicators-study/

[27] http://journals.sagepub.com/doi/full/10.1177/1759313117712180

[28] Interactive global current wind, weather, ocean, and pollution conditions as forecast by supercomputers and updated every 3 hours: https://earth.nullschool.net/

3.2. Site selection

This activity requires access to a coastal area. While the techniques used and skills developed can be applied at a single site, the activity best meets curricula requirements if students are able to access at least two or three contrasting locations preferably along the same coastline.

The UK offers four options for shoreline management[29]: (1) No active intervention; (2) Hold the (existing defence) line (i.e., replace or maintain existing artificial defences to maintain the current shoreline position); (3) Managed realignment (e.g., allow natural evolution of the shoreline, but with active management of certain processes to direct evolution in certain ways); and (4) Advance the line (i.e., construction of new defences on the seaward side of existing defences). Ideally, site selection would include at least two contrasting locations with regards to management approach; for example:

- an unprotected stretch of coast with no active intervention;
- a highly engineered coastline consisting of hard engineering structures (e.g., groynes, seawalls, breakwaters, dikes);
- a section of coast managed using soft engineering approaches (e.g., dune regeneration, artificial reefs, mangrove or marsh creation, vegetation planting).

In the example field area (Point of Ayr), this activity could be completed with visits to sites 2 and 4:

- Site 2 (Talacre Beach, on the seaward side of the Gronant and Talacre Dunes) represents a stretch of coast protected by natural sand dunes that are themselves actively managed to maintain their natural function. This is one of the only sections of natural coastline along the North Wales coast;
- Site 4 (Prestatyn Beach, on the seaward side of the Prestatyn sea defences) represents the heavily engineered coastal front of an urban area.

While sites 1 and 3 do not allow a full suite of data collection (owing to seashore proximity and/or access issues), they do offer insights into coastal defence and management; as such, they may be worth a visit to collect supporting data:

- Site 1 (Talacre Coastal Embankment) represents an earthen embankment that straddles the line between hard and soft coastal engineering. Situated behind the dune system, the embankment does not directly impact on the shoreline, but rather provides a secondary level of defence on the landward side of the main defence system (i.e., the dunes);
- Site 3 (Gas Colliery Quay Wall and Revetment) represents hard coastal engineering designed to protect an industrial site.

[29] http://apps.environment-agency.gov.uk/wiyby/134834.aspx

3.3. Pre-fieldwork activities

3.3.1. Questions & hypotheses

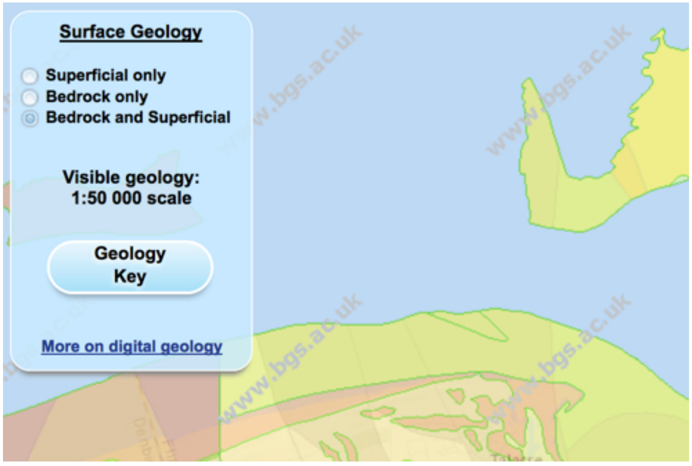
Identification of scientific questions & hypotheses: Students should be required to develop a series of scientific questions and associated hypotheses to test through fieldwork. For example, these could relate to;

- the nature of coastal evolution as a function of hard vs. soft engineering;
- coastal erosion rates as a function of managed intervention vs. no intervention;
- coastline morphology and sedimentary conditions above/below coastal defences.

3.3.2. Metadata collection

Field area cartography: before embarking on fieldwork, students should source relevant maps of the study area. Students should identify each proposed study site on the map and then use the map to extract information on the study site setting. Depending on map type, students should identify local and regional scale coastal morphology, identify the geological setting and consider what impacts this might have on coastal evolution, identify proximal natural features/processes, identify types of land use and human infrastructure, and where information is available, how land use has changed over time. Map types may include:

- location on global and UK scale maps;
- current and past Ordnance Survey maps of the study area;
- geological map of the study area (see example below)[30];



- current and past aerial and satellite images of the study area;
- maps of designated (i.e., protected) areas in and around the field area[31];
- Environment Agency coastal erosion maps of target areas[32].

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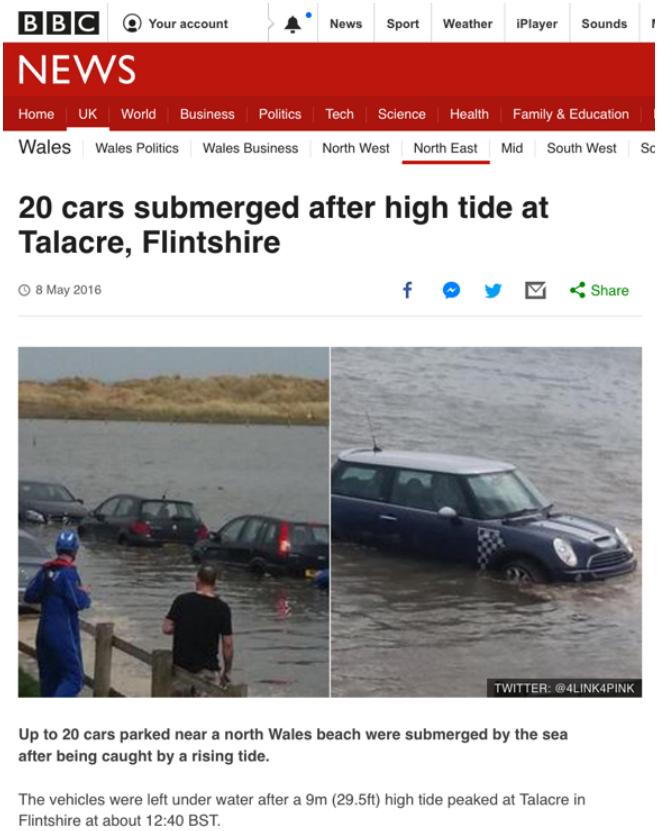
30 e.g., the British Geological Survey (BGS) iGeology App for smart phones provides geological maps and borehole data for the United Kingdom (http://www.bgs.ac.uk/igeology/). The BGS GeoIndex provides multi-layer maps of geological and other relevant information, available online (http://www.bgs.ac.uk/geoindex/) or as a download to use with GIS applications. Example map shows an iGeology screenshot of Point of Ayr geological map

31 http://www.natureonthemap.naturalengland.org.uk/magicmap.aspx

32 http://apps.environment-agency.gov.uk/wiyby/134831.aspx

Other secondary data sources: students should be encouraged to identify and source other secondary data that may provide insights into the field site (e.g., Environment Agency records and information[33], tidal records[34], flood risk maps[35], newspaper reports, planning applications, local guides and publications[36], etc.).

The image below shows a screenshot of BBC report on a 2016 tidal flooding event at Talacre[37].



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20 cars submerged after high tide at Talacre, Flintshire

8 May 2016

Share

Up to 20 cars parked near a north Wales beach were submerged by the sea after being caught by a rising tide.

The vehicles were left under water after a 9m (29.5ft) high tide peaked at Talacre in Flintshire at about 12:40 BST.

3.3.3. Plan of work

Site selection: students (particularly at A Level) should be involved in the planning of fieldwork. Where possible, this could include site selection from relevant maps or from pre-fieldwork scouting trips to the proposed field area. Where sites have already been selected (e.g., for Point of Ayr), students should be asked to consider why those sites have been selected (e.g., accessibility, notable natural or human features of interest).

Students should consider what coastal processes and landforms could be measured at each site and the most appropriate techniques for measuring those processes should be

[33] https://www.gov.uk/government/organisations/environment-agency
[34] https://www.bodc.ac.uk/data/hosted_data_systems/sea_level/uk_tide_gauge_network/ and http://www.ntslf.org/networks
[35] https://flood-map-for-planning.service.gov.uk/
[36] Print copies of local guides are available from the Danger Point information centre
[37] http://www.bbc.co.uk/news/uk-wales-north-east-wales-36243086

selected (e.g., by reference to this document or through reference to other fieldwork guides or past fieldwork experience). When selecting and planning fieldwork techniques, students should consider the role of sampling on the quality and relevance of their data[38].

On completion of fieldwork planning and metadata collection, students should review the study aims and objectives, including scientific questions and hypotheses, and: (i) confirm that the proposed approach will address the scientific questions, and (ii) ensure that the hypotheses remain relevant in light of new information from metadata collection.

3.3.4. Logistical planning

Students should be encouraged to develop a realistic plan for fieldwork, including a proposed timetable of site visits that takes into account the number and locations of field sites, the number of people within a group, the time required for data collection at each site and the time available for fieldwork.

Prior to fieldwork, students should be required to procure or construct appropriate equipment to complete the proposed data collection activities.

Students should be asked to consider the health & safety implications of the chosen field sites and data collection techniques. Students should be encouraged to create, or contribute to, risk assessment development. Guidelines on fieldwork safety and planning, including guidance on the preparation of risk assessments, have been published by the Field Studies Council and can be found on the RGS-IBG website[39].

[38] https://www.rgs.org/schools/teaching-resources/sampling-techniques/
[39] https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/risk-assessments/

3.4. Measurable processes and field data collection techniques

The following section contains a list of fieldwork techniques that are relevant to the study of coasts and coastal defences. All or some of these techniques could be incorporated into a field project, depending on the exact scope and on the time available. In general, students should be encouraged to think carefully about which techniques will best address their scientific questions AND meet the time and budgetary constraints of the fieldwork.

Each of the measurement techniques could be employed during a single site visit. This would provide a snapshot of the coast at a given location for a given time. However, repeat measurements at different times (e.g., before and after a storm event, winter vs. summer) could provide a richer and longer-term dataset for student analysis.

A number of additional extension activities could also be considered for the most advanced students; for example, students could be encouraged to calculate wave energy at different locations, and then be asked to design appropriate rock amour protection using Hudson's equation. Alternatively, they could measure the various attributes of existing rock armour and use Hudson's equation to identify the largest waves against which the rock armour will remain effective. The details of Hudson's equation are beyond the scope of this guide, but can be found online[40].

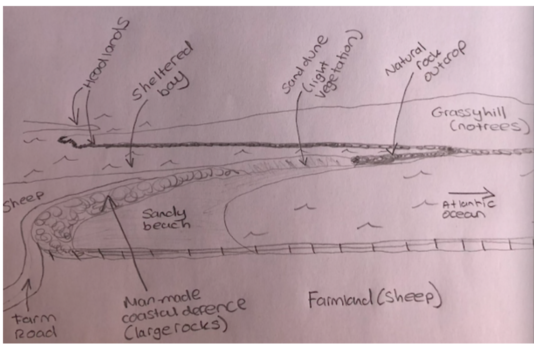
[40] e.g., https://www.brighthubengineering.com/geotechnical-engineering/93060-using-hudsons-equation-for-riprap/ and http://www.pilebuck.com/highways-coastal-environment-second-edition/chapter-6-coastal-revetments-wave-attack/ and https://www.dec.ny.gov/docs/water_pdf/waverosionrevetment.pdf

3.4.1. Field notebook

On arrival at each field site, students should record observational data on the field site setting in their field notebook. In some professional settings, a field notebook (hand-written or digital) is a legal document that could be used in legal proceedings[41]. For other professionals, the information recorded in a field notebook could be critical for later stages of data processing. Learning good field notebook skills is a critical part of professional fieldwork training. In this activity, the following should be recorded for each field site:

- date, time, weather conditions and mood of the investigator (these can impact on the quality of data collection);
- name of the field site and location (i.e., GPS waypoint and/or latitude and longitude from a smart phone, handheld GPS or paper map);
- brief description of the site, including surrounding land use and infrastructure, landforms and site conditions (vegetation, human impacts);
- observed management approaches to coastal defence. The UK offers four options for shoreline management[42]: (1) No active intervention; (2) Hold the (existing defence) line (i.e., replace or maintain existing artificial defences to maintain the current shoreline position); (3) Managed realignment (e.g., allowing natural evolution of the shoreline, but with active management of certain processes to direct evolution in certain ways); and (4) Advance the line (i.e., construction of new defences on the seaward side of existing defences);
- site sketch with critical features clearly labelled;
- where data are available, a note of storms in the study area in the days, weeks and month prior to data collection should be made;
- data on selected measurements.

