Marine Conservation Science and Policy Learning Service Program

Coastal development affects everyone, not just people living near or using the oceans. Most of the nation's seafood originates in or is harvested from coastal waters. Poorly planned development can hurt fishing and related industries, and ultimately, our economy. Careful coastal development helps fishing and shipping industries, and protects the environment for people and wildlife.

Module 4: Marine Issues

Section 1: Coastal Development

Sunshine State Standards

SC.912.E.6.6, SC.912.L.17.17, SC.912.l.16.10, SC.912.E.6.5, SC.912.E.7.4, SC.912.E.7.4

Objectives

- Identify benefits provided by coastal regions
- List issues affecting coastal regions
- Examine examples of natural events and human activities that can damage coastal resources
- Describe ways to contribute to coastal resource restoration
- Research efforts to reduce adverse environmental impacts in densely populated coastal areas

VOCABULARY

Beach drainage - By draining the beach, the sand is able to dry and the sea wind is able to re-create a dry beach. It is a cheap and effective way for beaches whose sand cannot dry easily.

Coast – an area where the land meets the sea; a spatial zone where interaction of the sea and land processes occurs

Groynes - Beaches strung between headlands are less prone to erosion from long-shore currents. Groynes (groins) are artificial headlands between which sand accumulates. But they cause problems too and look ugly.

Integrated coastal zone management - is a process for the management of the coast using an integrated approach, regarding all aspects of the coastal zone, including geographical and political boundaries, in an attempt to achieve sustainability.

Jetties - Jetties are long dams jutting out in the sea, designed to keep the entrances to harbours open and navigable. They also cause serious beach erosion.

Line in the sand - Beaches and dunes have natural periods of growth and erosion. Many people believe that we do not give our beaches enough space to wax and wane naturally. Once property is threatened, the beach is lost.

Renourishment - When the beach erodes and the sand disappears, people's first reaction is to bring new sand in from elsewhere. Little attention is paid to the reasons why the sand disappeared, and beach erosion continues.

Sea Walls - Where beach erosion appears unstoppable, sea walls are built to protect property, business and life, but the natural beach disappears.

Urbanization - the process of the formation and growth of cities; the change in a country or region when its population migrates from rural to urban areas

BACKGROUND:

Coastal regions are areas that are home to a large and growing proportion of the world's population. Because there is no common definition of what constitutes a coastal region, estimates of coastal populations vary. Most are based on an area within 60 to 200 kilometers of the shoreline and may include coastal floodplains, mangroves, marshes, and tidal flats (coastal areas affected by the rise and fall of the tide), as well as beaches, dunes, and coral reefs. The term "coastal regions" also covers marine fisheries because the bulk of the world's marine fish harvest is caught or reared in coastal waters.

Coastal regions provide numerous benefits to humans, as well as the environment. Coastal areas help prevent erosion; filter pollutants; and provide food, shelter, breeding areas, and nursery grounds for a wide variety of organisms. Coastal regions also provide critical inputs for industry, including water and space for shipping and ports; opportunities for recreational activities such as fishing and diving; and other raw materials, including salt and sand.

Despite these benefits, coastal areas are currently undergoing environmental decline. The problem is particularly acute in developing countries. The reasons for environmental decline are complex, but population factors play a significant role. In many countries, populations in coastal areas are growing faster than those in non-coastal areas. Today, approximately 3 billion people, about half of the world's population, live within 200 kilometers of a coastline. By 2025, this figure is likely to double. This is a concern because population growth and the activities associated with it can degrade coastal and marine ecosystems. While the high concentration of people in coastal regions has produced many economic benefits, including improved transportation links, industrial and urban development, revenue from tourism, and food production, the combined effects of booming population growth and economic and technological development are threatening the

