Unit 7: Coastal processes

Key enquiry question:
How can coastlines vary in terms of their processes and landforms?

The geographical context

No matter where you are in the UK, you are never more than 116km (72 miles) from the sea. Students may experience the coast on family holidays, but visiting for fieldwork requires them to view it through a different 'lens'.

The coastline which looks fixed on a map is, of course, constantly evolving. Coastal landforms change as the tide advances and retreats, wind blows sand inland often building dune systems and fine silt is deposited on salt marshes. The coast is eroded in some areas and accretes in others. The energy dispersed as each wave breaks on the shore has an impact on the beach sediment.

Stretches of the UK coastline have become familiar to generations of geography teachers for the rate of change that takes place there. Disappearing farms at Mappleton, East Yorkshire, the coastal defences at Barton on Sea, Hampshire, and the retirement properties in Happisburgh, Norfolk, have featured in numerous geography case studies and videos. Indeed, some areas now have special names: the 'Jurassic Coast' in Dorset takes in the impressive rock arch at Durdle Door and beautiful curve of Lulworth Cove. The geomorphological processes which change the 'shape' of the coastline occur at varying rates; some may even happen while the students are watching but most must be discovered through various sources.

A manageable unit for fieldwork is a measured stretch of beach with suitable access points. For management purposes, each beach – from the wide, flat and sandy sweep of Holkham beach in Norfolk, to the shelving pebbles of Budleigh Salterton in Devon – sits within a 'cell' (see Unit 8) yet is obviously an open system. Material can be added or removed from a number of different directions. The relationship between the place where data is collected and the surrounding areas needs to be taken into account. The various processes that shape a stretch of coastline create particular landforms, which students can locate and study in detail – for example, by sketching and taking digital images.

Enquiry questions

The key enquiry question in this unit is 'How can coastlines vary in terms of their processes and landforms?'. Alternatives include:

- How does beach morphology change in response to wave energy?
- How/to what extent does geology and coastal orientation influence the shape of a stretch of coastline and its landforms?
- How has erosion and deposition at a location changed over time?
- How important is coastal management in influencing the nature of coastal landforms?
- How distinctive is your chosen coastal case study area?

Figure 1: The sea in action at Cromer in Norfolk. *Photo: Bryan Ledgard.*

Figure 2: Fieldwork on Holkham beach, Norfolk.
Photo: Bryan Ledgard.

Menu of fieldwork techniques

The techniques suggested here have been used for coastal environment enquiries. You could add to this menu or adapt the materials to suit your context.

- Beach profile measurements - students measure beach distances from low tide and angles using ranging poles (see **Recording sheet 7A**) and produce cross sections for a number of sites along the coastline.
- Beach sediment analysis - involves comparing sediment in different areas of the beach, if these samples are recorded at the same sites as the profiles, students can relate the two sets of data.
- Wave analysis - wave frequency can be observed and related to wave type (i.e. whether the waves are constructive or destructive). Capturing video footage of wave patterns in the swash zone over a given length of time will allow analysis to continue back in the classroom.
- Groynes and longshore drift assessment - students gather data to assess the strength and direction of longshore drift, sediment movement and susceptibility to erosion as well as the effectiveness of coastal management.
- Coastal landform research - students search the Geograph website (see **General guidance sheet 2**) for images of landforms before venturing into the field to identify them.
- Field sketches - students sketch landforms and add annotations. Back in the classroom they can add further information from secondary research (e.g. from the Geograph website) as required.
- Comparing images - students refer to historic postcards/images to investigate longer term change to the stretches of coastline.
- Comparing maps - students usethe Where's the Path website to indicate rates of coastal erosion over time (see **General guidance sheet 5**).
- Geographic information systems - allow students to place layers of different mapped information over each other in order to analyse patterns in coastal environments (e.g. coastal erosion at Mappleton in East Yorkshire). These are supplied as datasets (see the Natural England website and **General guidance sheet 6**).

Locations

Health and safety is the most important consideration in coastal fieldwork (see **General guidance sheet 1**). Choose locations with good access for fieldwork at low tide. Avoid stretches of coastline with known hazards (such as unsafe cliffs at the back of the beach). Students should stay away from all cliffs, a warning that can prompt discussions about the likelihood and reasons for cliff collapses, and the connection with weather conditions.