Examples of field notebook, sketching and photography good practice have been developed by the University of Liverpool[43] and the RGS-IBG[44]. A good site sketch gives a sense of scale and the spatial distribution of features. The images below show an example field sketch and accompanying photograph[45]; it can be seen that field sketches do not need to be artistic, they merely need to convey the main features of a site.

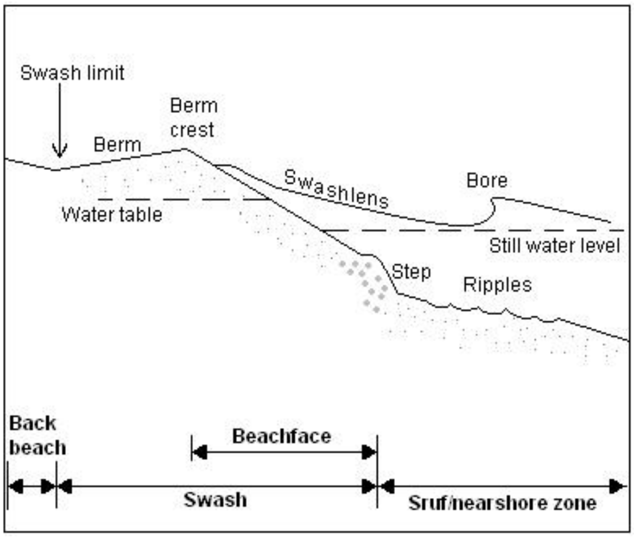


[41] https://www.abcls.ca/wp-content/uploads/pdfs/Field-notes-Link-article-Oct-9-2015-Final.pdf
[42] http://apps.environment-agency.gov.uk/wiyby/134834.aspx
[43] http://www.esta-uk.net/fieldworkskills/tips.htm
[44] https://www.rgs.org/schools/teaching-resources/sketching-and-photography/
[45] Images courtesy of Tornillo Scientific. Image licence: CC-BY-SA 4.0

3.4.2. Description of coastal features, processes and coastal defence structures

What is measured?

Students should use simple visual observations and sketches to identify the main coastal landforms (e.g., beach, dunes, cliffs; see example sketch below[46]), processes (e.g., evidence for erosion/deposition, evidence of tides, waves) and coastal defences (e.g., groynes, seawalls). Students should consider multiple ways that a single process can come about; for example, erosion can be natural (wind erosion scars on dunes) or manmade (pathways through the dunes).



For flood defences, students can use bi-polar analysis, as detailed in online resources from the Field Studies Council[47], to qualitatively but consistently compare different defence structures. In this method, students use a point system to assess each feature in terms of different factors (e.g., susceptibility to erosion, aesthetic factors, lifespan, impact on other processes, etc.).

Qualitative descriptions of all features should also be made; for example, descriptions of land use on the seaward and landward sides of structures that run parallel to the coast (see image below left[48]) and notes on clear changes in landforms up-beach and down-beach of defences that run perpendicular to the coast (e.g., beach steepness and sediment height on either sides of groynes; see image below right[49]).

[46] Image by Maki Akiyama. Image licence: CC BY 3.0, from Wikimedia Commons
[47] https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/
[48] Image modified from: Pete Riches (https://www.flickr.com/photos/peteriches/4181386116/in/photolist-7nuGq5-aCDCLS-sPQgA8-nv6XTn-bxAVCF-mv5Eof-sAGbXD-6gX5wp-7FvUyk-f4iDDY-cFKXrw-6gX4zX-CdWfL-7E1Q8k-c2yW8Q-7FvUVr-cFKVfh-7FzPS5-cFKZuQ-6M3wAr-cFKUqQ-tm7DTA-ddJg7C-8UqTsq-cFKVGu-cFKVpw-cFKUMG-dftkRY-cFL38o-cFL1Yo-7FzPYb-7FvUEn-cFKWXf-9dPnnj-cFKYCm-cFKXeN-9dLqxM-7E5EEq-7FC13t-9q8DYD-oYEwA-6VHaVc-cFL1b3-cFKZFS-cFKZ9u-cFKYTj-cFKXHq-ddJaoQ-6hgGzR-9nqdxw). Image licence: CC-BY 2.0
[49] Image modified from: Beatrice Murch (https://www.flickr.com/photos/blmurch/952523971). Image licence: CC-BY-SA 2.0

Note, some soft-engineering coastal defences may not be immediately obvious; for example, earthen embankments and features designed to protect and reinforce dunes. At Talacre, the dunes contain specially designed wooden sand-ladders on pathways to reduce erosion (see images below[50]), and in some places Christmas trees have been buried in the sand to help stabilise the dunes[51].

Students should identify any points of weakness (e.g., gaps) in coastal defences and consider why these gaps exist.

[50] Images courtesy of RGS-IBG. Image licence: CC-BY-SA 4.0

[51] Christmas trees are visible within the base of dunes on the seaward side. More information can be found at the Eni UK Field Centre. https://www.bbc.co.uk/news/av/uk-wales-25639536/christmas-trees-used-to-rebuild-talacre-sand-dunes-after-tidal-storms

Site requirements

Any coastal location. Ideally, multiple locations with different management approaches should be compared.

Equipment and associated costs

This activity only requires a field notebook and pencil. A camera can also be useful to record observations, but should not replace note taking and field sketches.

Number of data points needed (data resolution)

The number of observations will depend on the site and the coastal defence systems in place. However, students should be encouraged to consider carefully the landscape, as many soft coastal defences can be discrete.

Professional measurement techniques

Basic field site observations are critical for fieldwork at any level. However, many professional coastal studies will also use secondary data to identify key features (e.g., maps, management reports, etc.).

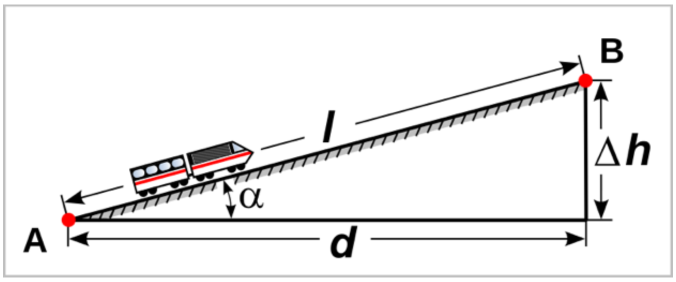
3.4.3. Beach profiles (gradient)

What is measured?

Beach profiles allow an assessment of shoreline morphology. Profiles at different locations along the coast can be used to compare and contrast the impacts of coastal management approaches. Beach profiles can also be used to investigate seasonal changes in coastal morphology or the impact of storm events.

Profiles are created by measuring the beach gradient, where gradient is equal to the difference in height between two sites divided by the distance between those sites. See below a diagram of 'gradient'[52], where:

$$gradient = \Delta h / d$$



Gradient is measured by placing two measuring poles at sites a known distance apart (see image below[53]). The angle between the matching height horizons on each measuring pole is measured using a clinometer. For best results, students should take multiple gradient measurements from the shore across the full width of the beach. A new measurement should start wherever there is a significant change or break in the gradient.

[52] Madcap, from Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Grade_dimension.svg). Image licence: Image in the public domain

[53] Measuring gradient by the Field Studies Council (https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/). Image licence: CC_BY

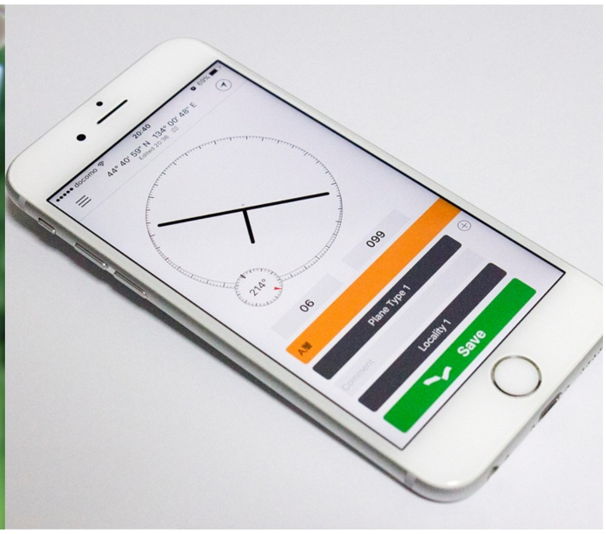
Guidance on performing beach profiles is available from the RGS-IBG[54] and from other online resources[55].

Site requirements

Safe access to a beach. Preferably students will be able to access multiple locations along a beach or on proximal beaches to compare and contrast profiles relating to different management regimes and/or natural processes.

Equipment and associated costs

Low cost gradient measurements require two surveying poles (metre rulers will usually work) and a clinometer (see image below left[56]). Clinometers can be purchased cheaply, can be constructed from basic stationery[57] or are available at lost cost for use on smartphones[58] (see image below right[59]).



Number of data points needed (data resolution)

Each individual profile will contain a number of data points, with gradient measurements taken between each break in slope across the width of the beach.

Students should create enough profiles to compare and contrast the impacts of different features/conditions on a beach profile (e.g., above and below coastal defence features, at the same location before and after storm events, at the same location in different seasons).

[54] https://www.rgs.org/schools/teaching-resources/coasts-(1)/
[55] http://www.geography-site.co.uk/pages/skills/fieldwork/fluvial/grad.html
[56] Image modified from: Silva Expedition 4 compass-clinometer (https://en.wikipedia.org/wiki/Silva_compass#/media/File:Silva_compass,_Expedition_4.jpg). Image licence: CC-BY-SA 3.0
[57] https://www.rgs.org/schools/teaching-resources/make-your-own-clinometer/
[58] e.g., https://itunes.apple.com/gb/app/seelevel-visual-clinometer/id333213338?mt=8
[59] Image modified from: Rufiyaa (https://commons.wikimedia.org/wiki/File:Clinometer_on_smartphone.jpg). Image licence: CC-BY-SA 4.0

Professional measurement techniques

Professional surveying techniques often rely on simple surveying poles and professional clinometers; however, some surveyors will use theodolites (see image below[60]) and laser equipment to measure distances and gradients. Over wider scales, gradient can also be extracted from LiDAR data, topographical maps, satellite data and digital elevation models (DEMs).

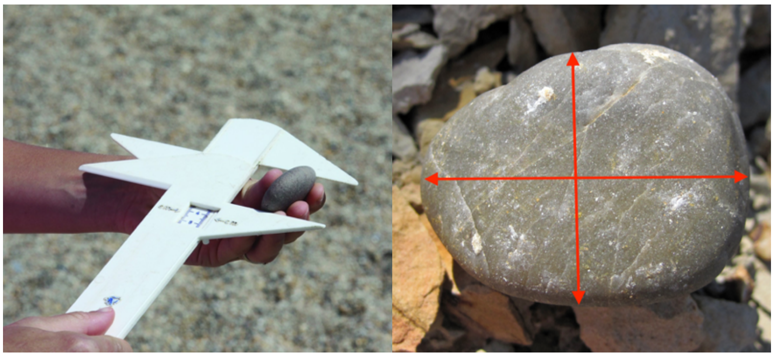
[60] Image by Kenneth Allen (http://www.geograph.ie/photo/4190504). Image licence: CC-BY-SA 2.0

3.4.4. Sediment analysis (grain sizes and sediment movement)

What is measured?