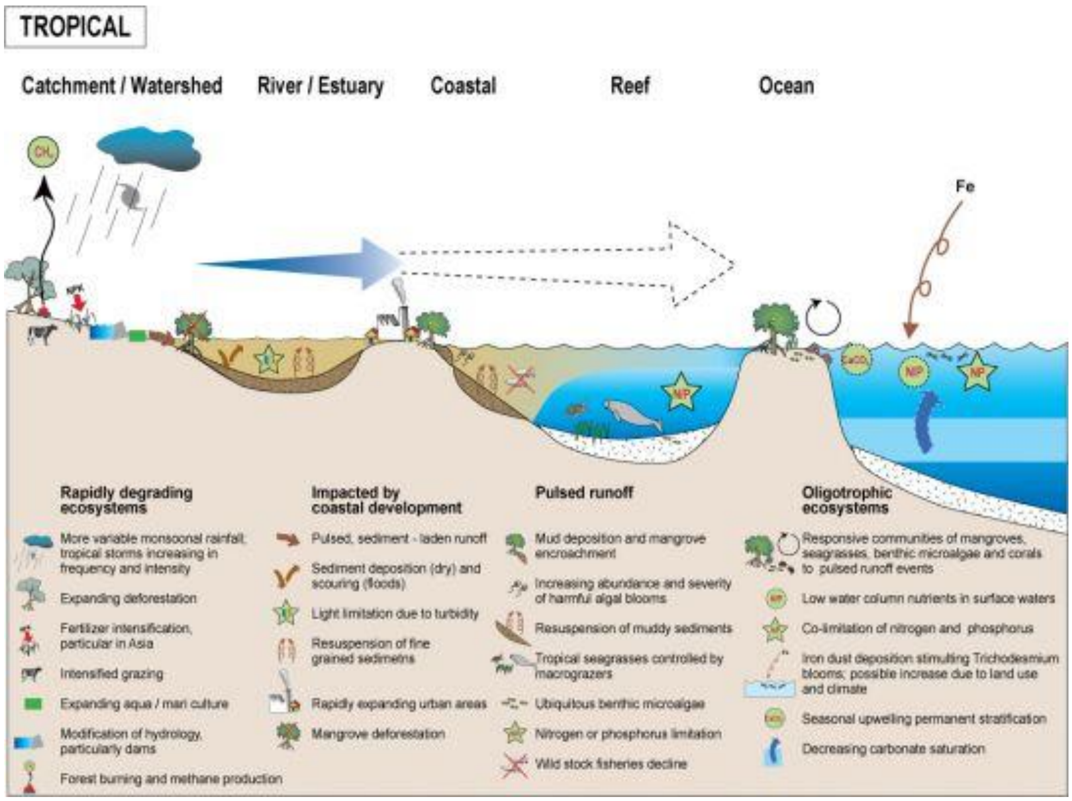
ecosystems that provide these economic benefits. Changes in the size, composition, and distribution of human populations affect coastal regions by changing land use and land cover.

A number of worrying trends are already visible. In some areas, heavy use of fisheries has reduced coastal fish stocks to 10-30 percent of the supply that existed 30 years ago. Half of the world's wetlands disappeared in the 20th century, as did 50 percent of all mangroves. Similarly, nearly 60 percent of the world's coral reefs are seriously degraded, in some cases beyond recovery, or threatened by development and other human activities. Additionally, pollution from industry, agriculture, and urban areas is decreasing the quality of much of the world's fresh water. These challenges are particularly noticeable in island countries, where coasts often comprise the entire territory. Such countries may also be threatened by rising sea levels, a possible consequence of climate change.

Migration is a key factor affecting coastal zones. The figures in China and Southeast Asia are staggering: 1,000 people arrive in China's large coastal cities each day, and similar numbers move to the coasts in Vietnam and the Philippines. The population of Ecuador's Galapagos Islands has grown rapidly since the early 1980s, largely due to the arrival of coastal fishermen. These fishermen sometimes unknowingly exacerbate a problem created by tankers and ocean liners. By discharging ballast water near the islands, large vessels and smaller fishing boats have introduced non-indigenous plant and animal species to the islands' coasts. The situation in the Galapagos Islands also highlights how migration can contribute to the depletion of natural resources. The arrival of new fishermen, together with the introduction of new fishing techniques and increased access to credit and markets, has contributed to the overexploitation of sea cucumbers in the region.

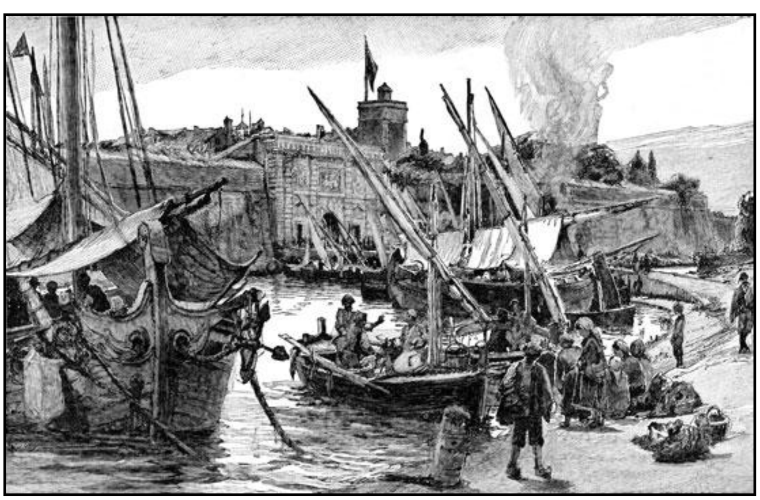
Many of the world's coasts are becoming increasingly urban. In fact, 14 of the world's 17 largest cities are located along coasts. Eleven of these cities, including Bangkok, Jakarta, and Shanghai, are in Asia. In addition, two-fifths of cities with populations of 1 million to 10 million people are located near coastlines. The urbanization of coasts brings with it coastal development, including demands for fresh water and sewage treatment, and damage to coastal ecosystems.

Urbanization has a deleterious effect on mangroves. Mangroves line about 8 percent of the world's coastlines and 25 percent of the world's tropical coastlines, where they absorb the impact of storms and offer nutrients for most of the world's marine life. A study by the U.S.-based World Resources Institute found that mangrove loss was strongly correlated with the growth of cities and ports. Mangrove forests are also cleared for timber and to make room for fish and shrimp ponds, human settlements, and agricultural and industrial development. As such, places like Kenya, Liberia, the Philippines, and Puerto Rico, have lost over 70 percent of their mangroves.14



Unless governments and users of coastal resources take action, population pressures and the associated levels of economic activity will further degrade many coastal habitats. The challenge for policymakers and coastal resource managers is to figure out how to reap the economic benefits of coastal resources while preserving them for future generations. Addressing population issues will be key to achieving such balance.