Although it is often possible to visit two contrasting locations on the same day, the coastal areas you choose must enable students to complete their enquiry fieldwork within the time available, especially with respect to obtaining enough meaningful data using questionnaires. Capture of video and digital still images allows students to complete fieldwork virtually, back in the classroom. Finally, ensure that appropriate permissions have been obtained.

Sequence of enquiry

- Students choose a key enquiry question (e.g. How can coastlines vary in terms of their processes and landforms?) then devise sub-questions (e.g. what is the underlying geology of each area? What similarities and differences are there in terms of beach geomorphology? What changes have occurred in the past? What differences might students notice if they were to return to the same area in five or ten year's time?). Risk assessments can be discussed at this point.
- Students prepare for data collection (e.g. practice using the beach measurements techniques in the school grounds, familiarise themselves with coastal landforms).
- Either before or after the fieldwork, students' research secondary data (e.g. collect historic postcards and make notes on any evidence of coastal management in the location).
- Students visit the location(s) and carry out data collection (e.g. beach profile measurements, beach sediment measurements, wave analysis and groynes and longshore drift assessment).
- Back in the classroom, students share fieldwork data and amalgamate it with secondary data (e.g. annotate their own photos of coastal landforms and make comparisons with images from the Geograph website).
- They present, analyse and draw conclusions from the data to answer their chosen enquiry question.
- As a follow-up, students should also carry out an evaluation of the enquiry fieldwork: what would they change? How could they improve their data gathering?

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Fieldwork techniques

Resources

Download the coastal processes resources from ***www.geography.org.uk/fieldworkenquiry***.

- 7A: Beach profiles measurements
- 7B: Wave analysis
- 6A: (includes) Power's Index
- General guidance 1: Health and safety
- General guidance 2: Websites and other materials
- General guidance 4: Useful apps
- General guidance 5: Maps, images and 3D modelling
- General guidance 6: Using GIS

Beach structure and profiles

Students measure beach profiles (distances and angles) at three sites, using ranging poles and starting at the low-tide mark (Figure 3). They identify the key breaks of slope and divide the profile into sections. **Recording sheet 7A** explains how to carry out these measurements.

To ensure that there are opportunities for comparison with sites along the beach, to speed up the data collection, assign groups of students to gather data at specific sites. They should also assess human influences on the beach profile (e.g. groyne construction) and identify berms or storm ridges. Where possible, make previous profiles available for comparison.

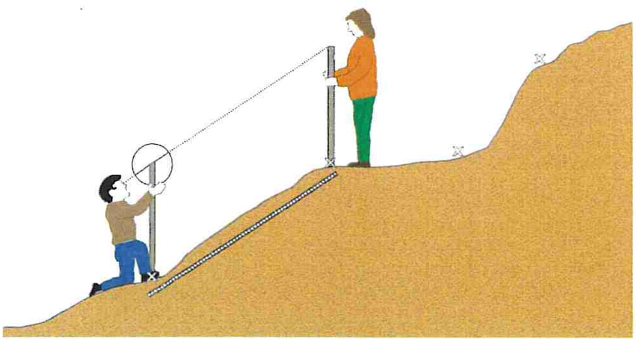


Figure 3: Measuring a beach profile.

Beach morphology and sediment

It is helpful for students to look at sediment movements as inputs and outputs through a cell as shown in Figure 4. Students could think of ways they could measure the various inputs and outputs to and from the beach cell. Beaches are mainly made up of clastic and biotic sediments. Clastic sediment refers to pebbles and sand, biotic sediment refers to shells, but beaches vary widely in the type of sand and balance of other material.

Students can use a modified version of **Recording sheet 6A** to carry out their measurement and recording (it includes a copy of Power's Index). On some beaches it may be possible to record the mix of clastic and biotic sediments from a small sample or visually. The dominant sediment could be recorded.

Beach sediment is subject to movement by waves, and different areas of the beach may behave differently. While litter may be the focus for an enquiry on beach management, its presence is useful here as an indicator of tides. The strandline provides a marker of a previous high tide, thus helping identify sections of the beach which are affected less frequently by waves.

As they form part of our coastal defences many beaches display warnings prohibiting the removal of sediment.