Beach sediment analysis includes the characterisation of beach material along a beach profile (parallel or perpendicular to the coastline. Sediment analysis at different locations along the coast can be used to compare and contrast the impacts of coastal management approaches, to investigate seasonal changes in beach material and to investigate the impact of storm events on beach material. Where appropriate and possible, beach material can be analysed to investigate the sources of sediments. Data on sediments and sediment sorting can be used in conjunction with longshore drift to consider material transport along a coastline.

For pebbles, use callipers or a ruler to measure and record the longest and shortest axis (see images below[61], or for a more detailed investigation, measure the a, b and c axes[62]). This process should be repeated 10 times for each sample point. If investigating the origin of coastal material, you may also consider describing the pebble, taking a photograph or even collecting it for further analysis back in the classroom.



The grain size of sand can be qualitatively assessed by comparison to a geological grain size chart or by using a series of sieves.

Further data analysis, including calculation of pebble roundness, should be completed back in the classroom (see post-fieldwork activities).

Additional guidance on performing beach sediment analysis is available from the RGS-IBG[63].

Site requirements

Safe access to a beach. Preferably students will be able to access multiple locations along a beach or on proximal beaches to compare and contrast sediment size and sorting under different conditions.

61 (left) Using callipers to measure the a, b and c axes of a pebble; image modified from: Field Studies Council (https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/), image licence: CC_BY / (right) Image modified from: James St. John (https://www.flickr.com/photos/jsjgeology/39200485210). Image licence: CC-BY 2.0
62 https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/
63 https://www.rgs.org/schools/teaching-resources/coasts-(1)/

Equipment and associated costs

Ideally, pebble dimensions should be measured using callipers, which can be purchased cheaply or at moderate cost; a normal ruler can be used for less accurate data collection.

Geological grain size charts can be purchased cheaply[64]. Sieve sets for soil and sand grain size analysis range in price; however, they are durable and can be used for many years.

Number of data points needed (data resolution)

To ensure fair sampling, a consistent sampling technique should be used at each site.

For sandy beaches, samples of sand could be collected at designated intervals across or along a beach profile (e.g., every 2 m from the low-tide mark to the back of the beach). The chosen interval will depend on the width or length of the transect being investigated.

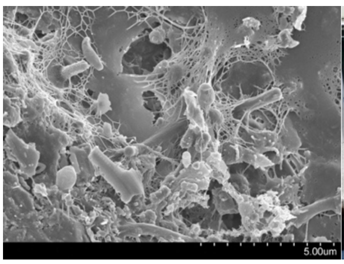
For pebbles, a ranging pole or foot could be placed at each measurement interval and 10 of the pebbles touching or closest to that pole or foot could be selected. Alternatively, a quadrat could be used and the 10 largest pebbles selected for measurement.

Students should collect samples from enough points to allow them to compare and contrast the impacts of different features/conditions on beach sediment sorting and budget (e.g., across the beach width, above and below coastal defence features, the same point before and after storm events, the same point in different seasons).

Multiple measurements of each variable allows for the calculation of an average (e.g., mean or median) and an indicator of data spread (e.g., standard deviation).

Professional measurement techniques

Professional sediment analysis can include the simple collection and measurement techniques described above, but may also employ more intensive examinations of pebble and sand composition/morphology using expensive, high-tech laboratory equipment; for example, scanning electron microscopes (SEMs; see image below left[65] and centre[66]) and laser granulometers (see image below right [67]).

[64] https://www.ukge.com/en-gb/Grain-Size-Cards__p-2796.aspx
[65] Image by ZEISS Microscopy (https://www.flickr.com/photos/zeissmicro/10710025785). Image licence: CC-BY-SA 2.0
[66] SEM sand grain image courtesy of the Lewis Lab at Northeastern University (https://www.flickr.com/photos/adonofrio/albums/72157623620596451). Image created by Anthony D'Onofrio, William H. Fowle, Eric J. Stewart and Kim Lewis. Image licence: CC-BY 2.0
[67] Mastersizer 3000 laser granulometer. By Plogeo. Image licence: CC BY-SA 4.0, from Wikimedia Commons

3.4.5. Longshore drift

What is measured?

Longshore drift is the movement of material along a coastline; it is impacted by coastline morphology, coastal defences, seasons and weather conditions.

Guidance on measuring longshore drift is available from the RGS-IBG[68]. To measure longshore drift, students should select a distance along which to measure (e.g., 10 m), and this should be demarcated using a tape measure. A floating object is placed in the water at the start point and a stopwatch is used to time how long it takes the object to travel the designated distance. Alternatively, students can choose a set time (e.g., 2 minutes) and then measure the distance travelled within that time.

Site requirements

Safe access to a beach. Preferably students will be able to access multiple locations along a beach or on proximal beaches to compare and contrast longshore drift under different conditions.

Equipment and associated costs

Longshore drift can be cheaply measured using a tape measure, stopwatch and a floating object. The floating object should be easy to see (e.g., a bright colour). As there is a chance that the floating object will be lost, the object should be biodegradable (e.g., an orange).

Number of data points needed (data resolution)

Longshore drift can be measured three to five times at each site to yield an average (e.g., mean) value along with an indicator of data spread (e.g., standard deviation). Students should measure longshore drift at multiple locations (e.g., above and below coastal defences or other major coastal features).

Professional measurement techniques

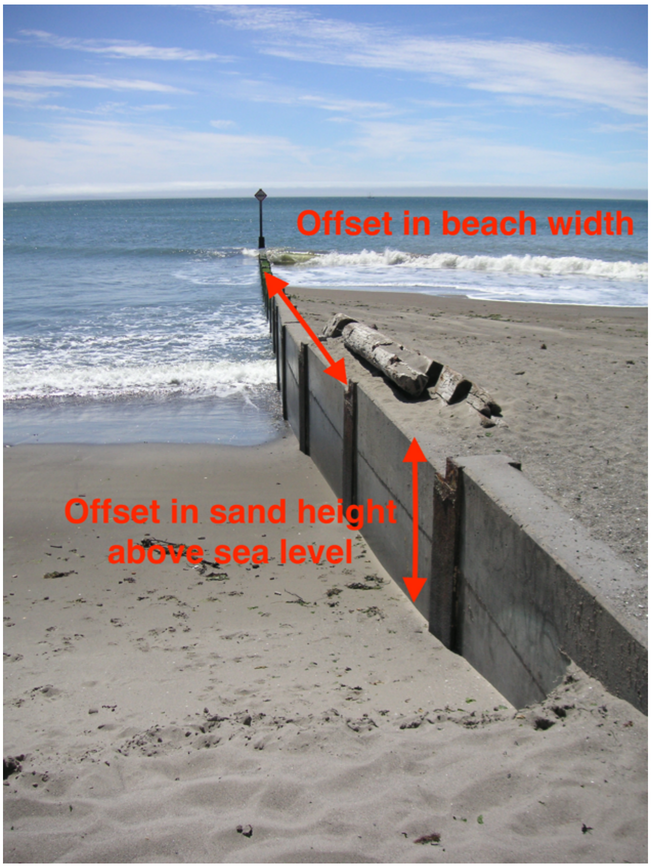
Longshore drift can be professionally measured using the simple technique outlined above; however, more accurate high-tech approaches can also be used (e.g., current meters, streamer traps, Fourier transform analysis of pixels in video imagery[69]).

[68] https://www.rgs.org/schools/teaching-resources/coasts-(1)/
[69] https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2003JC001774

3.4.6. Sediment distribution around man-made features

What is measured?

Natural sediment movement is interrupted by human structures; for example, sand will accumulate against one side of groynes. To assess the impact of human structures on sediment movement, students can measure the distance between the top of the groyne and the top of sand on either side of the groynes (see image below right[70]).



Guidance on measuring the impact of groynes is available from the RGS-IBG[71].

Site requirements

Safe access to a beach with groynes or other human features running perpendicular to the coastline.

Equipment and associated costs

This measurement requires only a meter ruler.

[70] Image modified from: Beatrice Murch (https://www.flickr.com/photos/blmurch/952523971). Image licence: CC-BY 2.0
[71] https://www.rgs.org/schools/teaching-resources/coasts-(1)/

Number of data points needed (data resolution)

Multiple measurements should be taken at regular intervals (e.g., every 1 m) on both sides of the groyne and along its full length (e.g., from the low tide mark to the top of the beach). Data can then be presented either as an average measurement (e.g., mean or median) with an indicator of data spread (e.g., standard deviation), or as individual data points distributed along a linear feature.

Professional measurement techniques

The interruption of sediments along coastlines is often professionally assessed using aerial and satellite imagery.

3.5. Post-fieldwork activities

In the professional world, fieldwork often represents only a small part of a project's duration. The post-fieldwork data analysis stage is usually the longest part of any study. Here we outline some of the main steps in the post-fieldwork process and highlight some of the key post-fieldwork calculations and analyses performed using the data collected from coastal field sites.

3.5.1. Data organisation & input

On return to the classroom, students should transfer field data from their field notebook onto a computer or tablet. Students should consider the best storage options for their data (e.g., Microsoft Excel, Microsoft Word, ArcGIS, Google Earth). If data were collected by a group, students should consider approaches to data management and data sharing (e.g., Google Drive, Dropbox). It may be appropriate for each group to develop a brief data management plan.

3.5.2. Data analysis & visualisation

Students should consider the most appropriate statistical techniques[72] and chart types to analyse and present their data. Students should ensure that they consider the accuracy and limitations of their data; this should be clearly stated in their final report.

Coastal-specific data analysis methods and calculations can be found in section 3.6 (below).

Students should be encouraged to consider how GIS tools could help them to visualise and present their data. Guidance on getting started with GIS in the classroom is available online[73].To support GIS education in schools, ESRI have made ArcGIS Online free for all UK schools. Full details, including help getting started and guidance on using ArcGIS for recording and reporting on fieldwork, are available online[74].

Based on the field data collected and any supporting metadata, students should provide an interpretation for their findings. They should return to their original scientific questions and hypotheses and use their results to show how these were met (or not). Students should also be encouraged to think about how their data may have changed under different field conditions (e.g., after a storm event, during different seasons). Students should consider how climate change might impact on their field sites.

Students should consider the positive and negative aspects of the different coastal management approaches used at the field sites. This assessment should be based on collected data, but should also consider other factors (e.g., cost of structures, economic and social impacts of flooding).

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[72] https://www.rgs.org/schools/teaching-resources/fsc-statistical-methods/
[73] Getting started with GIS in teaching (https://www.rgs.org/CMSPages/GetFile.aspx?nodeguid=5ca2377b-d8f4-4aa9-bc97-72fde503bb7e&lang=en-GB); Using Google Earth for fieldwork (https://www.rgs.org/schools/teaching-resources/google-earth-as-a-fieldwork-tool/); Getting started with ArcGIS and ESRI (https://schools.esriuk.com/teaching-resources/#-)
[74] https://schools.esriuk.com/

For each identified defence system, students should consider why it was chosen and identify its primary function. They should consider the consequences if it was not there and identify any other features (natural or man-made) that are needed to ensure the structure behaves as planned. Students should consider the implications of a breach event (e.g., flood water coming over the defence system).

3.5.3. Data reporting & sharing

In some professional settings (e.g., academic research), making your data publicly accessible is often a requirement. In others, data are protected by corporate confidentiality; however, they must still be prepared in such a way that findings can be reported back to a client.

