Waves and Tides

Waves

Waves are the result of the transfer of energy from wind to water as it blows across the surface of a sea or lake. As the wind blows stronger, the friction between the wind and the water increases, which in turn causes the waves to increase in size. The amount of energy transferred to the water depends on the velocity of the wind, the length of time the wind is blowing, and the length of the **fetch**. Fetch is the distance of open water over which the wind blows, and is proportionate to wave height; and fetch increase, so does the size of the wave. This is one reason why waves in the North Sea are generally smaller than those on the United Kingdom's Atlantic coasts. Additionally, waves that only travel short distances are known as **sea**, whilst those that travel long distances are known as **swell**. The only wave type that is not caused by energy transfer from wind to water are **tsunami** waves, which are caused by submarine shockwaves generated by seismic activity.

Wave terminology (Figure 1)

- The **crest** and **trough** are the highest and lowest points of a wave.
- **Wave height (*H*)** is the distance between each crest and trough.
- **Wave period (*T*)** is the time taken for a wave to travel one wave length, and is often calculated by counting the number of crests per minute.
- **Wave length (*L*)** is the distance between two consecutive crests. It is calculated using the following formula;

$$L = 1.56T^2$$

- **Wave velocity (*C*)**, or **wave celerity**, is the speed of a crest over a period of time.
- **Wave steepness (*H* ÷ *L*)** is the ratio of the wave height to the wave length. This never exceeds 1:7, as beyond that point the wave will break. The steepness of a wave will determine its effect on a beach.
- **Wave energy (*E*)** in deep water is defined as ;

$$E \propto LH^2$$

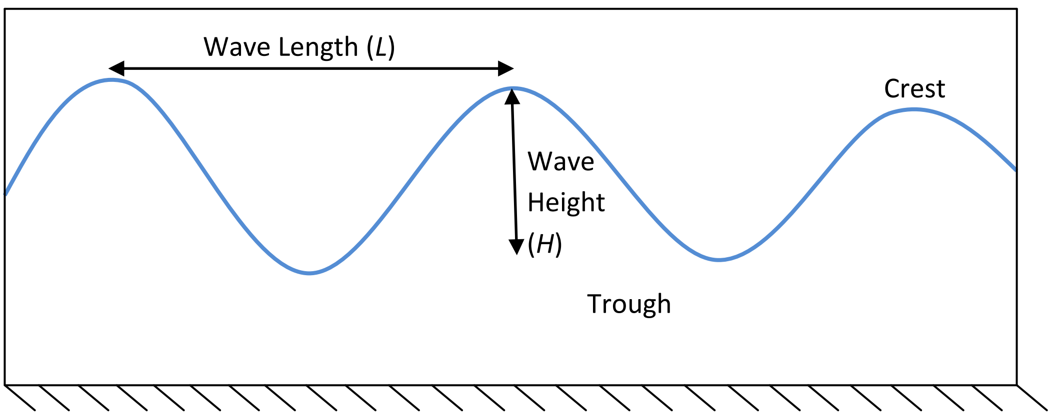

Figure 1

When waves meet the shore

In deep water, the water in a wave moves in a circular motion, as the seabed does not exert a frictional force on the sea surface. However, as waves move into shallow water, friction from the seabed increases, causing the base of the wave to slow down and altering the water's rotation from circular to elliptical. This causes the wave length to decrease, and the wave height and steepness to increase until the wave breaks. This point is known as the **plunge line** and the wave becomes a body of foaming water, or **swash**. Any water running back down the beach is called **backwash** (Figure 2). The movement of waves and water in the **surf zone** creates turbulence and currents, the three main ones being **longshore** (moving along the shoreline), **rip** (moving offshore creating gaps in waves) and **undertow** (offshore currents on the seabed).