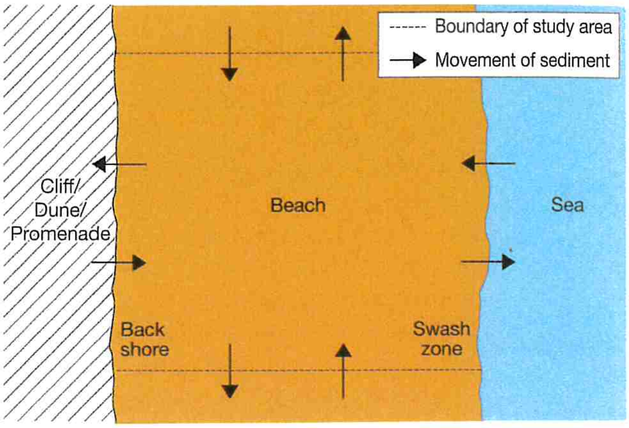


Figure 4: A beach cell showing sediment movements.

Wave analysis

The frequency with which waves break on the shore is related to the conditions (e.g. wind speed and direction) and the nature of the area immediately offshore (e.g. steepness of coastal shelf). Students can estimate the wave height, which is affected by the fetch, the potential distance over which the wind can blow uninterrupted across open sea. Students should record the wind speed and wind direction.

Wave frequency can be identified by observation and recording the time between wave crests reaching the breaking point (**Recording sheet 7B**) using a stopwatch (or the stopwatch app on a mobile phone). Alternatively students can count the number of waves per minute and after repeating this three times they work out an average. Ask students to observe any wave refraction that occurs as the wave approaches the beach.

Using a video camera (or a mobile phone) students record a few minutes of the waves breaking in the swash zone. They can replay the video and see the interplay between the waves, and the way that sediment may be moving, as well as confirm the wave type.

Figure 6: Groynes on Cromer beach, Norfolk. *Photo: Alan Parkinson.*

Groyne and longshore drift assessment

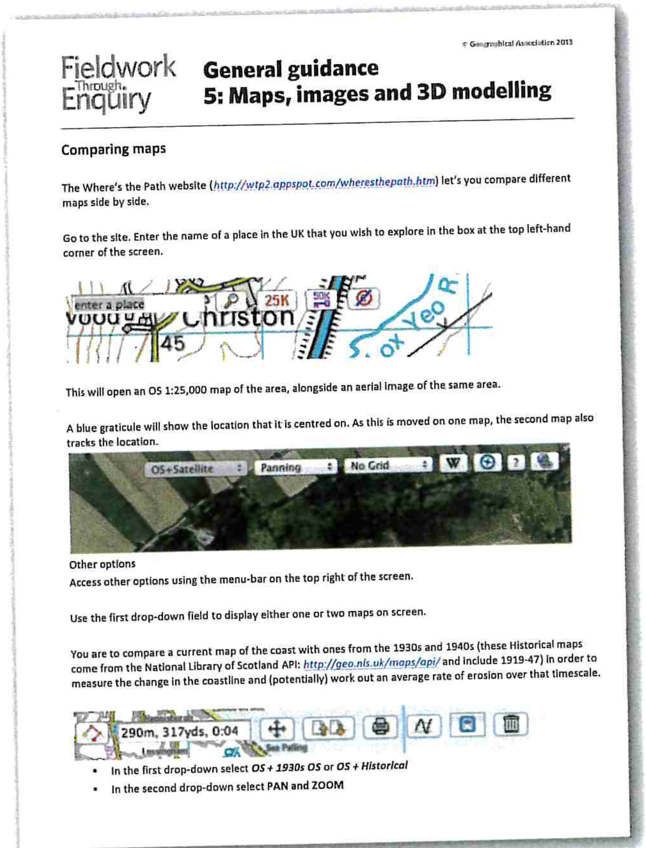
Before embarking on any measurements take a bucket of brightly painted pebbles or corks and place them in the break zone. Mark the start position with a ranging pole and see what happens over the next 15 minutes. The movement of the material should be clear and match the wind and wave direction of that day. This may not necessarily be the usual direction of longshore drift. One of the common features on beaches, groynes are intended to be a semi-permeable barrier to the movement of sediment. They are constructed at right-angles to the shore to prevent beaches from becoming denuded of sand. Longshore drift causes sediment to accumulate on the up-drift side of groynes, there tends to be more sediment there than on the down-drift side. Sediment also builds further out into the sea on the up-drift side of groynes, differences that are usually visible aerial imagery (e.g. Google Maps).