Students should consider how their data, analyses and interpretations could be shared with their teachers and classmates (e.g., written report, class presentation). Students could also consider how their data and their analyses could be shared with a broader audience (e.g., creating a report for the school webpage; organising a school based scientific conference, including students from other classes or even other local schools; sharing data with citizen-science sharing platforms[75]).

[75] e.g., the British Geological Survey mySoil app (http://www.bgs.ac.uk/mysoil/); The About GLOBE programme of the United States Government (https://www.globe.gov/about/overview)

3.6. Coast-specific data analysis methods & calculations

3.6.1. Pebble data (pebble roundness)

To assess pebble roundness, use the long and short axis measurements of pebbles to perform particle shape analysis[76]. Students can then use an index to assess pebble roundness. For example, the Cailleux index can be calculated as follows:

$R = 2r \times 1000 / L$

where R = Cailleux roundness
r = average radius of curvature (obtained from a chart)
L = average length of pebbles (in sample)

[76] http://serc.carleton.edu/files/NAGTWorkshops/sedimentary/activities/particle_shape.pdf and https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/ and https://www.geography-fieldwork.org/gcse/coasts/coastal-processes/fieldwork/ and https://serc.carleton.edu/files/NAGTWorkshops/sedimentary/activities/particle_shape.pdf

4. Fieldwork project 2: dune habitats and human management

4.1. Introduction

Dune systems provide critical coastal functions, including natural defence against flooding and providing a habitat for a variety of species. In addition, dune systems often represent tourist attractions and leisure sites for local communities.

Given both their importance and sensitivity, most natural dune systems in the UK are under some form of dune management. This may involve the monitoring of species, the creation of habitats to support and/or re-introduce flora and fauna and soft engineering to support dune structures and reduce erosion.

This activity asks students to perform dune transects, collecting data on dune morphology and comparing the productivity of dune habitats at different locations in a managed dune system.

4.1.1. Links to curricula

At GCSE, this activity directly contributes to the study of physical landscapes in the UK, a core module for all of the exam boards. In each case, coastal landscapes are given as one of the three study options. Students will consider dune biodiversity and the roles of climate change, human impact and management. This is particularly relevant to the restoration of habitats damaged by humans (Educas).

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can address each of the skills areas specified for GCSE geography by the Department of Education.

- Cartographic skills: use different types of maps (e.g., topographical, aerial, hazard) at a range of scales (e.g., national, regional, local) to extract information about a study area (e.g., latitude, longitude, geological setting, topographical setting, local infrastructure, landforms); students should also be able to produce sketch maps and interpret cross-sections and transects.
- Graphical skills: students should be able to use and apply appropriate graphs and charts (e.g., line charts, bar charts, etc.); they should also be able to produce hand-drawn images to present and record information.
- Numerical skills: students should appreciate the concepts of number, area and scale, and the relationships between units; they should collect fieldwork data and understand its limitations (e.g., accuracy, sample size, etc.).
- Statistical skills: select and use statistical techniques appropriate to the data type;
- Develop research and fieldwork planning skills, including the development of hypotheses, the planning of appropriate fieldwork procedures and consideration of health and safety.
- Present findings with a text report that should be descriptive, analytical and critical.

At A Level, this activity falls within the study of Systems and Landscapes. Student will investigate coastal processes and landforms, and the relationship between then. They will also consider the role of humans in the landscape (e.g., management/impact) and future coastal change as a result of climate change.

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can develop many of the skills required by the Department of Education for A Level geography students.

- Understand, collect and use different types of geographical information (e.g., qualitative vs. quantitative, primary vs. secondary).
- Collect and analyse information, and critically assess data sources, methodologies and data outputs/reporting, including the ability to identify data misuse and sources of error.
- This module has a particular focus on the use of quantitative data, for which students should be able to: collect, analyse and present geo-referenced data; apply appropriate statistical and data plotting techniques; perform simple calculations.

4.1.2 'Real-world' examples

As a critically important coastal resource, dunes are widely studied and monitored by government agencies, academic researchers and commercial organisations Although these studies may use more stringent methodological protocols and expensive, high-tech equipment, the basic analysis approaches available to GCSE and A Level students are directly comparable to those used by 'real-world' practitioners. Example of 'real-world' projects and studies related to coastal dune systems include:

- a 2005 document outlining guidance on the monitoring of sand dune habitats in the UK (produced by the Joint Nature Conservation Committee)[77]. Among the methods outlined, the use of small sampling units to identifying vegetation is included. This is entirely consistent with the fieldwork to be conducted by the students. This document provides excellent guidance on designing a sampling system; it could be consulted by students in the planning stage;
- a 2001 impact assessment of sand dune mining in Michigan[78]. Dune mining along the western shores of lake Michigan has continued for over a century; however, the practice remains controversial. This impact assessment aimed to identify the geological background to the dune system, the range in dune morphologies, the ecological and vegetational characteristics of the dune systems, the local hydrology and the socio-economic contribution of the sand dunes. The assessment also outlines criteria for identifying at risk areas of the dunes;
- a 2017 study from Japan considered dune ecosystem services and their role in supporting the sake brewing industry[79]. The study concluded that the hydrological regime supported by the dune system facilitated the development of the industry, but that political and economic conditions along with coastal development ultimately led to the industry demise;

[77] http://jncc.defra.gov.uk/pdf/CSM_coastal_sand_dune.pdf
[78] https://www.michigan.gov/documents/deq/GIMDL-GGGEIS_216135_7.pdf
[79] https://link.springer.com/article/10.1186%2Fs40645-017-0142-9

- A 2000 guide from Scottish Natural Heritage on managing coastal erosion in dune systems[80]. The report provides an excellent overview of dune systems and processes and dune management options, including a comprehensive list of specific dune management strategies;
- A 2018 blog post that explores some of the negative issues associated with sand dune stabilisation using 'soft' engineering in Oregon, United States[81]. In this location, stabilisation using an invasive species of European Beach Grass has resulted in significant environmental challenges along the Pacific Coast of the US.

With the advent of new technologies, the professional study of coastal change is increasingly employing complex computer modelling and remote analysis techniques, including aerial and satellite remote sensing data, which allow for rapid analysis over large areas. For example:

- a 2016 Master thesis that used remote sensing to monitor changes in coastal dune vegetation in Canada[82]. The results of the study provide baseline data for local authorities. The automated classification system based on remote sensing images was found to be 97% accurate.

Students should be encouraged to think about possible sources of publicly available remote sensing or modelling data for their field site (e.g., Google Earth, Google Maps, Met Office satellite imagery, earth[83]).

[80] https://www.nature.scot/sites/default/files/2017-07/Publication%202000%20-%20Beach%20Dunes%20-%20a%20guide%20to%20managing%20coastal%20erosion%20in%20beach%20dune%20systems.pdf
[81] http://geotripper.blogspot.com/2018/08/the-flip-side-of-dune-stabilization.html?m=1
[82] http://dr.library.brocku.ca/bitstream/handle/10464/9290/Brock_Hague_Brodie_2016.pdf?sequence=2
[83] Interactive global current wind, weather, ocean, and pollution conditions as forecast by supercomputers and updated every 3 hours: https://earth.nullschool.net/

4.2. Site selection

This activity requires access to a managed coastal dune area. For best results, students should be able to access different areas of the dunes, including those where different management strategies are in places (e.g., parking infrastructure on dunes, dunes fortified by soft engineering, virgin dune areas) and/or a full transect across the dunes, from the seaward side to the landward side.

In the example field area (Point of Ayr), this activity could be completed with a visit to site 2 (the Gronant and Talacre dunes). In particular, students could collect data at various different locations within the dune system, including: (1) 'native' dunes with no active management; (2) areas of salt marsh; (3) areas of habitat regeneration (e.g., where habitats have been recreated for the reintroduction of the natterjack toad); (4) along-side pathways constructed to manage human traffic; (5) around the concrete foundations of old holiday chalets that once existed within the dunes (and resulted in the introduction of invasive plant species); (6) at locations around the dune car park, which is slowly being reduced in size by way of fence move-back to allow for dune restoration (see images below[84]); and (7) at locations along a transect from the beach-front through the dunes to Talacre village.

Information on the locations and conditions of these sites are available from the education centre. In addition, past quadrat data from areas of salt marsh may also be available on request.

[84] Images courtesy of RGS-IBG. Image licence: CC-BY-SA 4.0

4.3. Pre-fieldwork activities

4.3.1. Questions & hypotheses

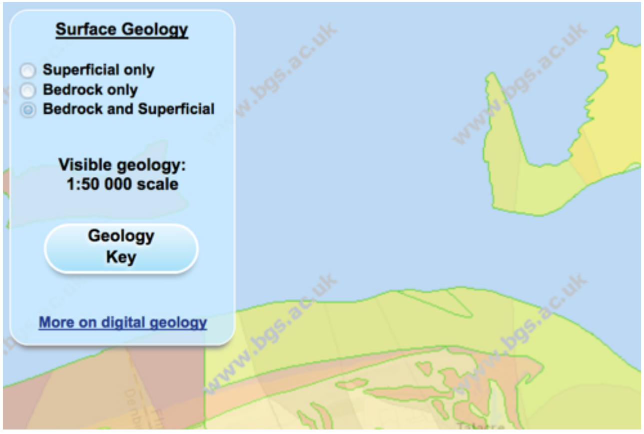
Identification of scientific questions & hypotheses: students should be required to develop a series of scientific questions and associated hypotheses to test through fieldwork; for example, these could relate to;

- The relative levels of biodiversity between different dune sites;
- Pros and cons of active management in maintaining or re-developing dune habitats;
- The role of dune habitats in supporting ecosystem services;
- Relationships between dune morphology and biodiversity.

4.3.2. Metadata collection

Field area cartography: before embarking on fieldwork, students should source relevant maps of the study area. Students should identify each proposed study site on the map and then use the map to extract information on the study site setting. Depending on map type, students should identify local and regional scale coastal morphology, identify the geological setting and consider what impacts this might have on coastal evolution, identify proximal natural features/processes, identify types of land use and human infrastructure, and where information is available, how land use has changed over time. Map types may include:

- location on global and UK scale maps;
- current and past Ordnance Survey maps of the study area;
- geological map of the study area (see example below)[85];



- current and past aerial and satellite images of the study area;
- maps of designated (i.e., protected) areas in and around the field area[86];
- Environment Agency coastal erosion maps of target areas[87].

[85] e.g., the British Geological Survey (BGS) iGeology App for smart phones provides geological maps and borehole data for the United Kingdom (http://www.bgs.ac.uk/igeology/). The BGS GeoIndex provides multi-layer maps of geological and other relevant information, available online (http://www.bgs.ac.uk/geoindex/) or as a download to use with GIS applications. Example map shows an iGeology screenshot of Point of Ayr geological map
[86] http://www.natureonthemap.naturalengland.org.uk/magicmap.aspx
[87] http://apps.environment-agency.gov.uk/wiyby/134831.aspx

Other secondary data sources: students should be encouraged to identify and source other secondary data that may provide insights into the field site (e.g., Environment Agency records and information[88], tidal records[89], flood risk maps[90], newspaper reports, planning applications, local guides and publications[91], etc.).

The image below shows a screenshot of BBC report on a 2016 tidal flooding event at Talacre[92].

BBC | Your account | News | Sport | Weather | iPlayer | Sounds

NEWS

Home | UK | World | Business | Politics | Tech | Science | Health | Family & Education

Wales | Wales Politics | Wales Business | North West | North East | Mid | South West

20 cars submerged after high tide at Talacre, Flintshire

8 May 2016

Share

TWITTER: @4LINK4PINK

Up to 20 cars parked near a north Wales beach were submerged by the sea after being caught by a rising tide.