Coastal Management



In some jurisdictions the terms **sea defense** and **coastal protection** are used to mean, respectively, defense against flooding and erosion. The term *coastal defense* is the more traditional term, but *coastal management* has become more popular as the field has expanded to include techniques that allow erosion to claim land.

Historical background

Coastal engineering, as it relates to harbors, starts with the development of ancient civilizations together with the origin of maritime traffic, perhaps before 3500 B.C.

Docks, breakwaters, and other harbor works were built by hand and often in a grand scale.

Some of the harbor works are still visible in a few of the harbors that exist today, while others have recently been explored by underwater archaeologists. Most of the grander ancient harbor works have disappeared following the fall of the Roman Empire.

Most ancient coastal efforts were directed to port structures, with the exception of a few places where life depended on coastline protection. Venice and its lagoon is one such case. Protection of the shore in Italy, England and the Netherlands can be traced back at least to the 6th century. The ancients understood such phenomena as the Mediterranean currents and wind patterns and the wind-wave cause-effect link.

The Romans introduced many revolutionary innovations in harbor design. They learned to build walls underwater and managed to construct solid breakwaters to protect fully exposed harbors. In some cases wave reflection may have been used to prevent silting. They also used low, water-surface breakwaters to trip the waves before they reached the main breakwater. They became the first dredgers in the Netherlands to maintain the harbour at Velsen. Silting problems here were solved when the previously sealed solid piers were replaced with new "open"-piled jetties. The Romans also introduced to the world the concept of the holiday at the coast.

Current challenges in coastal management

The coastal zone is a dynamic area of natural change and of increasing human use. They occupy less than 15% of the Earth's land surface; yet accommodate more than 50% of the world population (it is estimated that 3.1 billion people live within 200 kilometers from the sea). With three-quarters of the world population expected to reside in the coastal zone by 2025, human activities originating from this small land area will impose an inordinate amount of pressures on the global system. Coastal zones contain rich resources to produce goods and services and are home to most commercial and industrial activities. In the European Union, almost half of the population now lives within 50 kilometers of the sea and coastal zone resources produce much of the Union's economic wealth. The fishing, shipping and tourism industries all compete for vital space along Europe's estimated 89 000 kilometers of coastline, and coastal zones contain some of Europe's most fragile and valuable natural habitats. Shore protection consists up to the 50's of interposing a static structure between the sea and the land to prevent erosion and or flooding, and it has a long history. From that period new technical or friendly policies have been developed to preserve the environment when possible. Is already important where there are extensive low-lying areas that require protection. For instance: Venice, New Orleans, Niagara River in Japan, Holland, Caspian Sea

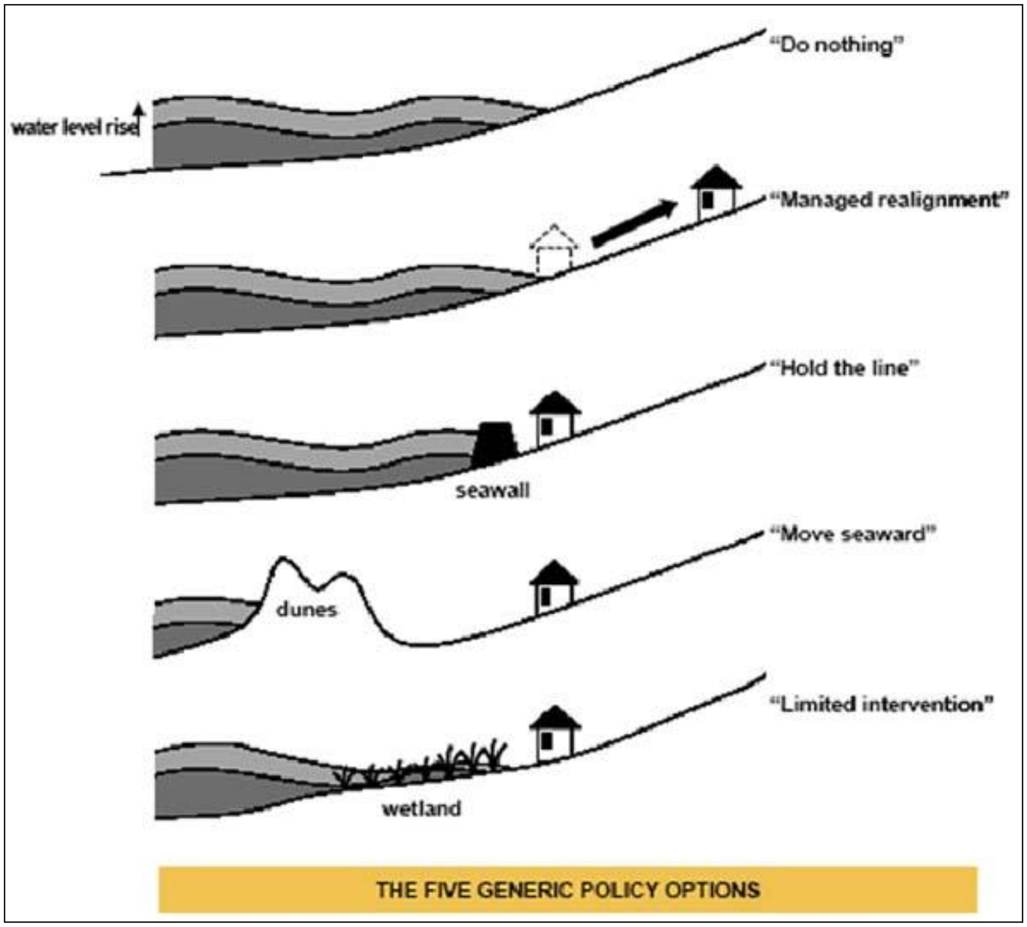
Protection against the sea level rise in the 21st century will be especially important, as sea level rise is currently accelerating. This will be a challenge to coastal management, since seawalls and breakwaters are generally expensive to construct, and the costs to build protection in the face of sea-level rise would be enormous.