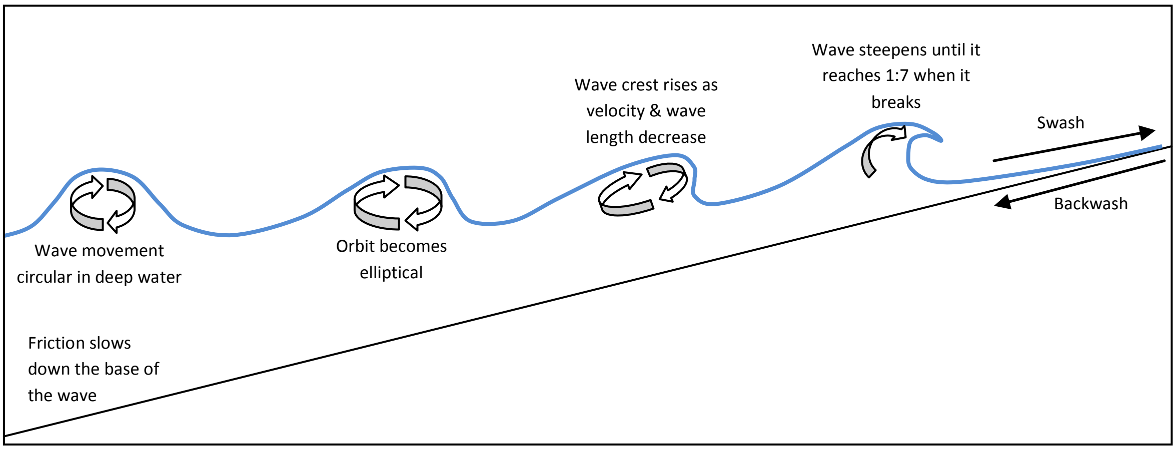

Figure 2

Wave types

- **Spilling waves** occur on gently sloping beaches, where the crest breaks and spills down the face of the wave;
- **Plunging waves** occur where the beach is steeper, and are characterised by a steep wave face with the crest curling over the top;
- **Surging waves** occur on the steepest beaches, with smooth wave faces and little foam or bubbles;
- **Collapsing waves** are a combination of plunging and surging waves.

Wave refraction

When waves meet an irregular shoreline, they tend to become shore parallel as the drag from the seabed slows and bends waves at different rates. This process is known as **refraction**, and is illustrated in Figure 3;

