

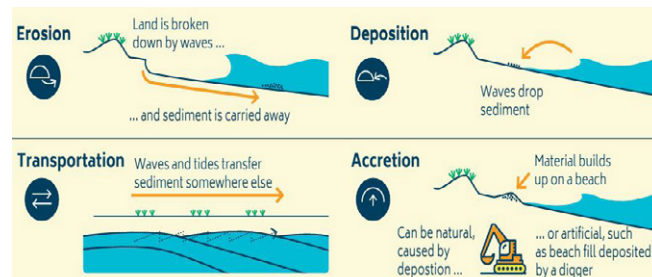
Introduction to Coastal Processes

Coastal processes refer to the natural forces that shape the coastline and its adjacent areas. These processes are driven by a combination of factors, including waves, water levels, currents and winds.

Why are Coastal Processes Important?

The coastal environment is dynamic and its morphology is shaped by interactions between its structure (for example rocky cliffs versus sandy beaches) and these natural forces. Understanding coastal processes is crucial for any work near the coastline to ensure that the potential impacts/extent of any coastal change are appropriately understood. In particular, understanding of coastal processes is critical for the following reasons.

Sediment Transport: Sediment movement along the coast is influenced by coastal processes. Accurate knowledge of sediment transport patterns is essential for coastal planning, as well as for activities like beach nourishment, harbour maintenance and coastal engineering projects.



Coastal Stability/Erosion/Deposition: Stability is crucial for the preservation of coastal ecosystems, protection of property, and human safety. When coastal processes, such as wave action and sediment transport, are balanced the shoreline is generally stable. However, when these processes are out of balance they can contribute to erosion and deposition of sediment along the coast. By comprehending these processes, we can predict erosion patterns, protect vulnerable areas and implement effective coastal management strategies.



Flood Risk and Storm Surge: Coastal processes significantly impact the vulnerability of coastal areas to flooding and storm surge. Understanding the interaction of waves, water levels (including tides, surge and sea level rise), and currents during storm events allows for accurate prediction and modelling of flood risks. This knowledge is crucial for developing

appropriate coastal management strategies, implementing early warning systems, and ensuring the safety of coastal communities.

Climate Change Adaptation: Coastal areas are particularly vulnerable to climate change impacts, including sea-level rise and increased storm intensity. Coastal processes shape the response of coastlines to these changes. By understanding these processes, we can assess the potential impacts, develop adaptation strategies, and incorporate climate change considerations into coastal planning and management.

Infrastructure Planning: Coastal processes influence the suitability and durability of coastal infrastructure, such as ports, harbours, and coastal structures. Proper consideration of coastal processes ensures the design and construction of resilient infrastructure that can withstand the dynamic coastal environment.



Water Levels

Water level variations play a fundamental role in coastal processes, influencing the dynamics of coastal environments and shaping the interactions between land and sea. Understanding why water levels fluctuate and their significance is essential for comprehending coastal processes and their impacts on coastal areas.

Factors Influencing Coastal Water Levels

Tides: Tides are the primary driver of water level variations along the coastline. The magnitude and timing of the tides differs around the state; however tides are regular and predictable. Many other components that make up the total water level at the shoreline are more irregular and/or are less predictable.

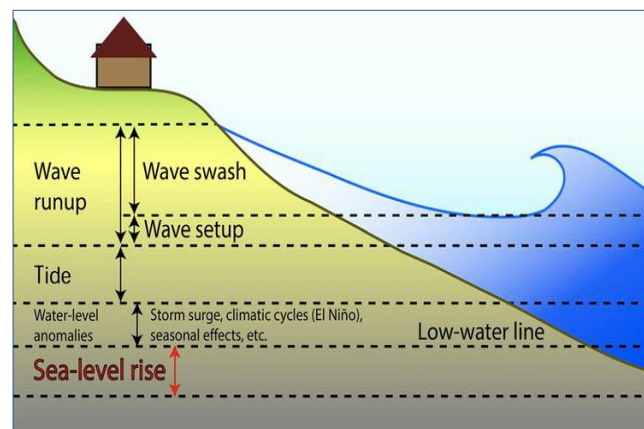
Storm Surge: Storm Surge refers to the abnormal change in water level as a result of winds, waves and barometric pressure differences. Storm surge can be either positive (increased water levels) during periods of onshore wind directions and low barometric pressure, or negative (decreased water levels) during periods of offshore wind directions and high barometric pressures.

Wave Setup and Runup: As waves approach the shore, they cause temporary fluctuations in water level known as wave setup and runup. These variations are influenced by wave height, period, and direction, as well as the coastal topography. Wave setup generally

results in a steady water level increase, while wave runup is cyclical and is associated with waves rushing up the shoreline.

Seasonal and Longer-Term Variations: Seasonal variations in water level occur due to phenomena such as the Leeuwin Current, which can increase water levels during summer by as much as 0.3 m. Longer term variations, such as those caused by the El Niño Southern Oscillation (ENSO) and other climate cycles can lead to annual to decadal changes in water levels.