Use a compass to identify the direction the groynes face. Measurements can be taken from the top of the groyne to the beach either side to calculate the difference in height. Students can photograph the groynes and patterns of accumulated/denuded beach material and annotate their images back in the classroom, with any damage noted.

Comparing maps

Geographic information systems (GIS) can be used to map data and visualise patterns and relationships, as GIS make use of data which has been geo-located or referenced. When carrying out fieldwork, students may be directed to locations whose co-ordinates or latitude and longitude are known. Back in the classroom, data collected at these points can be accurately mapped and patterns explored.

The 'Where's the Path' app enables students to view two different maps side-by-side to assess the relationship between them. Digitised map files (shapefiles) can be obtained from, for example, Natural England can be used in GIS packages. **General guidance sheet 5** provides guidance on comparing maps from the past and present as well as accessing other digital map sources.



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Fieldwork Through Enquiry

General guidance
5: Maps, images and 3D modelling

Comparing maps

The Where's the Path website (http://wtp2.appspot.com/wheresthepath.htm) let's you compare different maps side by side.

Go to the site. Enter the name of a place in the UK that you wish to explore in the box at the top left-hand corner of the screen.

This will open an OS 1:25,000 map of the area, alongside an aerial image of the same area.

A blue graticule will show the location that it is centred on. As this is moved on one map, the second map also tracks the location.

Other options
Access other options using the menu-bar on the top right of the screen.

Use the first drop-down field to display either one or two maps on screen.

You are to compare a current map of the coast with ones from the 1930s and 1940s (these Historical maps come from the National Library of Scotland API: http://geo.nls.uk/maps/api/ and include 1919-47) in order to measure the change in the coastline and (potentially) work out an average rate of erosion over that timescale.

- In the first drop-down select *OS + 1930s OS* or *OS + Historical*
- In the second drop-down select PAN and ZOOM

Figure 7: Comparing maps in coastal fieldwork (**General guidance sheet 5**).

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Data presentation, analysis and conclusions

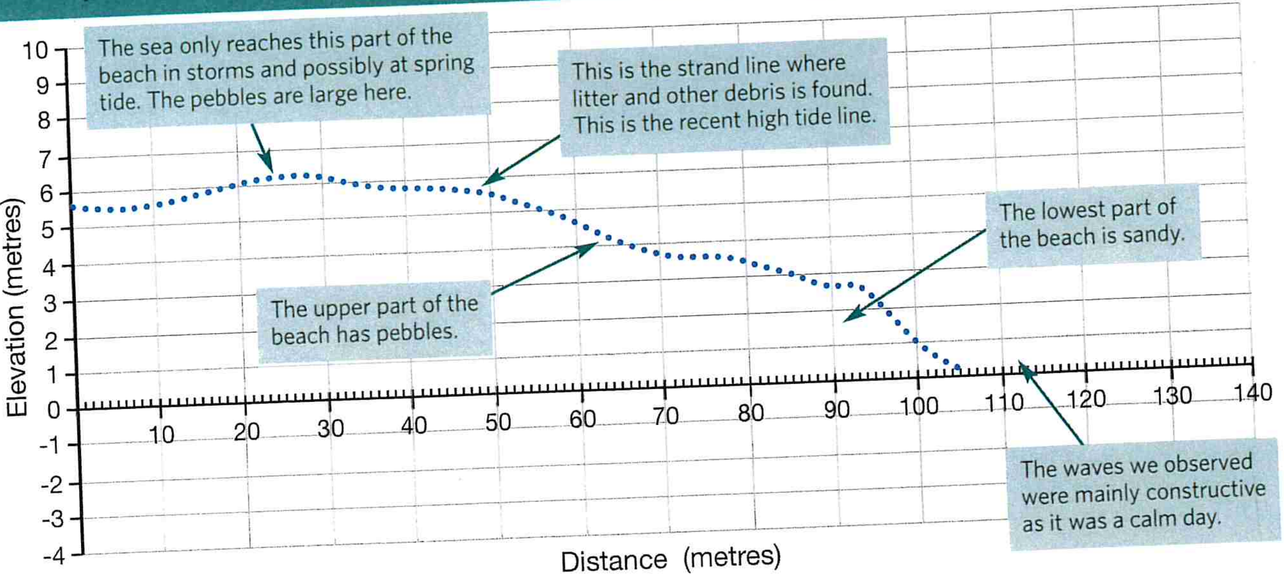

Figure 9: A student's annotated beach profile.