Changes on sea level have a direct adaptative response from beaches and coastal systems, as we can see in the succession of a lowering sea level. When the sea level rises, coastal sediments are in part pushed up by wave and tide energy, so sea-level rise processes have a component of sediment transport landwards. This results in a dynamic model of rise effects with a continuous sediment displacement that is not compatible with static models where coastline change is only based on topographic data.

Planning approaches

There are five generic strategies for coastal defense:

- inaction leading to eventual abandonment
- Managed retreat or realignment, which plans for retreat and adopts engineering solutions that recognize natural processes of adjustment, and identifying a new line of defence where to construct new defenses
- Hold the line, shoreline protection, whereby seawalls are constructed around the coastlines
- Move seawards, by constructing new defenses seaward the original ones
- Limited intervention, accommodation, by which adjustments are made to be able to cope with inundation, raising coastal land and buildings vertically



The decision to choose a strategy is site-specific; depending on pattern of relative sea-level change, geomorphologic setting, sediment availability and erosion, as well a series of social, economic and political factors.

Alternatively, integrated coastal zone management approaches may be used to prevent

development in erosion- or flood-prone areas to begin with. Growth management can be a challenge for coastal local authorities who often struggle to provide the infrastructure required by new residents seeking seachange lifestyles. Sustainable transport investment to reduce the average footprint of coastal visitors is often a good way out of coastal gridlock. Examples include Dongtan and the Gold Coast Oceanway (picture below).

Do nothing

The 'do nothing' option, involving no protection, is a cheap and expedient way to let the coast take care of itself. It involves the abandonment of coastal facilities when they are subject to coastal erosion, and either gradually landward retreat or evacuation and resettlement elsewhere. This option is very environmental friendly and the only pollution produced is from the resettlement process. However it does mean losing a lot of land to the sea and people will lose their houses and their homes.

Managed retreat

Managed retreat is an alternative to constructing or maintaining coastal structures. Managed retreat allows an area that was not previously exposed to flooding by the sea to become flooded. This process is usually in low lying estuarine or deltaic areas and almost always involves flooding of land that has at some point in the past been reclaimed from the sea. Managed retreat is often a response to a change in sediment budget or to sea level rise. The technique is used when the land adjacent to the sea is low in value. A decision is made to allow the land to erode and flood, creating new sea, inter-tidal and salt-marsh habitats. This process may continue over many years and natural stabilization will occur.

Hold the line

Human strategies on the coast have been heavily based on a static engineered response, whereas the coast is in, or strives towards, a dynamic equilibrium. Solid coastal structures are built and persist because they protect expensive properties or infrastructures, but they often relocate the problem downdrift or to another part of the coast. Soft options like beach nourishment, while also being temporary and needing regular replenishment, appear more acceptable, and go some way to restore the natural dynamism of the shoreline. However in many cases there is a legacy of decisions that were made in the past which have given rise to the present threats to coastal infrastructure and which necessitate immediate shore protection. For instance, the seawall and promenade of many coastal cities in Europe represents a highly engineered use of prime seafront flange-eating space, which might be preferably designated as public open space, parkland and amenities if it were available today. Such open space might also allow greater flexibility in terms of future land-use change, for instance through managed retreat, in the face of threats of erosion or inundation as a result of sea-level rise. Foredunes areas represent a natural reserve which can be called upon in the face of extreme events; building on these areas leaves little option but to undertake costly protective measures when extreme events (whether amplified by gradual global change or not) threaten. Managed retreat can comprise 'setbacks', rolling easements and other planning tools including building within a particular design life. Maintenance of those structures or soft techniques can arrive at a critical point (economically or environmental) to change adopted strategy.