The vehicles were left under water after a 9m (29.5ft) high tide peaked at Talacre in Flintshire at about 12:40 BST.

4.3.3. Plan of work

On completion of fieldwork planning and metadata collection, students should review the study aims and objectives, including scientific questions and hypotheses, and: (i) confirm that the proposed approach will address the scientific questions, and (ii) ensure that the hypotheses remain relevant in light of new information from metadata collection.

Site selection: students (particularly at A Level) should be intimately involved in the planning of fieldwork. Where possible, this could include site selection from relevant maps or from pre-fieldwork scouting trips to the proposed field area. Where sites have already been selected (e.g., for Point of Ayr), students should be asked to consider why those sites have been selected (e.g., accessibility, notable natural or human features of interest).

[88] https://www.gov.uk/government/organisations/environment-agency
[89] https://www.bodc.ac.uk/data/hosted_data_systems/sea_level/uk_tide_gauge_network/ and http://www.ntslf.org/networks
[90] https://flood-map-for-planning.service.gov.uk/
[91] Print copies of local guides are available from the Danger Point information centre
[92] http://www.bbc.co.uk/news/uk-wales-north-east-wales-36243086

Students should consider different areas within the dune system (e.g., natural, managed, human infrastructure) and choose appropriate techniques for assessing biodiversity in those areas (e.g., by reference to this document or through reference to other fieldwork guides or past fieldwork experience). When selecting and planning fieldwork techniques, students should consider the role of sampling on the quality and relevance of their data[93].

4.3.4. Logistical planning

Students should be encouraged to develop a realistic plan for fieldwork, including a proposed timetable of site visits that takes into account the number and locations of field sites, the number of people within a group, the time required for data collection at each site and the time available for fieldwork.

Prior to fieldwork, students should be required to procure or construct appropriate equipment to complete the proposed data collection activities.

Students should be asked to consider the health & safety implications of the chosen field sites and data collection techniques. Students should be encouraged to create, or contribute, to risk assessment development. Guidelines on fieldwork safety and planning, including guidance on the preparation of risk assessments, have been published by the Field Studies Council and can be found on the RGS-IBG website[94].

[93] https://www.rgs.org/schools/teaching-resources/sampling-techniques/
[94] https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/risk-assessments/

4.4. Measurable processes and field data collection techniques

The following section contains a comprehensive list of fieldwork techniques that are relevant to the study of dune systems. All or some of these techniques could be incorporated into a field project, depending on the exact scope and on the time available. In general, students should be encouraged to think carefully about which techniques will best address their scientific questions AND meet the time and budgetary constraints of the fieldwork.

Each of the measurement techniques could be employed during a single site visit. This would provide a snapshot of the coast at a given location for a given time. However, repeat measurements at different times (e.g., before and after a storm event, winter vs. summer) could provide a richer and longer-term dataset for student analysis.

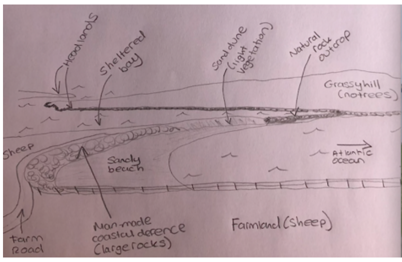
This activity asks students to assess dune morphology and biodiversity at sites along dune transects. Transect routes may or may not be chosen to pass through specific dune features (e.g., areas of active management).

4.4.1. Field notebook

On arrival at each field site, students should record observational data on the field site setting in their field notebook. In some professional settings, a field notebook (hand-written or digital) is a legal document that could be used in legal proceedings[95]. For other professionals, the information recorded in a field notebook could be critical for later stages of data processing. Learning good field notebook skills is a critical part of professional fieldwork training. In this activity, the following should be recorded for each field site:

- date, time, weather conditions and mood of the investigator (these can impact on the quality of data collection);
- name of the field site and location (i.e., GPS waypoint and/or latitude and longitude from a smart phone, handheld GPS or paper map);
- brief description of the site, including surrounding land use and infrastructure, landforms and site conditions (vegetation, human impacts). Particular note should be taken of vegetation, visible evidence of physical damage, traces of past activity and occupation, areas of vulnerability (e.g., erosion, pollution) and evidence for management activities;
- observed management approaches for coastal defence. The UK offers four options for shoreline management[96]: (1) No active intervention; (2) Hold the (existing defence) line (i.e., replace or maintain existing artificial defences to maintain the current shoreline position); (3) Managed realignment (e.g., allowing natural evolution of the shoreline, but with active management of certain processes to direct evolution in certain ways); and (4) Advance the line (i.e., construction of new defences on the seaward side of existing defences);
- site sketch with critical features clearly labelled;
- where data are available, a note of storms in the study area in the days, weeks and month prior to data collection should be made;
- data on selected measurements.

Examples of field notebook, sketching and photography good practice have been developed by the University of Liverpool[97] and the RGS-IBG[98]. A good site sketch gives a sense of scale and the spatial distribution of features. The images below show an example field sketch and accompanying photograph[99]; it can be seen that field sketches do not need to be artistic, they merely need to convey the main features of a site.



[95] https://www.abcls.ca/wp-content/uploads/pdfs/Field-notes-Link-article-Oct-9-2015-Final.pdf
[96] http://apps.environment-agency.gov.uk/wiyby/134834.aspx
[97] http://www.esta-uk.net/fieldworkskills/tips.htm
[98] https://www.rgs.org/schools/teaching-resources/sketching-and-photography/
[99] Images courtesy of Tornillo Scientific. Image licence: CC-BY-SA 4.0

4.4.2. Identification of dune features, processes, human infrastructure and coastal defence structures

What is measured?

Students should use simple visual observations and sketches to identify the main dune processes (e.g., evidence for erosion/deposition, etc.) and human infrastructure (e.g., pathways, car parks, old foundations, coastal defence structures).

Note, some soft-engineering coastal defences may not be immediately obvious; for example, at Talacre, some dunes contain specially designed wooden sand-ladders on pathways to reduce erosion (see images below[100]), and in some places Christmas trees have been buried in the sand to help stabilise the dunes[101].

Students should consider multiple ways that a single process can come about; for example, erosion can be natural (wind erosion scars on dunes) or manmade (pathways through the dunes).

Site requirements

Any dune location. Ideally, a transect through the dunes, from the shoreline to the land behind the dunes, should be used. Where possible, this should cross multiple locations with different management approaches. Where not possible, discrete sites that represent specific management policies or processes may be selected, even if off-transect.

[100] Images courtesy of RGS-IBG. Image licence: CC-BY-SA 4.0
[101] Christmas trees are visible within the base of dunes on the seaward side. More information can be found at the Eni UK Field Centre. https://www.bbc.co.uk/news/av/uk-wales-25639536/christmas-trees-used-to-rebuild-talacre-sand-dunes-after-tidal-storms

Equipment and associated costs

This activity only requires a field notebook and pencil. A camera can also be useful to record observations, but should not replace note taking and field sketches.

Number of data points needed (data resolution)

The number of observations will depend on the site. However, students should be encouraged to consider carefully the landscape, as many dune features can be discrete.

Professional measurement techniques

Basic field site observations are critical for fieldwork at any level. However, many professional coastal studies will also use secondary data to identify key features (e.g., maps, management reports, etc.).

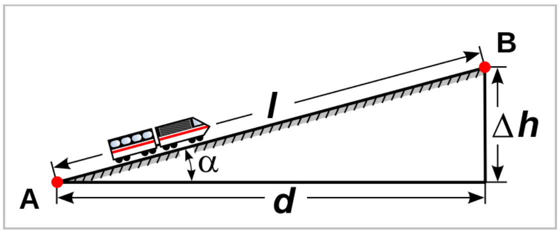
4.4.3. *Dune morphology*

What is measured?

Dune morphology provides data on the health of the dune system and on the strength of on-going dune processes. Dune morphology is assessed by creating dune profiles from multiple gradient measurements, where gradient is equal to the difference in height between two sites divided by the distance between those sites.

Profiles are created by measuring dune gradients, where gradient is equal to the difference in height between two sites divided by the distance between those sites. See below a diagram of 'gradient'[102], where:

$$gradient = \Delta h / d$$



Gradient is measured by placing two measuring poles at sites a known distance apart (see image below[103]). The angle between the matching height horizons on each measuring pole is measured using a clinometer. For best results, students should take multiple gradient measurements across each individual dune along a transect from the shoreline to the backside of the dune system. A new measurement should start wherever there is a significant change or break in the gradient.

More detailed guidance on dune profiling is available from the RGS-IBG[104]. Detailed guidance on how to measure gradient is available online[105].

[102] Madcap, from Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Grade_dimension.svg). Image licence: Image in the public domain

[103] Measuring gradient. Image modified from: Field Studies Council (https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/). Image licence: CC_BY

[104] https://www.rgs.org/schools/teaching-resources/ecosystems/

[105] http://www.geography-site.co.uk/pages/skills/fieldwork/fluvial/grad.html

Site requirements

Access to the full width of an active coastal dune system. For managed and protected dunes, permission may be needed for students to venture off designated pathways.

Equipment and associated costs

Low cost gradient measurements require two surveying poles (metre rulers will usually work) and a clinometer (see image below left[106]). Clinometers can be purchased cheaply, can be constructed from basic stationery[107] or are available at lost cost for use on smartphones[108] (see image below right[109]).


Number of data points needed (data resolution)

Each individual profile will contain a number of data points, with gradient measurements taken between each break in slope across the width of each dune. Profiles can be continuous across the whole width of the dune system, including multiple dunes.

Professional measurement techniques

Professional surveying techniques often rely on simple surveying poles and professional clinometers; however, some surveyors use theodolites (see image below[110]) and lasers to measure distances and gradients. Over wider scales, gradient can also be extracted from LiDAR and satellite data, topographical maps and digital elevation models (DEMs).

[106] Image modified from: Silva Expedition 4 compass-clinometer (https://en.wikipedia.org/wiki/Silva_compass#/media/File:Silva_compass,_Expedition_4.jpg). Image licence: CC-BY-SA 3.0
[107] https://www.rgs.org/schools/teaching-resources/make-your-own-clinometer/
[108] e.g., https://itunes.apple.com/gb/app/seelevel-visual-clinometer/id333213338?mt=8
[109] Image modified from: Rufiyaa (https://commons.wikimedia.org/wiki/File:Clinometer_on_smartphone.jpg). Image licence: CC-BY-SA 4.0
[110] Image modified from: Kenneth Allen (http://www.geograph.ie/photo/4190504). Image licence: CC-BY-SA 2.0

4.4.4. Species abundance

What is measured?

Species abundance provides a quantitative measure of biodiversity in sand dune systems. Abundance can simply be measured as the percentage of area covered by vegetation, or more specifically as the percentages of area covered by specific species of vegetation.

In both cases, data should be collected from within quadrats[111] (see image below[112]) placed at regular intervals along the dune transect or within specific areas of interest within a dune system. To identify and quantify exact species, identification charts are available for purchase at low cost (e.g., from the Field Studies Council[113]). They may also be available from local educational facilities and field centres.

ACFOR is commonly used for measuring species abundance within quadrats (A = ABUNDANT, greater than/equal to 30%; C = COMMON, 20% to 29%; F = FREQUENT, 10% to 19%; O = OCCASIONAL, 5% to 9%; and R = RARE, 4% or less). Detailed guidance on using the ACFOR system for species abundance is available from the RGS-IBG[114].

Site requirements

Access to the full width of an active coastal dune system. For managed and protected dunes, permission may be needed for students to venture off designated pathways.

Equipment and associated costs

Quadrats can be purchased cheaply[115]; if funds are not available, simple quadrats could also be constructed using basic classroom materials.