Sea Level Rise: Climate change, driven by factors like melting glaciers and thermal expansion of seawater, has led to a gradual increase in global sea levels with ongoing increases expected into the future. As sea level rise increases, the total water level caused by the combination of each of the different influencing factors will also increase.



Source: Vitousek, 2017

The Importance of Coastal Water Levels

Coastal Erosion and Deposition: Water levels determine the reach and intensity of wave action, which is a key driver of coastal erosion and deposition. During high water level events waves can act on higher sections of the beach profile, such as the dunes, that are not normally vulnerable to wave attack. This can result in much more rapid erosion of the shoreline.

Coastal Flooding and Vulnerability: Water levels, particularly during storm events, influence coastal flooding and the vulnerability of coastal areas. Higher water levels caused by other influencing factors, such as Sea Level Rise, can increase the extent and severity of coastal flooding.

Coastal Engineering and Infrastructure Design: Water levels are vital parameters to consider when designing coastal infrastructure such as ports, harbours and coastal protection structures. Understanding the range of water levels, including extreme events, is crucial for designing resilient and sustainable coastal projects.

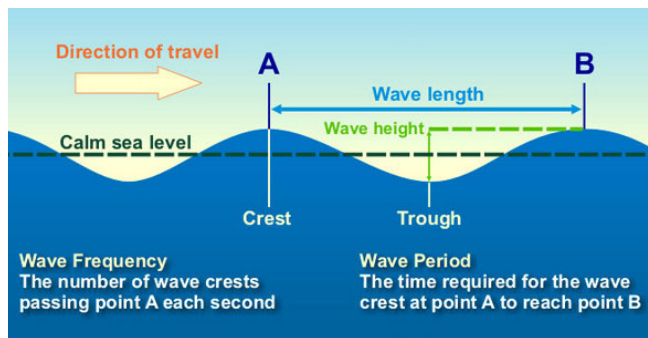


Waves in the Nearshore Environment

Waves play a crucial role in shaping the morphology of the nearshore environment due to the substantial energy they carry. This wave energy drives various coastal processes such as sediment transport, erosion and deposition.

Describing Wave Characteristics

Waves are generally defined by a number of different parameters that summarise the key attributes of the wave. These key parameters are shown in the figure below. It is important to note that there is a direct relationship between wave period and wave length, so a wave with a longer wave period will have a longer wavelength. Also, the longer the period / wavelength, the faster the wave travels.



Source: NOAA, 2023

Types of Waves

From a coastal processes perspective there are three main types of wave that need to be considered – seas, swell and boat wake.

Seas: Seas are waves that are generated by the local wind conditions of a meteorological event. They are generally a jumble of various different wave heights and have relatively shorter periods, resulting in more steeply sloping waves.

Swell: Swell waves are those that have not been generated by the local wind. Instead, they are waves that have propagated from distant meteorological events. Swell is characterised by regular, reasonably consistent wave heights and well defined wave periods. Wave periods are generally quite long (>8 seconds), resulting in more gently sloping waves.

Boat Wake: Boat Wake is an important consideration on protected waterways as it can result in wave heights that would not be experienced due to naturally generated seas or swell. Boat wake can result in wave heights of up to 0.8 m, with periods typically in the order of 3 to 4 seconds. Boat wake generally results in steeply sloping waves.

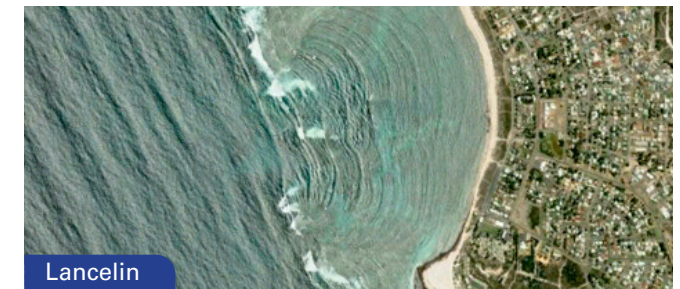
Wave Transformations

Waves can undergo a variety of transformations as they travel through the nearshore environment. These changes are predominately caused by changes in the elevation of the sea bed or by sheltering provided by reefs and islands.

Wave transformation processes include:

- Diffraction – the spreading out of waves as they pass through a gap between structures.

- Refraction – the change in direction of waves due to differences in water depths (as waves slowdown in shallower water).
- Shoaling – the increase in wave height and steepness that occurs as waves travel into shallower water.
- Breaking – the spilling of waves when they become too steep following shoaling, creating a zone of turbulence.



Each of these wave transformation processes occur to different extents for different wave heights and periods. Generally, Swell waves, with longer periods, will undergo more transformation than shorter period Seas.