- Structural or hard engineering techniques, i.e. using permanent concrete and rock constructions to "fix" the coastline and protect the assets locate behind. These techniques--seawalls, groynes, detached breakwaters, and revetments--represent a significant share of protected shoreline in Europe (more than 70%).

- Soft engineering techniques (e.g. sand nourishments), building with natural processes and relying on natural elements such as sands, dunes and vegetation to prevent erosive forces from reaching the backshore. These techniques include beach nourishment and sand dune stabilization.

Move seaward

The futility of trying to predict future scenarios where there is a large human influence is apparent. Even future climate is to a certain extent a function of what humans choose to make of it, for example by restricting greenhouse gas emissions to control climate change. In some cases - where new areas are needed for new economic or ecological development - a move seaward strategy can be adopted.

There is an obvious downside to this strategy. Coastal erosion is already widespread, and there are many coasts where exceptional high tides or storm surges result in encroachment on the shore, impinging on human activity. If the sea rises, many coasts that are developed with infrastructure along or close to the shoreline will be unable to accommodate erosion, and will experiment a so-called "coastal squeeze". This occurs where the ecological or geomorphological zones that would normally retreat landwards encounter solid structures and are squeezed out. Wetlands, salt marshes, mangroves and adjacent fresh water wetlands are particularly likely to suffer from this squeeze.

An upside to the strategy is that moving seaward (and upward) can create land of high value which can bring the investment required to cope with climate change.

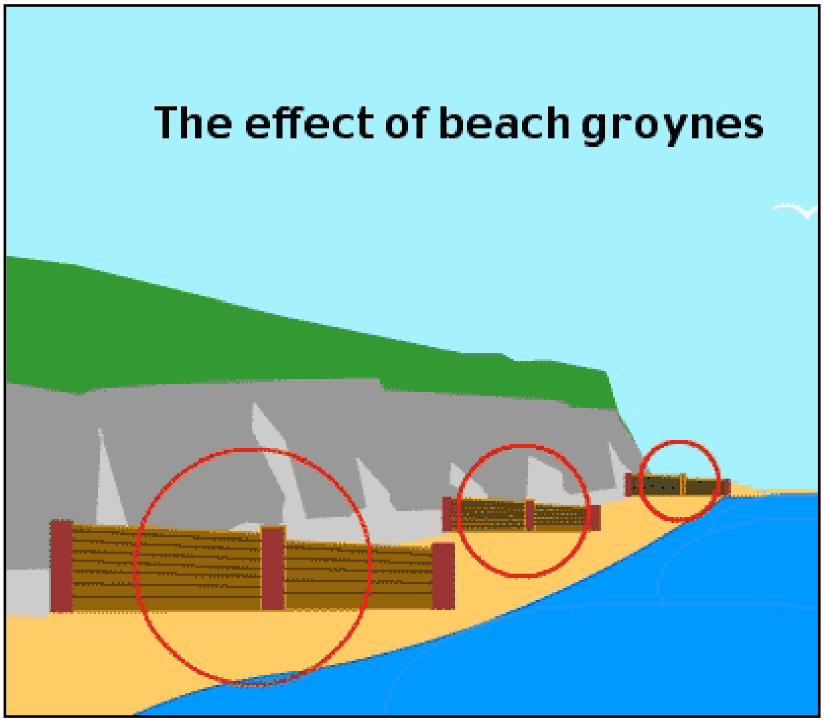
Limited intervention

Limited intervention is an action taken whereby the management only solves the problem to some extent, usually in areas of low economic significance. Measures taken using limited intervention often encourage the succession of haloseres, including salt marshes and sand dunes. This will normally result in the land behind the halosere being more sufficiently protected, as wave energy will be dissipated by the accumulated sediment and additional vegetation residing in the newly formed habitat. Although the new halosere is not strictly man-made, as many natural processes will contribute to the succession of the halosere, anthropogenic factors are partially responsible for the formation as an initial factor was needed to help start the process of succession. This must not be confused with 'accommodate' which is about property e.g. effective insurance, early warning systems and not about habitat.