As several sites have been surveyed along a stretch of coastline much of the data should be presented on a map. This should reveal some variations.

Beach profile

Students draw their beach profiles to scale on graph paper for every site at each location, and annotate each one (Figure 9). Before constructing the profile it is important to discuss the vertical scale. This will need to be exaggerated vertically, especially on beaches that show a very subtle gradient. The profile can then become a place to display a range of data that has been collected, such as the dominant type of sediment, any evidence of sorting on the beach, the position of features such as berms, the strand line, and any human impacts.

The profiles could also be located on a map and, if using GIS, a map could be generated with points showing particular areas of interest. This would allow the digital images the students take to be geo-located.

Beach sediment analysis

On pebble beaches students could use Power's index to analyse the overall shape and size of the beach sediment and extrapolate data from this, for example:

- there is some evidence of sorting with distance along, or up the beach at location A, which reflects the prevailing westerly wind
- the type of sediment found here reflects the underlying geology
- there is also evidence that some beach material originates from an up drift direction.

This data could be added to a map showing the

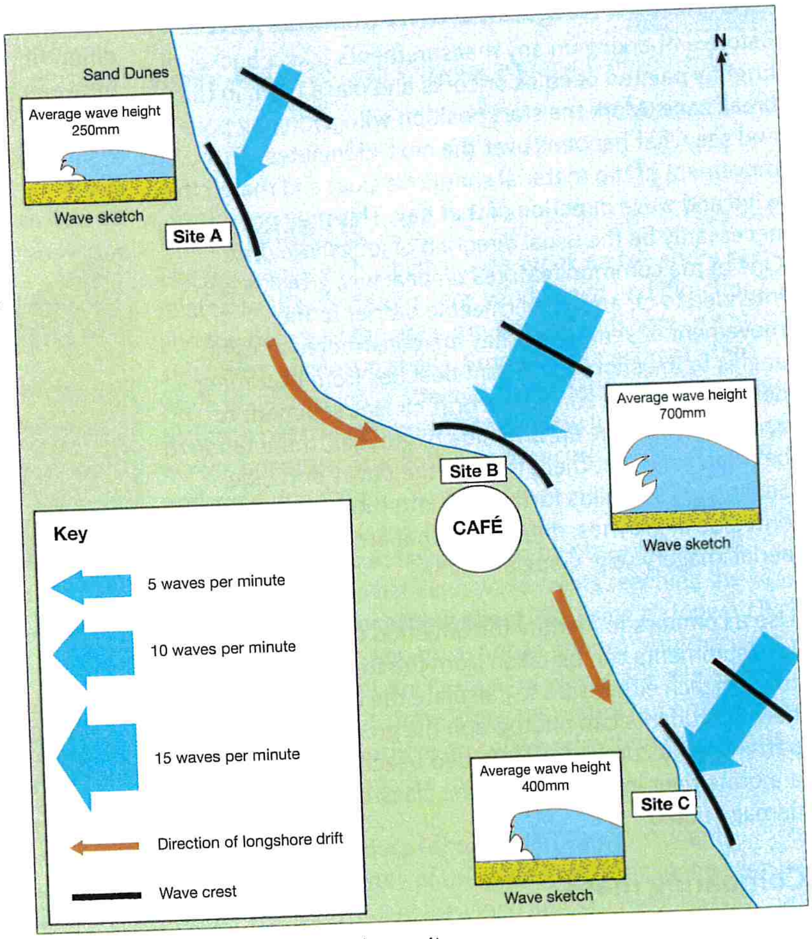

Figure 10: Wave analysis at three sites.

