Beaches On a Budget: Why Do Beaches Come and Go?


Long stretches of sand usually come to mind when we hear the word “beach.” But a beach is actually an accumulation of any sediment along a coastline. A sediment is any material that is deposited by waves. Usually that is sand or gravel, but there are mud beaches and beaches made up of much larger rock fragments, too. The make-up of a beach depends on the type of sediment available and on the ability of the waves, tides, and currents to move it.

Beaches are naturally dynamic, changing from wave to wave, season to season, and year to year. That is because wind, waves, and currents move the sediments around. The part of the beach where sediment transport occurs is called the “active beach.” As the figure below shows, the active beach is divided into three parts: the backshore, foreshore, and offshore. Behind the active beach is the coastal upland. This upland might be a dune, a cliff, a constructed seawall, a soil embankment, or another geological formation that provides a landward barrier for the beach.

Beaches on a Budget

Each beach has a “littoral budget.” “Littoral” refers to the shoreline. The “budget” is the amount and movement of sediments between different parts of the active beach, onto the beach from elsewhere, and away from the beach to another location offshore or downcurrent. Healthy beaches have balanced budgets—the net influx of sediment equals the net loss of sediment. It’s like earning and spending the same amount of money in a month.

Where do the sediments come from and where do they go? Coastal geologists refer to “sources” and “sinks” of beach sediment. Sources include:
- Skeletal material from coral reef ecosystems,
- Offshore deposits of sand that may be transported onshore by waves and currents,
- Other beaches from which wind or currents that run along the shoreline can transport sediments,
- Erosion of coastal uplands and points of land that jut out into the ocean.
Materials from new volcanic eruptions and lava flows, and
Sediments carried from inland by streams and rivers.

Sediment sinks include:
- Loss of sediments to deep water,
- Harbors and channels, which trap sand moving along or across the near-shore area,
- Transport of sediments offshore by currents and waves to underwater “sand banks” from which beaches can be replenished seasonally or after large storms,
- Transport of sediments along the shoreline to other beaches by currents and waves,
- “Impoundment” (trapping) behind seawalls, revetments, and other structures,
- Over-wash by high storm waves and surges, which flush sand inland where it cannot be redeposited onto the beach, and
- Wind loss inland due to strong onshore winds.

When there is an imbalance between sources and sinks, the beach will either erode or “accrete” (build up).

The Beach System

Many of the sandy beaches on Maui are part of a beach system that includes dunes and coral reefs, as well as the beach itself. Each element of the whole system is important in the natural cycle of beach erosion and accretion.

Beaches naturally erode and accrete in cycles that correspond with seasonal weather changes and episodic storm events. During a storm, or through the course of a high-wave season, nearly all of the sand may seem to disappear from a beach, and the dune may be almost entirely washed away.

But after a couple of weeks or a few months of calmer weather, the beach and dunes rebuild. On undeveloped beaches, this cycle usually results in the complete rebuilding of the beach and dune profile to what it was like before the storm event or high-wave season began.

Sand Dunes

Along the coast, just as inland, dunes are accumulations of windblown sand. Some coastal dunes are unvegetated, but most are covered with coastal plants. The thick root systems of most native plants help hold the sand in place, slowing the rate at which the dune erodes during high winds and waves. Plants such as naupaka and beach morning glory also help dunes rebuild by trapping windblown sand and growing up through the new layers of sand to build larger and wider dunes.

Like beaches, dunes are dynamic. They erode during times of high waves and accrete during normal wave conditions. Dunes are like sand savings accounts for beaches. High waves during storms and large swells erode the beach. They erode the dunes, too. This process, known as “scarping,” releases sand that was stored in the dunes to the active beach. The influx of sand from the dunes is often carried offshore where it accumulates into sandbars. These sandbars intercept large waves before they reach shore, lessening their impact on the coastline.

When the high-wave event subsides and normal wave patterns return, the waves dismantle the offshore sandbars and rebuild the beach. Sand blown inland from the beach can then rebuild the dunes. Although some sand may have been permanently washed away from the beach system into deep water by the storm, eventually the beach and the dunes regenerate to their prestorm profile. Most of the sand transported offshore during storms and stormy seasons is eventually reincorporated into the dune.

Coral Reefs

Coral reefs act as natural breakwaters in the beach system. They absorb much of the incoming wave energy and help protect the shoreline from wave erosion. Coral reefs and the invertebrates
and algae they support are also important sources of sand production for beaches as the skeletons and other hard structures they produce are eroded by waves and animal activity. Most of the light-colored sand on beaches comes from coral reef ecosystems. Because coral reefs buffer waves and produce sand, they slow the rate of coastal erosion and beach loss.