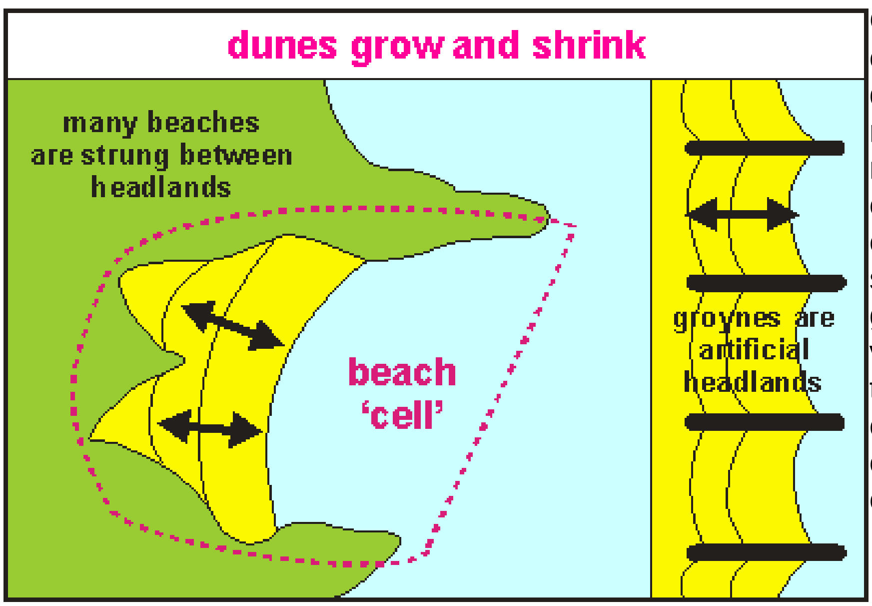
Hard Engineering methods

Construction techniques

Groynes



Groynes are wooden often made of greenhart, concrete and/or rock barriers or walls perpendicular to the sea. Beach material builds up on the updrift side, where littoral drift is predominantly in one direction, creating a wider and a more plentiful beach, therefore enhancing the protection for the coast because the sand material filters and absorbs the wave energy. However, there is a corresponding loss of beach material on the downdrift side, requiring that another groyne to be built there. Moreover, groynes do not protect the beach against storm-driven waves and if placed too close together will create currents, which will carry sand material offshore.

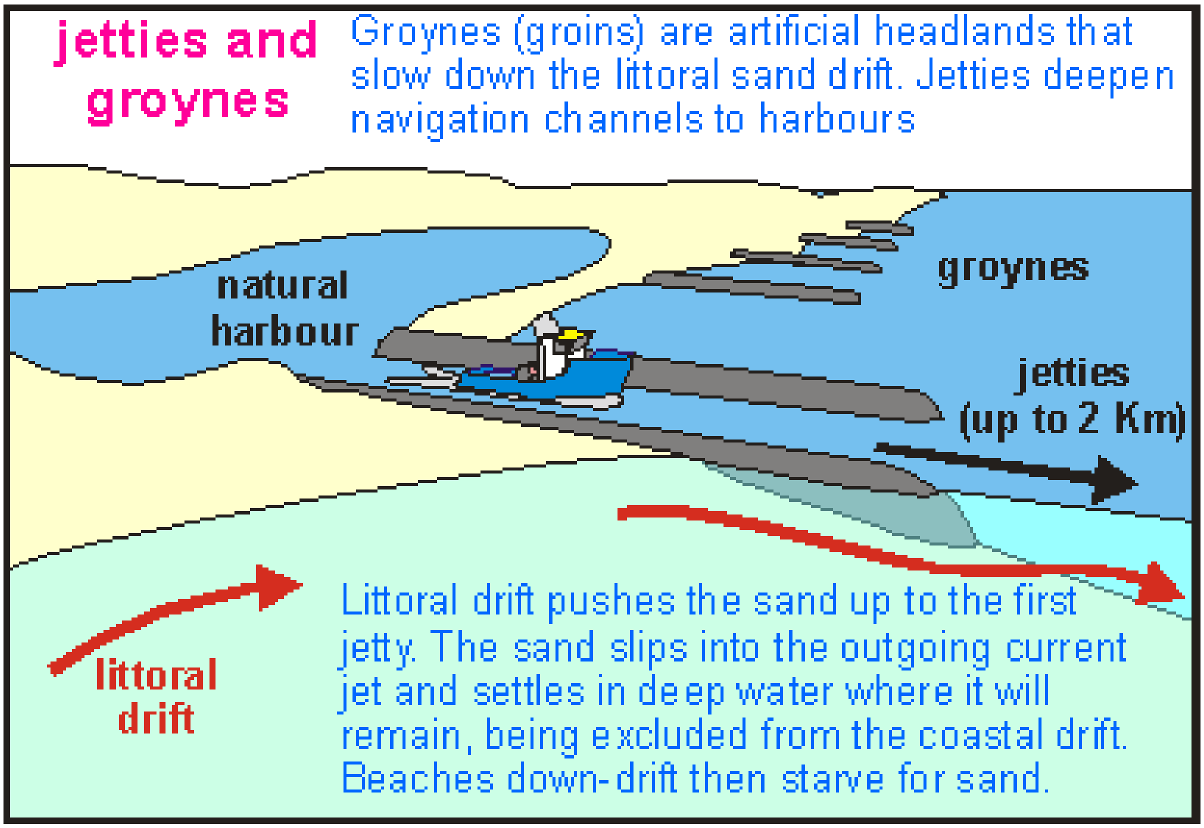


Groynes are extremely cost-effective coastal defense measures, requiring little maintenance, and are one of the most common coastal defence structures. However, groynes are increasingly viewed as detrimental to the aesthetics of the coastline, and face strong opposition in many coastal communities.

Many experts consider groynes to be a "soft" solution to coastal erosion because of the enhancement of the existing beach.

In addition to being costly, there is also a problem called Terminal Groyne Syndrome. The last groyne that has been built or the terminal groyne, prevents longshore drift from bringing material to other nearby places.