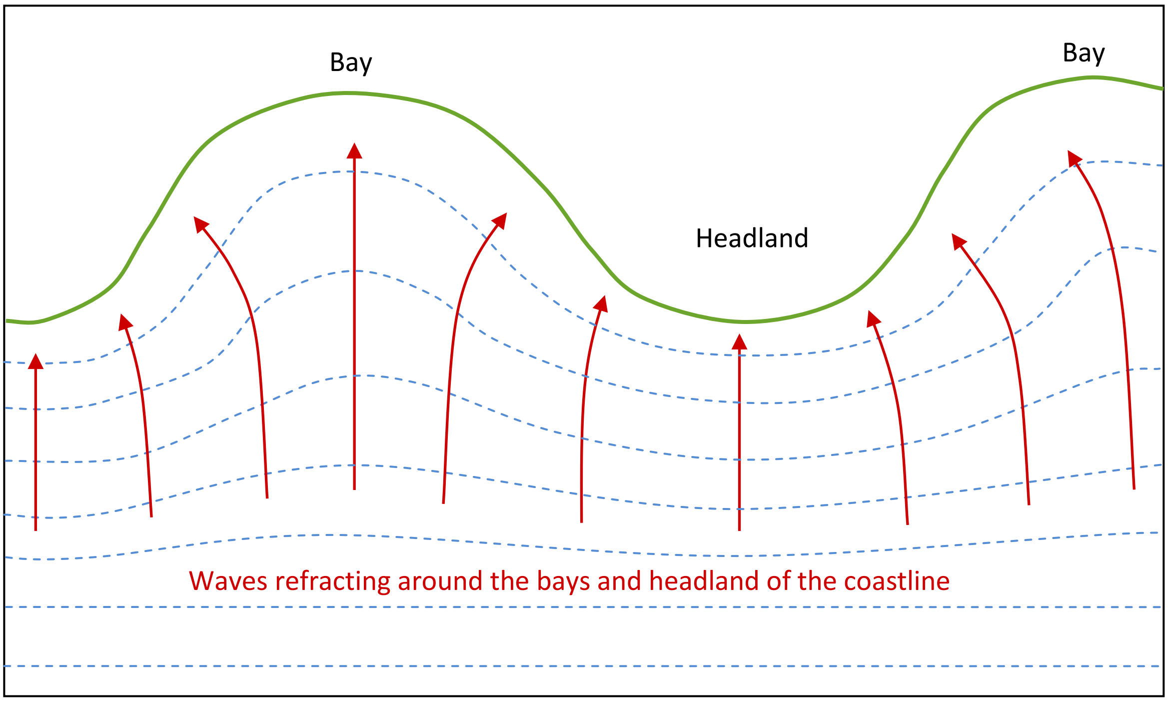

Figure 3

Tides

Tides are the regular movements of the oceans and seas caused by the gravitational forces of the Moon and the Sun, the rotation of the Earth, and the geomorphology of the seabed. The biggest influence is the Moon due to its short distance from Earth. It's gravitational field attracts water to the side of earth nearest it, creating a **high tide** on the side of the Earth nearest it, and a corresponding bulge on the opposite side. The areas between the bulges repel the water, leading to **low tides**. This means that as the Moon orbits the Earth, the high tide follows it. The tidal cycle is 12 hours 25 minutes long and occurs twice a day.

The lunar cycle is 29 days, and twice a month the Sun, Earth and Moon align (when the Moon is between the Sun and the Earth, or when the Earth is between the Sun and the Moon) creating a larger bulge, or **spring tide**. Between spring tides are **neap tides**, when the Moon isn't aligned with the Earth and the Sun, when the Moon's gravitational influence is reduced slightly by the Sun's. The strength of neap and spring tides also varies, as the Earth's orbit around the Sun is elliptical. Therefore, the closer the Earth is to the Sun, the stronger the tides.

The geomorphology of the seabed also affects the **tidal range**. As the Moon drags the water bulge around the Earth, land masses block the path of the bulge. This leads to a funneling effect on some areas e.g. the North Sea into the English Channel. This creates a high tidal range in narrow straits compared to open sea coasts.

The Earth's rotation is the final influence on tides. One result of the rotation is the **Coriolis force** creating two convection cells, one in each hemisphere. When cold polar air meets warm tropical air a low pressure weather front, or depression, is created. The lower air pressure allows the sea level to rise as there is a lower force pushing down on it. The same effect occurs during tropical cyclones. Another effect of frontal systems are increased wind speeds, which create larger waves. Combined with a higher sea level, this can create significant changes in the beach morphology, and increase the risk of flooding. A good example of this is the North Sea surge of 1953, when a deep low pressure moved south through the North Sea. Combined with gale-force winds, 6m waves, a high tide, and rivers discharging at flood levels, the Thames Estuary experienced a storm surge of 2.5m. This led to significant flooding and loss of life, and a major sea defence construction program.

Further reading

- Bird, E. (2000), *Coastal Geomorphology – An Introduction*. John Wiley & Sons Limited, Chichester.
- Haggett, P. (2001), *Geography – A Global Synthesis*. Pearson Education Limited, Harlow.
- Thomas, S. G., Goudie, A. (2000), *The Dictionary of Physical Geography (3rd Edition)*. Blackwell Publishing, Oxford.
- Waugh, D. (2000), *Geography – An Integrated Approach (3rd Edition)*. Nelson, Walton-on-Thames.
- Woodroffe, C.D. (2002), *Coasts – Form, Process and Evolution*. Cambridge University Press, Cambridge.