**Interfering with Nature**

Coastal erosion is at least partly a natural process. One contributing factor is the rising sea level. Since the last ice age, the sea level has risen nearly 110 meters (361 feet), and as it rises, the whole littoral (shoreline) system moves further inland. Coastal uplands are eroded, and the influx of sediment released to the active beach helps maintain the beach width. We can expect that coastal erosion will continue as sea level rise is currently averaging 2.5 centimeters (about one inch) per decade on Maui.

But sea level rise is only one cause of changing coastlines, and not the most visible and dramatic cause. In many cases, coastal erosion has been aggravated by human activities that reduce the amount of sand available to the beach. Sand mining, dune destruction, and harbor and channel construction, for example, have led to increased rates of coastal erosion on some beaches.

**Sand Mining**

Taking sand from the beach system leads to beach narrowing and a decrease in sand volume. Until the early 1970s, large volumes of sand were mined from beaches around Maui to provide cement aggregate for construction and lime for sugar cane processing. In fact, on Baldwin Beach, a large structure that once protected the lime kiln from the encroaching sea is now well out in the water because of subsequent coastal erosion.

**Dune Destruction**

During building construction, dunes are often bulldozed to flatten their tops, allowing better views of the ocean or to make way for construction. Changing the shape of the dunes changes how they respond to storm waves and reduces their ability to serve as a natural buffer. Further, if the dune is then covered with soil for landscaping, future storms will erode the fine sediments of the soil, carrying silt into the ocean.

Dunes are also damaged by people walking or driving over them. This destroys dune vegetation, which is critical to holding the sand in place. A dune with damaged or reduced vegetation cover is more susceptible to erosion and less able to rebuild.

**Harbor Construction**

Maintaining and expanding harbors and navigational channels change natural patterns of sediment transport. Sand transported by near-shore waves and currents is deposited into these artificial depressions and removed from the littoral system. Also, constructing harbors and channels can entail dredging parts of coral reefs, allowing larger waves to reach the shoreline and accelerate coastal erosion.

**Protecting Property**

Waves and currents naturally transport sediments along shorelines, within the active beach zone, and sometimes offshore. Episodic and seasonal erosion is a fact of life along the coastlines—and so is the landward migration of the shoreline. But that reality does not always fit well with people’s ideas about property. When people build in coastal areas, they want their homes, hotels, roads, and other structures to be standing on solid ground in ten, 50, or 150 years. And we want our beach parks to stay beach parks!

“Shoreline armoring” is a common approach to slowing coastal erosion, stabilizing coastlines, and protecting beachfront property. Armoring
structures include “seawalls,” “revetments,” and “groins” (see the figure on this page for an explanation). These structures usually halt coastal erosion in the immediate area, but they can lead to unintended consequences. On shorelines that have been retreating over time anyway, they often lead to beach loss. You’ll see this effect in action during your next class as you map changes in two Maui beaches over time.

Types of Shoreline Armoring

Seawall
A vertical or near-vertical type of shoreline armoring characterized by a smooth surface

![Seawall Image]

Revetment
A sloping type of shoreline armoring often constructed from large, interlocking boulders
Revetments tend to have a rougher (less reflective) surface than seawalls.

Groin
A structure resembling a wall, constructed perpendicular to the shoreline and extending into the ocean from the beach

![Groin Image]
Beaches On a Budget: Questions About the Reading

1) What is an active beach?

2) What is the opposite of shoreline erosion?

3) Explain the term “littoral budget,” using at least two examples of sources and sinks.
4) Describe the cycle of sand dune building, scarping, and rebuilding that happens during and after large storms.

5) Name two reasons why coral reefs are important to healthy beaches.
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6) Describe two human activities that aggravate coastal erosion and reduces the amount of sand available to the beach.
7) True to their name, “longshore” currents run along or parallel to the shore. These currents are important mechanisms for transporting sediment within the beach system. Sediment transported along shore feeds beaches along the entire coastline. Shoreline armoring interferes with longshore sediment transport. The diagrams below illustrate two different types of shoreline armoring that have been in place for several years. For each diagram:

a) Draw in the direction of the longshore current, and

b) Explain how the pattern of beach erosion and/or accretion is related to the armoring structure and the longshore current.

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**Groins**

Ocean

Sandy beach

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**Revetment**

Ocean

Sandy beach

Building