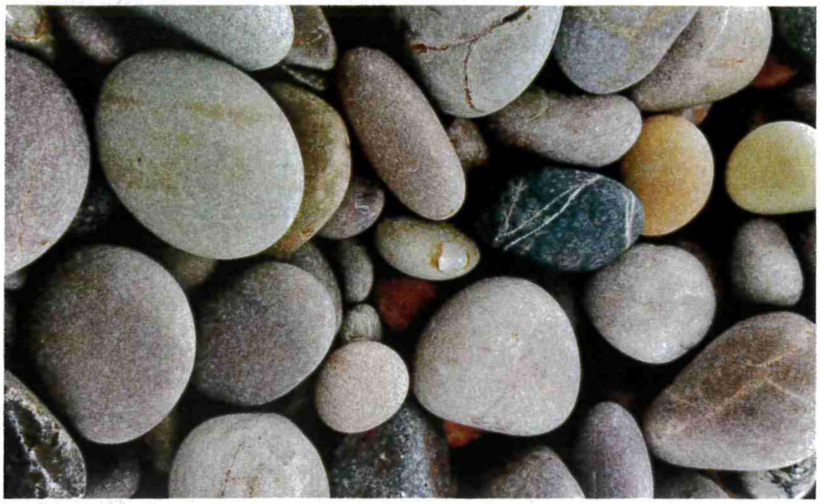

Figure 11: Beach sediment at Budleigh Salterton, Devon.
Photo: Alan Parkinson.

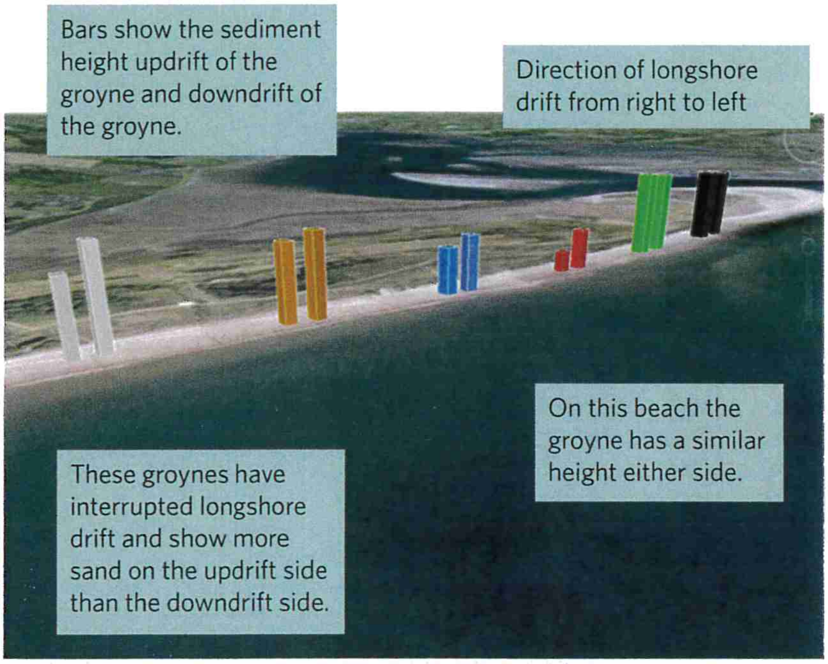

Figure 12: Screen grab of Dawlish Warren sediment heights on Google Earth.

Wave analysis

The wave frequency can be calculated and the type of wave can be categorised. Destructive waves are tall, have a strong backwash and higher wave frequency (13 waves per minute or more) than constructive waves. Constructive waves tend to deposit material on the beach, they are shorter in height than destructive waves, have a strong swash and much lower frequencies (well under 13 waves per minute).

This data can be displayed on a map of the sampling sites with proportional arrows showing the wave frequency and the wind direction (**Figure 10**). Students can calculate the fetch for that day using an atlas back at school and relate this to the wave type. The video clips of the wave could be analysed to record wave refraction and used in a presentation about the changes in the coastline or used in a debrief or to prepare students the following year.

Groyne and longshore drift assessment

Students present groyne and longshore drift data on a map or images to indicate how change occurs along a particular stretch of coastline. This example uses Google Earth polygons to visually present sediment heights (**Figure 12** and **General guidance sheet 6**).

Conclusions

Key enquiry question:
How can coastlines vary in terms of their processes and landforms?

Students should indicate the nature of **beach profiles and beach sediment analysis** at each site, and how they relate to factors such as geology, orientation, human impact as a way of exploring the differences they identified.

The groyne and wave analysis at specific locations should be described, with some explanation of the processes of longshore drift they observed. Students should indicate how the results varied between the two locations. They could also say something about the stability of the beach.

The specific differences between sites or stretches of coastline need to be explained by students using their data and images. These may include changes to sediment, wave type/frequency and how these are affected by coastal management. Students locate the coastline studied on a map, identify its main features and relate it to the enquiry question.

Students should comment on the processes they saw that day and if they are typical, for example, the weather may have been particularly calm or the wind not from the prevailing direction.