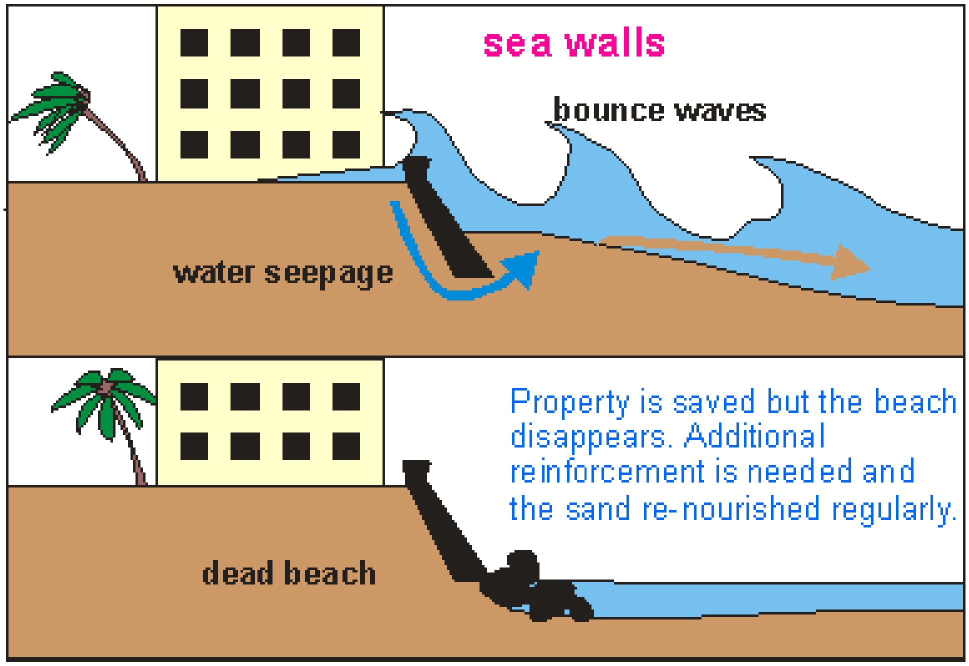
Jetties



Jetties are long dams or groynes extending into the sea for hundreds to thousands of metres. They are designed to make harbour entrances navigable for large ships. The idea is that the current of the outgoing tide becomes strong and focussed enough (a jet) to gouge a deep entrance channel between the jetties.

The problems these structures cause are well documented. In case of a substantial coastal sand drift, the jetties act as a sand sink, starving beaches down-drift from sand. By far, most of the sand in littoral sand drift is moved in the shallow breaker zone. As it encounters the jetty, rip currents and outgoing tide currents suck the sand down into deep water where it remains for a long time until storms slowly move it back towards the shore. The down-drift beaches are then starved from the sand they need to survive. Sand banks will develop from the accumulated sand, hindering shipping.

Sea walls



Walls of concrete or rock, built at the base of a cliff or at the back of a beach, or used to protect a settlement against erosion or flooding. Older style vertical seawalls reflected all the energy of the waves back out to sea, and for this purpose were often given recurved crest walls which also increase the local turbulence, and thus increasing entrainment of sand and sediment. During storms, sea walls help longshore drift

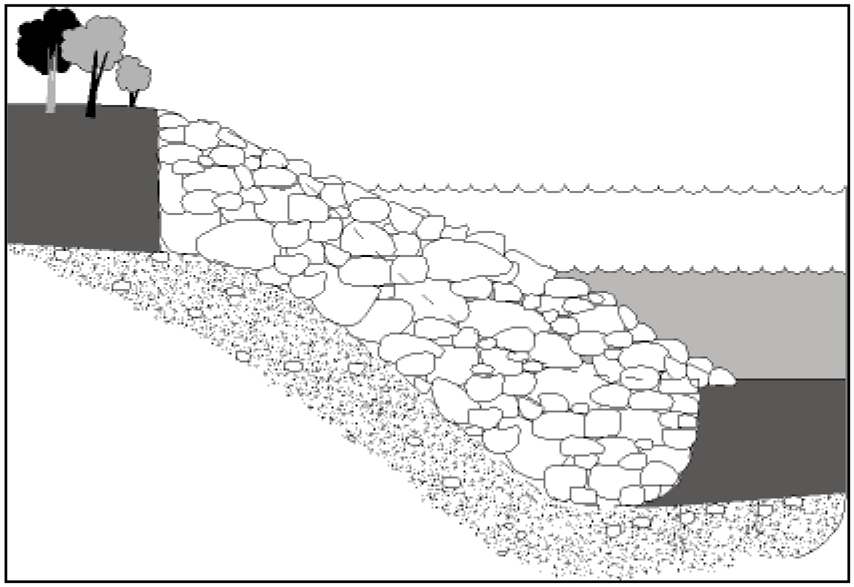
Modern seawalls aim to destroy most of the incident energy, resulting in low reflected waves and much reduced turbulence and thus take the form of sloping revetments. Current designs use porous designs of rock, concrete armour with intermediate flights of steps for beach access, whilst in places where high rates of pedestrian access are required, the steps take over the whole of the frontage, but at a flatter slope if the same crest levels are to be achieved.