The Importance of Understanding Waves

Waves are one of the biggest influencing factors on coastal morphology and sediment transport. Understanding incident wave conditions, including the impacts of wave transformation processes, is critical when undertaking coastal planning and management works.

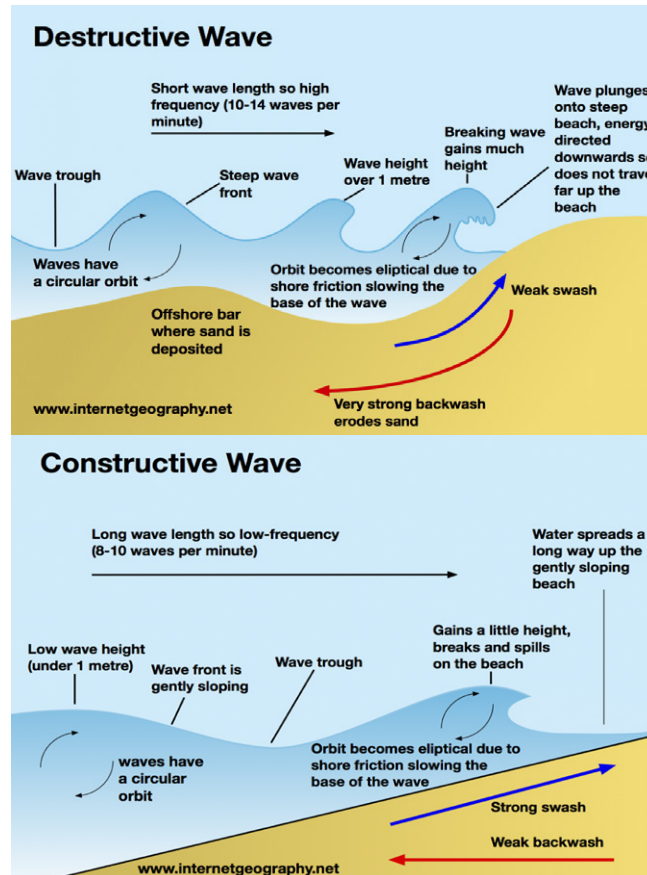
Coastal Sediment Transport

There are many different drivers of sediment transport along the coastline, including waves, winds and currents. In general, sediment transport by waves is the most significant form of sediment transport along the coastline, although this does vary from location to location.

There are two main forms of wave driven coastal sediment transport that occur in the nearshore area, Cross-Shore Transport and Longshore Transport (also known as Littoral Drift). For both forms of sediment transport, it is the turbulent action of wave breaking that is the driver of the highest sediment transport rates.

Cross-Shore Sediment Transport

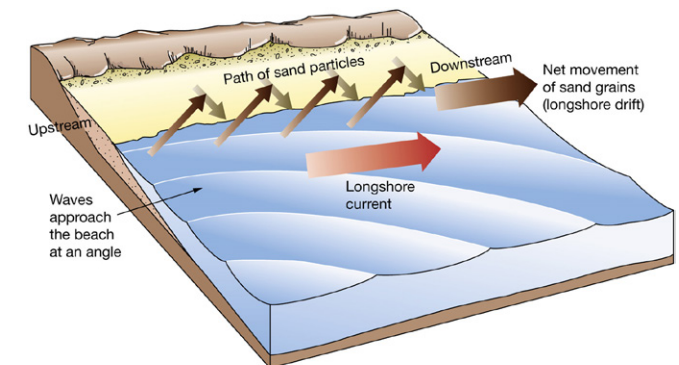
Cross-Shore Sediment Transport is the transportation of sediment in an onshore / offshore direction. Cross-Shore Transport can be both destructive, resulting in erosion of the shoreline and deposition of material into the nearshore area, or constructive, resulting in deposition of sediment onto the beach. Whether the Cross-Shore sediment transport is constructive or destructive depends largely on the characteristics of the incident waves. Waves that are shorter period with steeper wave fronts (i.e. Seas) are generally destructive, while longer period waves with more gently sloping wave fronts (i.e. Swell) are generally constructive.



Longshore Sediment Transport

Longshore Sediment Transport is the transportation of sediment along the shoreline. This form of transport occurs when waves approach the beach at an angle.

This results in wave breaking forces acting along the direction of the beach and driving sediment transport in this direction.



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The Importance of Seasonality

Wave climates typically vary with the seasons. From a metocean perspective there are two main seasons – a winter season and a summer season. Generally during the winter season there will be a higher proportion of energetic Sea wave conditions. This typically results in destructive waves that erode material from the beach whilst also moving sediment along the coastline in a certain direction. During summer, Swell wave conditions can dominate, resulting in constructive waves that deposit material onto the beach, whilst summer sea breezes can also result in longshore transport of sediment. Often the longshore transport of sediment in summer can be in the opposite direction to that experienced during winter, resulting in a seasonal sediment cycle.