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111 http://www.bbc.co.uk/bitesize/standard/biology/biosphere/investigating_an_ecosystem/revision/2/
112 (left) Image modified from: U. S. Fish and Wildlife Service - Northeast Region; image licence: CC BY 2.0, via Wikimedia Commons / (right) Image modified from: Popular Science Monthly Volume 80 1921; Image licence: Public Domain, via Wikimedia Commons
113 http://www.field-studies-council.org/publications/pubs/sand-dune-plants-identification-chart.aspx
114 https://www.rgs.org/schools/teaching-resources/ecosystems/
115 e.g., https://www.nhbs.com/q2-quadrat?bkfno=175986&ca_id=1495&gclid=CjwKCAjwj4zaBRABEiwA0xwsP0lSJ6jP97tuyWfIviJgAzPcGXIFdBkNc9mt0WMSI3EhM5sFFfM86xoC9f4QAvD_BwE

Species identification charts are available for purchase at low cost (e.g., from the Field Studies Council[116]). They may also be available from local educational facilities and field centres.

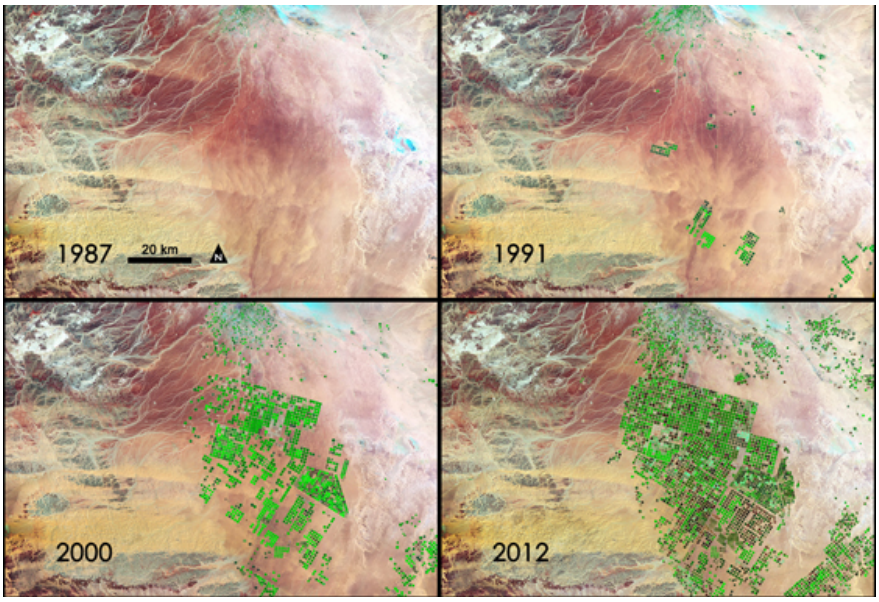
Number of data points needed (data resolution)

Quadrat data should be taken at multiple sites along a dune system transect (e.g., every 20 m), with the exact interval depending on the total length of the transect (e.g., the width of the dune system) and the time available, or at specific sites of interest within a managed dune system (e.g., near human infrastructure, around areas of habitat regeneration, etc.).

For each individual point, the quadrat should be placed on the ground randomly (e.g., tossed onto the ground from a short distance to ensure that a random area is sampled). This would ideally be repeated three to five times per site to provide average (e.g., mean) data for each location with an indicator of data spread (e.g., standard deviation).

Professional measurement techniques

Remote sensing techniques (e.g., satellite imagery; see example below of NASA/GSFC Landsat images of crop fields in Saudi Arabia[117]) are increasingly being used to monitor changes in vegetation cover, even on very small scales; however, quadrat data collection and ground truthing of satellite imagery remain important tools for field biologists and ecologists. This is particularly true when data on specific species are required.



[116] http://www.field-studies-council.org/publications/pubs/sand-dune-plants-identification-chart.aspx
[117] Center-pivot irrigation crops in Saudi Arabia. In this series of four Landsat images, the agricultural fields are about one kilometer across. Healthy vegetation appears bright green while dry vegetation appears orange. Barren soil is a dark pink, and urban areas, like the town of Tubarjal at the top of each image, have a purple hue. Image credit: NASA/GSFC (https://landsat.gsfc.nasa.gov/satellites-reveal-major-shifts-in-global-freshwater/). Image licence: NASA content – You may use this material for educational or informational purposes, including photo collections, textbooks, public exhibits, computer graphical simulations and Internet Web pages

4.4.5. Sediment (sand and soil) analysis

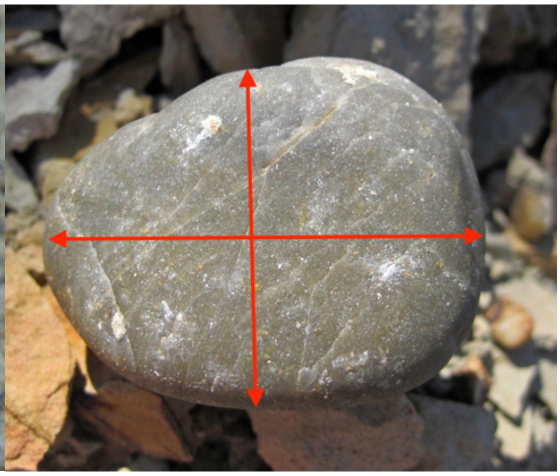
What is measured?

Sand, and where possible the soil underlying sand dunes, can be characterised during dune transects or at specific sites in dune systems (e.g., areas of human interference, around human infrastructure, areas of habitat regeneration). This type of investigation helps to identify sources of pollution and contamination, and the health of the dune system. Infiltration measurements can help to identify areas at greater risk of flooding.

Infiltration can be measured at low cost by placing a section of drainpipe on the ground surface, filling it with a set amount of water and timing how long it takes for the water to infiltrate the ground (details of this process are available from the RGS-IBG website[118]).

This activity can range from very simple (samples and analyses taken from the surface of the dune) to more in-depth (students dig small trenches or pits, within which they sample material and take measurements at different depth horizons (e.g., 5 cm, 10 cm, 50 cm, etc.).

Use callipers or a ruler to measure and record the longest and shortest axis (see image below[119], or for a more detailed investigation, measure the a, b and c axes[120]). If investigating the origin of beach material, you may also consider describing the pebble, taking a photograph or even collecting it for further analysis back in the classroom.



If investigating the origin of beach material, you may also consider describing the pebble, taking a photograph or even collecting it for further analysis back in the classroom. This process should be repeated 10 times for each sample point.

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[118] https://www.rgs.org/schools/teaching-resources/make-your-own-fieldwork-equipment-infiltration/
[119] (left) Using callipers to measure the a, b and c axes of a pebble; image modified from: Field Studies Council (https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/), image licence: CC_BY / (right) Image modified from: James St. John (https://www.flickr.com/photos/jsjgeology/39200485210). Image licence: CC-BY 2.0
[120] https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/

Further data analysis, including calculation of pebble roundness, should be completed back in the classroom (see post-fieldwork activities).

The grain size of sand can be qualitatively assessed by comparison to a geological grain size chart or by using a series of sieves.

Soil temperature and pH: in soils, temperature and pH are best measured *in situ* using a hand-held digital meter.

Infiltration can be measured at low cost by placing a section of drainpipe on the ground surface, filling it with a set amount of water and timing how long it takes for the water to infiltrate the ground (details of this process are available from the RGS-IBG website121).

More detailed guidance on soil analysis is available from the RGS-IBG[122].

Site requirements

Access to the full width of an active coastal dune system. For managed and protected dunes, permission may be needed for students to venture off designated pathways. Additional permissions may be needed to dig small trenches or pits. After analysis, these should be refilled and re-covered with sand (or the relevant topsoil material). This type of analysis may not be possible in very sensitive areas (e.g., areas of habitat regeneration).

Equipment and associated costs

Ideally, pebble dimensions should be measured using callipers, which can be purchased cheaply or at moderate cost; a normal ruler can be used for less accurate data collection.

Geological grain size charts can be purchased cheaply[123]. Sieve sets for soil and sand grain size analysis range in price; however, they are durable and can be used for many years.

Digital meters for the measurement of temperature and pH can be purchased at relatively low cost. (see image below for example of a digital pH meter[124]).

[121] https://www.rgs.org/schools/teaching-resources/make-your-own-fieldwork-equipment-infiltration/
[122] https://www.rgs.org/schools/teaching-resources/ecosystems/
[123] https://www.ukge.com/en-gb/Grain-Size-Cards__p-2796.aspx
[124] By Ildar Sagdejev [GFDL (http://www.gnu.org/copyleft/fdl.html). Image licence: CC BY-SA 4.0, from Wikimedia Commons

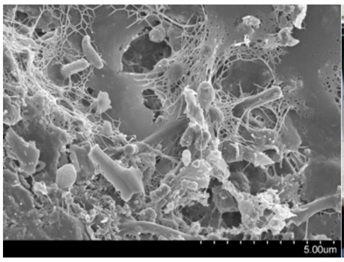
Infiltration measurements will require a section of drainpipe (or similar), a measured volume of water, a ruler and a stopwatch.

Number of data points needed (data resolution)

At least 5–10 repeat measurements of each variable (pH, temperature, infiltration, number of pebbles) should be taken for each location/soil horizon within a trench. This ensures that representative average values can be calculated along with an indicator of data spread (e.g., standard deviation).

Professional measurement techniques

Professional sediment analysis can include the simple collection and measurement techniques described above, but may also employ more intensive examinations of pebble and sand composition/morphology using expensive, high-tech laboratory equipment; for example, scanning electron microscopes (SEMs; see image below left[125] and centre[126]) and laser granulometers (see image below right [127]).



[125] Image by ZEISS Microscopy (https://www.flickr.com/photos/zeissmicro/10710025785). Image licence: CC-BY-SA 2.0
[126] SEM sand grain image courtesy of the Lewis Lab at Northeastern University (https://www.flickr.com/photos/adonofrio/albums/72157623620596451). Image created by Anthony D'Onofrio, William H. Fowle, Eric J. Stewart and Kim Lewis. Image licence: CC-BY 2.0
[127] Mastersizer 3000 laser granulometer. By Plogeo. Image licence: CC BY-SA 4.0, from Wikimedia Commons

4.5. Post-fieldwork activities

In the professional world, fieldwork often represents only a small part of a project's duration. The post-fieldwork data analysis stage is usually the longest part of any study. Here we outline some of the main steps in the post-fieldwork process and highlight some of the key post-fieldwork calculations and analyses performed using the data collected from coastal field sites.

4.5.1. Data organisation & input

On return to the classroom, students should transfer field data from their field notebook onto a computer or tablet. Students should consider the best storage options for their data (e.g., Microsoft Excel, Microsoft Word, ArcGIS, Google Earth). If data were collected by a group, students should consider approaches to data management and data sharing (e.g., Google Drive, Dropbox). It may be appropriate for each group to develop a brief data management plan.

4.5.2. Data analysis & visualisation

Students should consider the most appropriate statistical techniques[128] and chart types to analyse and present their data. Students should ensure that they consider the accuracy and limitations of their data; this should be clearly stated in their final report.

Coastal-specific data analysis methods and calculations can be found in section 4.6 (below).

Students should be encouraged to consider how GIS tools could help them to visualise and present their data. Guidance on getting started with GIS in the classroom is available online[129]. To support GIS education in schools, ESRI have made ArcGIS Online free for all UK schools. Full details, including help getting started and guidance on using ArcGIS for recording and reporting on fieldwork, are available online[130].

Based on the field data collected and any supporting metadata, students should provide an interpretation for their findings. They should return to their original scientific questions and hypotheses and use their results to show how these were met (or not). Students should also be encouraged to think about how their data may have changed under different field conditions (e.g., after a storm event, during different seasons). Students should consider how climate change might impact on their field sites.

Students should consider the positive and negative aspects of dune management strategies at their field sites. This assessment should be based on collected data, but should also consider other factors (e.g., cost of management schemes, economic and social impacts).

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[128] https://www.rgs.org/schools/teaching-resources/fsc-statistical-methods/
[129] Getting started with GIS in teaching (https://www.rgs.org/CMSPages/GetFile.aspx?nodeguid=5ca2377b-d8f4-4aa9-bc97-72fde503bb7e&lang=en-GB); Using Google Earth for fieldwork (https://www.rgs.org/schools/teaching-resources/google-earth-as-a-fieldwork-tool/); Getting started with ArcGIS and ESRI (https://schools.esriuk.com/teaching-resources/#-)
[130] https://schools.esriuk.com/

Students should also use their observations and data to identify the ecosystem services provided by the dunes; for example, (a) primary production (e.g., biomass as food for other animals); (b) sediment formation and nutrient recycling; (c) provision of resources (e.g., food for human consumption, water filtration, building materials); (d) regulating services (e.g., coastal protection); and (e) cultural services (e.g., recreation, research, education).

Students should consider evidence of past pressures acting on the dune system (e.g., historical activities) and trends in coastline development over time; they should decide to what extent these pressures still impact on the system today. They should consider current pressures and how they may impact on the dunes in the future and look at possible future pressures (e.g., sea level rise, changes in climate, increase in storm events) and how these may impact on the dune system.

4.5.3. Data reporting & sharing

In some professional settings (e.g., academic research), making your data publicly accessible is often a requirement. In others, data are protected by corporate confidentiality; however, they must still be prepared in such a way that findings can be reported back to a client.

Students should consider how their data, analyses and interpretations could be shared with their teachers and classmates (e.g., written report, class presentation). Students could also consider how their data and their analyses could be shared with a broader audience (e.g., creating a report for the school webpage; organising a school based scientific conference, including students from other classes or even other local schools; sharing data with citizen-science sharing platforms[131]).

[131] e.g., the British Geological Survey mySoil app (http://www.bgs.ac.uk/mysoil/); The About GLOBE programme of the United States Government (https://www.globe.gov/about/overview)

4.6. Coast-specific data analysis methods & calculations

4.6.1. Pebble data (pebble roundness)

To assess pebble roundness, use the long and short axis measurements of pebbles to perform particle shape analysis[132]. Students can then use an index to assess pebble roundness. For example, the Cailleux index can be calculated as follows:

R = 2r x 1000 / L

where R = Cailleux roundness
r = average radius of curvature (obtained from a chart)
L = average length of pebbles (in sample)

[132] http://serc.carleton.edu/files/NAGTWorkshops/sedimentary/activities/particle_shape.pdf and https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/ and https://www.geography-fieldwork.org/gcse/coasts/coastal-processes/fieldwork/ and https://serc.carleton.edu/files/NAGTWorkshops/sedimentary/activities/particle_shape.pdf

5. Fieldwork project 3: competing human interests in coastal areas

5.1. Introduction

Coastal areas are often under intense pressure from varying human interests, including (but not limited to) environmental protection, heavy industry, local communities and tourism. Managing these competing interests remains difficult and highly dependent on the social, economic and political climate at local, regional and national levels.

In this simple, observational study, students are asked to consider current human and coastal pressures on a site, how these may have changed over time and what mitigation measures have been (or could be) put in place to alleviate these issues. Students should also consider the potential future implications of climate change (e.g., flooding, rising sea level, extreme weather) and of commercial, residential and/or industrial development at the site.

5.1.1. Links to curricula

At GCSE, this activity directly contributes to the study of physical landscapes in the UK, a core module for all of the exam boards. In each case, coastal landscapes are given as one of the three study options. In particular, students will consider the role of human impact and management.

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can address each of the skills areas specified for GCSE geography by the Department of Education.

- Cartographic skills: use different types of maps (e.g., topographical, aerial, hazard) at a range of scales (e.g., national, regional, local) to extract information about a study area (e.g., latitude, longitude, geological setting, topographical setting, local infrastructure, landforms); students should also be able to produce sketch maps and interpret cross-sections and transects.
- Graphical skills: students should be able to use and apply appropriate graphs and charts (e.g., line charts, bar charts, etc.); they should also be able to produce hand-drawn images to present and record information.
- Numerical skills: students should appreciate the concepts of number, area and scale and the relationships between units; they should collect fieldwork data and understand its limitations (e.g., accuracy, sample size, etc.).
- Statistical skills: select and use statistical techniques appropriate to the data type;
- Develop research and fieldwork planning skills, including the development of hypotheses, the planning of appropriate fieldwork procedures and the consideration of health and safety.
- Present findings with a text report that should be descriptive, analytical and critical.

At A Level, this activity falls within the study of Systems and Landscapes. In particular, students will consider the role of humans in the landscape (e.g., management/impact) and future coastal change as a result of climate change.

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can develop many of the skills required by the Department of Education for A Level geography students.

- Understand, collect and use different types of geographical information (e.g., qualitative vs. quantitative, primary vs. secondary).
- Collect and analyse information, and critically assess data sources, methodologies and data outputs/reporting, including the ability to identify data misuse and sources of error.
- This module includes the use of semi-quantitative and qualitative data, for which students should be able to: understand the use of mixed-method approaches (e.g., qualitative land mapping, interviews, analysis of secondary data sources); understand the opportunities and limitations of qualitative data; appreciate the ethical and socio-political implications of collecting, studying and representing data about humans and their communities.

5.1.2 'Real-world' examples

Coastal conflicts arising from competing interests and pressures are evident at different scales along most populated coastlines. Examples of 'real-world' coastal conflicts include:

- on-going legal battles in California, where public access to beaches is enshrined in law, but access routes to the coastline often cross private property[133];
- coastal development in areas with high population densities and high tourist numbers. For example, the attached report looks at coastal land use and development along the Gulf of Maine[134], highlighting driving forces and pressures (e.g., population change, property values, natural coastal processes), the impacts of these pressures and potential avenues to address these issues (e.g., integrated management, land-use planning, conservation). The report provides a list of possible indicators for assessing coastal pressures; such a list could be adapted by students for the assessment of local fieldwork sites.

133 https://www.theguardian.com/environment/2018/feb/23/martins-beach-california-vinod-khosla
134 http://www.gulfofmaine.org/2/wp-content/uploads/2014/03/coastal-land-use-theme-paper.pdf

5.2. *Site selection*

This activity requires access to any stretch of coastline. For best results, students should access multiple areas of the coast with different competing human pressures (e.g., heavy industry, residential areas, tourist resources, conservation areas, etc.).

In the example field area (Point of Ayr), this activity could be completed with visits to sites 1, 2, 3 and 4:

- Site 1 (Talacre village and holiday park), situated at the end of the Talacre coastal embankment, this site is at the edge of Talacre village and Holiday Park. This area represents the crossroads between numerous competing interests, including local residents, tourists, heavy industry and conservation. Of particular interest could be the current and new car parks (see images below of the old car park [left] and new car park [right][135]). Parking issues have been at the forefront of development in Talacre. The old car park is currently being phased out, allowing regeneration of the dune system. In tandem, new parking areas are being developed over a 10-year period. Students could consider the positive and negative aspects of this change for different stakeholders;


- Site 2 (Talacre Beach, on the seaward side of the Gronant and Talacre Dunes) represents a stretch of coast protected by natural sand dunes that are themselves actively managed to maintain their natural function. This is one of the only sections of natural coastline along the North Wales coast. Conservation of the site is important both for coastal flood defence and to protect habitats. However, the area is also heavily used for leisure and tourism and sits above a major gas pipeline. Of particular historical interest are the still-visible foundations of holiday cottages built within the dunes to house evacuees from Liverpool during World War II;
- Site 3 (Gas Colliery Quay Wall and Revetment) represents hard coastal engineering designed to protect an industrial site. However, the site is also surrounded by designated areas that are actively managed for the conservation of habitats, and is used for leisure purposes by local residents;
- Site 4 (Prestatyn Beach, on the seaward side of the Prestatyn sea defences) represents the heavily engineered coastal front of an urban area. The area contains many competing commercial, residential and leisure interests.

[135] Images courtesy of RGS-IBG. Image licence: CC-BY-SA 4.0

5.3. Pre-fieldwork activities

5.3.1. Questions & hypotheses

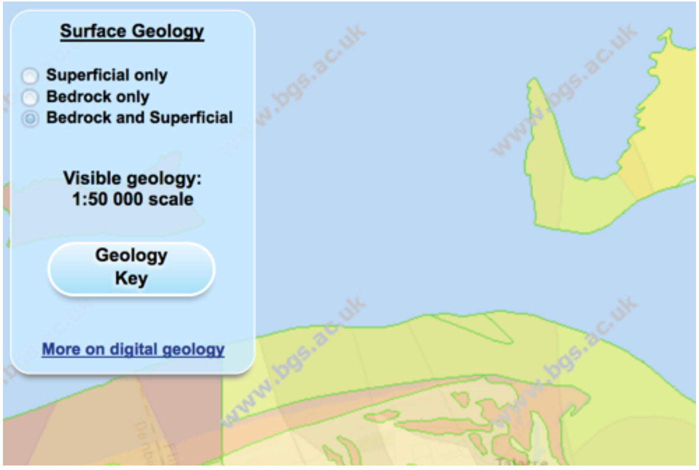
Identification of scientific questions & hypotheses: students should be required to develop a series of scientific questions and associated hypotheses to test through fieldwork; for example, these could relate to;

- number of competing coastal pressures as a function of population density;
- differences in coastal management approaches for different stakeholders (e.g., big industry vs. local residents vs. local government).

5.3.2. Metadata collection

Field area cartography: before embarking on fieldwork, students should source relevant maps of the study area. Students should identify each proposed study site on the map and then use the map to extract information on the study site setting. Depending on map type, students should identify local and regional scale coastal morphology, identify the geological setting and consider what impacts this might have on coastal evolution, identify proximal natural features/processes, identify types of land use and human infrastructure, and where information is available, how land use has changed over time. Map types may include:

- location on global and UK scale maps;
- current and past Ordnance Survey maps of the study area;
- geological map of the study area (see example below)[136];

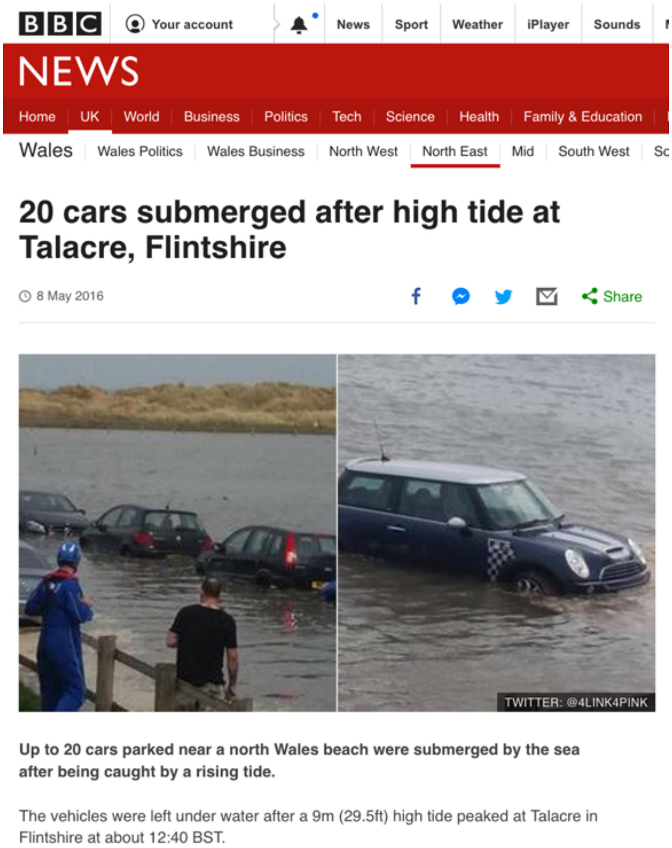


- current and past aerial and satellite images of the study area;
- maps of designated (i.e., protected) areas in and around the field area[137];
- Environment Agency coastal erosion maps of target areas[138].

136 e.g., the British Geological Survey (BGS) iGeology App for smart phones provides geological maps and borehole data for the United Kingdom (http://www.bgs.ac.uk/igeology/). The BGS GeoIndex provides multi-layer maps of geological and other relevant information, available online (http://www.bgs.ac.uk/geoindex/) or as a download to use with GIS applications. Example map shows an iGeology screenshot of Point of Ayr geological map
137 http://www.natureonthemap.naturalengland.org.uk/magicmap.aspx
138 http://apps.environment-agency.gov.uk/wiyby/134831.aspx

Other secondary data sources: students should be encouraged to identify and source other secondary data that may provide insights into the field site (e.g., Environment Agency records and information[139], tidal records[140], flood risk maps[141], newspaper reports, planning applications, local guides and publications[142], etc.).

The image below shows a screenshot of BBC report on a 2016 tidal flooding event at Talacre[143].



20 cars submerged after high tide at Talacre, Flintshire

8 May 2016

Share

Up to 20 cars parked near a north Wales beach were submerged by the sea after being caught by a rising tide.

The vehicles were left under water after a 9m (29.5ft) high tide peaked at Talacre in Flintshire at about 12:40 BST.

On completion of fieldwork planning and metadata collection, students should review the study aims and objectives, including scientific questions and hypotheses, and: (i) confirm that the proposed approach will address the scientific questions, and (ii) ensure that the hypotheses remain relevant in light of new information from metadata collection.

5.3.3. Plan of work

Site selection: students (particularly at A Level) should be intimately involved in the planning of fieldwork. Where possible, this could include site selection from relevant maps or from pre-fieldwork scouting trips to the proposed field area. Where sites have already been

[139] https://www.gov.uk/government/organisations/environment-agency
[140] https://www.bodc.ac.uk/data/hosted_data_systems/sea_level/uk_tide_gauge_network/ and http://www.ntslf.org/networks
[141] https://flood-map-for-planning.service.gov.uk/
[142] Print copies of local guides are available from the Danger Point information centre
[143] http://www.bbc.co.uk/news/uk-wales-north-east-wales-36243086

selected (e.g., for Point of Ayr), students should be asked to consider why those sites have been selected (e.g., accessibility, notable natural or human features of interest).

Students should consider coastal areas subjected to different pressures (e.g., holiday parks, residential areas, industrial areas, the beach front, etc.) and choose appropriate techniques for compiling a comprehensive inventory of competing interests (e.g., by reference to this document or through reference to other fieldwork guides or past fieldwork experience). When selecting and planning fieldwork techniques, students should consider the role of sampling on the quality and relevance of their data[144].

5.3.4. Logistical planning

Students should be encouraged to develop a realistic plan for fieldwork, including a proposed timetable of site visits that takes into account the number and locations of field sites, the number of people within a group, the time required for data collection at each site and the time available for fieldwork.

Prior to fieldwork, students should be required to procure or construct appropriate equipment to complete the proposed data collection activities.

Students should be asked to consider the health & safety implications of the chosen field sites and data collection techniques. Students should be encouraged to create, or contribute to, risk assessment development. Guidelines on fieldwork safety and planning, including guidance on the preparation of risk assessments, have been published by the Field Studies Council and can be found on the RGS-IBG website[145].

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[144] https://www.rgs.org/schools/teaching-resources/sampling-techniques/
[145] https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/risk-assessments/

5.4. Measurable processes and field data collection techniques

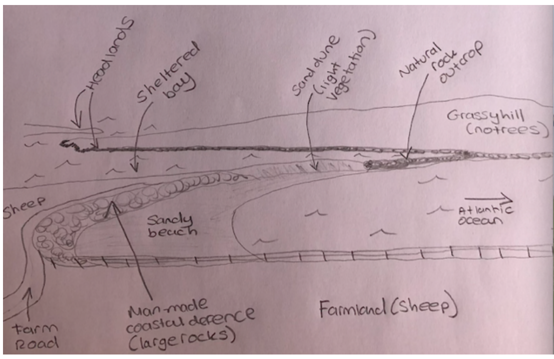
In this activity, students are asked to compile an inventory of competing pressures in a coastal area. For example, at a dune location, competing pressures and stakeholders could include: leisure site for local residents, tourist attractions for outside visitors, traffic and parking, local businesses, near-by industry, environmental groups, local authorities, natural coastal processes, etc. To increase the complexity of data collection, this simple inventory could be supported by quantitative data collection.

5.4.1. *Field notebook*

This activity requires students to make careful observations of their field site. To this end, students' field notebooks are of particular importance. On arrival at each field site, students should record observational data on the field site setting in their field notebook. In some professional settings, a field notebook (hand-written or digital) is a legal document that could be used in legal proceedings[146]. For other professionals, the information recorded in a field notebook could be critical for later stages of data processing. Learning good field notebook skills is a critical part of professional fieldwork training. In this activity, the following should be recorded for each field site:

- date, time, weather conditions and mood of the investigator (these can impact on the quality of data collection);
- name of the field site and location (i.e., GPS waypoint and/or latitude and longitude from a smart phone, handheld GPS or paper map);
- brief description of the site, including surrounding land use and infrastructure, landforms and site conditions (vegetation, human impacts);
- site sketch with critical features clearly labelled. A good site sketch should give a sense of scale and the spatial distribution of features around the site;
- data on selected measurements.

Examples of field notebook, sketching and photography good practice have been developed by the University of Liverpool[147] and the RGS-IBG[148]. A good site sketch gives a sense of scale and the spatial distribution of features. The images below show an example field sketch and accompanying photograph[149]; it can be seen that field sketches do not need to be artistic, they merely need to convey the main features of a site.



146 https://www.abcls.ca/wp-content/uploads/pdfs/Field-notes-Link-article-Oct-9-2015-Final.pdf
147 http://www.esta-uk.net/fieldworkskills/tips.htm
148 https://www.rgs.org/schools/teaching-resources/sketching-and-photography/
149 Images courtesy of Tornillo Scientific. Image licence: CC-BY-SA 4.0

5.4.1. Identification of stakeholders, competing processes (human and natural) and human infrastructure

What is measured?

Students should use simple visual observations and sketches to identify the main stakeholders and processes operating around the site.

If a more in-depth study is warranted/required to meet educational needs, students could also be asked to collect more quantitative data to support their inventory. For example, this could include:

- pedestrian and vehicle traffic counts at each locality to assess traffic levels. Students should count for a set period of time (e.g., 5 minutes) and should consider the error introduced by time of day, weather conditions, etc.;
- litter surveys, perhaps using a quadrat system;
- simple questionnaires to collect the subjective viewpoints of different stakeholders;
- simple land use maps (e.g., number/area of residences, community facilities, businesses, etc., in a given area); this assessment could be performed using a combination of aerial images (see below for an example from Talacre[150]) and ground-truthing (i.e., observations and data collected during fieldwork). Data could be reported in terms of area covered by different land-use/property types (in m^3) and/or as tallies of numbers of buildings/features within each category.

[150] Annotated Google Maps image

A report into coastal land-use management along the Gulf of Maine provides a template of possible indicators that could be adapted by students to compare coastal pressures at different sites.[151]

Site requirements

Any coastal area. This activity will yield the best results where students can visit and compare multiple coastal locations with different stakeholders or processes providing competing pressures.

Equipment and associated costs

This activity requires a field notebook and pencil. If simple surveys are included, students may need a stopwatch. For basic land-use mapping, students will require a tape measure or access to a GPS-enabled device to take waypoints.

Number of data points needed (data resolution)

The number of observations will depend on the site and on the types of data collected. Students should ensure that their data are representative (e.g., for traffic surveys, students should consider the error introduced by time of day, weather conditions, etc.).

For measurements of flow (e.g., road traffic), students should count vehicles for at least 5–10 minutes. Ideally, this exercise would be repeated at different times of day.

Where possible, repeat measurements should be taken so that an average measurement can be reported (e.g., mean or median) along with an indicator of data spread (e.g., standard deviation).

Professional measurement techniques

Basic field site observations are critical for fieldwork at any level. However, many professional coastal studies will also use secondary data to identify key features (e.g., maps, management reports, etc.).

[151] http://www.gulfofmaine.org/2/wp-content/uploads/2014/03/coastal-land-use-theme-paper.pdf

5.5. *Post-fieldwork activities*

In the professional world, fieldwork often represents only a small part of a project's duration. The post-fieldwork data analysis stage is usually the longest part of any study. Here we outline some of the main steps in the post-fieldwork process and highlight some of the key post-fieldwork calculations and analyses performed using the data collected from coastal field sites.

4.5.1. Data organisation & input

On return to the classroom, students should transfer field data from their field notebook onto a computer or tablet. Students should consider the best storage options for their data (e.g., Microsoft Excel, Microsoft Word, ArcGIS, Google Earth). If data were collected by a group, students should consider approaches to data management and data sharing (e.g., Google Drive, Dropbox). It may be appropriate for each group to develop a brief data management plan.

4.5.2. Data analysis & visualisation

Students should consider the most appropriate statistical techniques[152] and chart types to analyse and present their data. Students should ensure that they consider the accuracy and limitations of their data; this should be clearly stated in their final report.

Students should be encouraged to consider how GIS tools could help them to visualise and present their data. Guidance on getting started with GIS in the classroom is available online[153].To support GIS education in schools, ESRI have made ArcGIS Online free for all UK schools. Full details, including help getting started and guidance on using ArcGIS for recording and reporting on fieldwork, are available online[154].

Based on the field data collected and any supporting metadata, students should provide an interpretation for their findings. They should return to their original scientific questions and hypotheses and use their results to show how these were met (or not). Students should also be encouraged to think about how their data may have changed under different field conditions (e.g., after a storm event, during different seasons). Students should consider how climate change might impact on their field sites.

Using a combination of field-based observations and supporting metadata, students should create a network showing the interconnections between stakeholders, pressures and processes. Using metadata and observations, they could also be asked to consider how these pressures have changed with time, and how they may change in the future with climate change (e.g., flooding, rising sea level, extreme weather) and with commercial, residential and/or industrial development at the site. Metadata resources could include changing property prices, changing land use, proposals for new developments, etc.

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[152] https://www.rgs.org/schools/teaching-resources/fsc-statistical-methods/
[153] Getting started with GIS in teaching (https://www.rgs.org/CMSPages/GetFile.aspx?nodeguid=5ca2377b-d8f4-4aa9-bc97-72fde503bb7e&lang=en-GB); Using Google Earth for fieldwork (https://www.rgs.org/schools/teaching-resources/google-earth-as-a-fieldwork-tool/); Getting started with ArcGIS and ESRI (https://schools.esriuk.com/teaching-resources/#-)
[154] https://schools.esriuk.com/

4.5.3. Data reporting & sharing

In some professional settings (e.g., academic research), making your data publicly accessible is often a requirement. In others, data are protected by corporate confidentiality; however, they must still be prepared in such a way that findings can be reported back to a client.

Students should consider how their data, analyses and interpretations could be shared with their teachers and classmates (e.g., written report, class presentation). Students could also consider how their data and their analyses could be shared with a broader audience (e.g., creating a report for the school webpage; organising a school based scientific conference, including students from other classes or even other local schools; sharing data with citizen-science sharing platforms[155]).

[155] e.g., the British Geological Survey mySoil app (http://www.bgs.ac.uk/mysoil/); The About GLOBE programme of the United States Government (https://www.globe.gov/about/overview)