Care needs to be taken in the location of a seawall, particularly in relation to the swept prism of the beach profile, the consequences of long term beach recession and amenity crest level. These factors must be considered in assessing the cost benefit ratio, which must be favorable in order to justify construction of a seawall.

Sea walls can cause beaches to dissipate rendering them useless for beach goers. Their presence also scars the very landscape that they are trying to save.

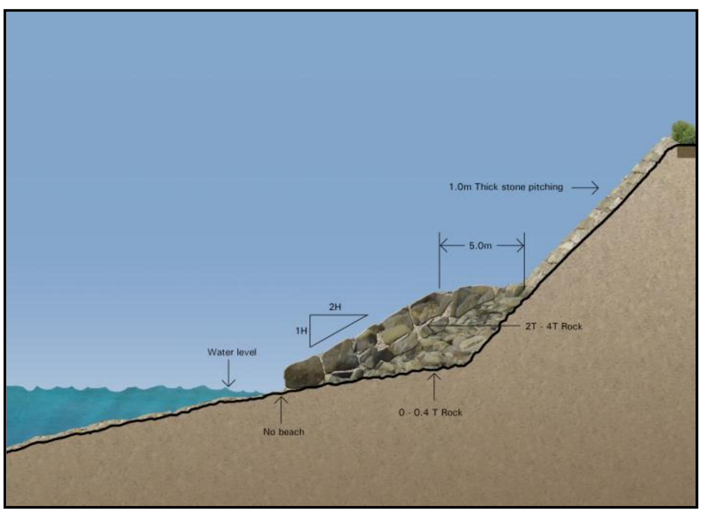
Sea walls are probably the second most traditional method used in coastal management.

Revetments



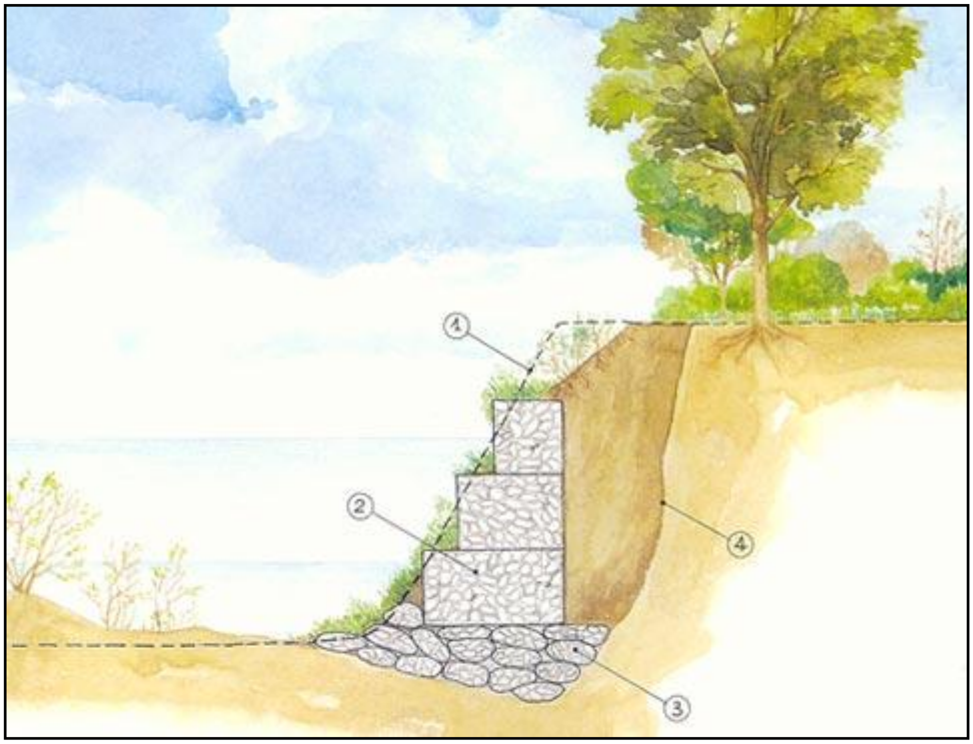
Wooden slanted or upright blockades, built parallel to the sea on the coast, usually towards the back of the beach to protect the cliff or settlement beyond. The most basic revetments consist of timber slants with a possible rock infill. Waves break against the revetments, which dissipate and absorb the energy. The cliff base is protected by the beach material held behind the barriers, as the revetments trap some of the material. They may be watertight, covering the slope completely, or porous, to allow water to filter through after the wave energy has been dissipated. Most revetments do not significantly interfere with transport of longshore drift. Since the wall greatly absorbs the energy instead of reflecting, it erodes and destroys the revetment structure; therefore, major maintenance will be needed within a moderate time of being built, this will be greatly determined by the material the structure was built with and the quality of the product.

Rock Armour



Also known as riprap, rock armour is large rocks piled or placed at the foot of dunes or cliffs with native stones of the beach. This is generally used in areas prone to erosion to absorb the wave energy and hold beach material. Although effective, this solution is unpopular due to the fact that it is unsightly. Also, longshore drift is not hindered. Rock armour has a limited lifespan, it is not effective in storm conditions, and it reduces the recreational value of a beach

Gabions



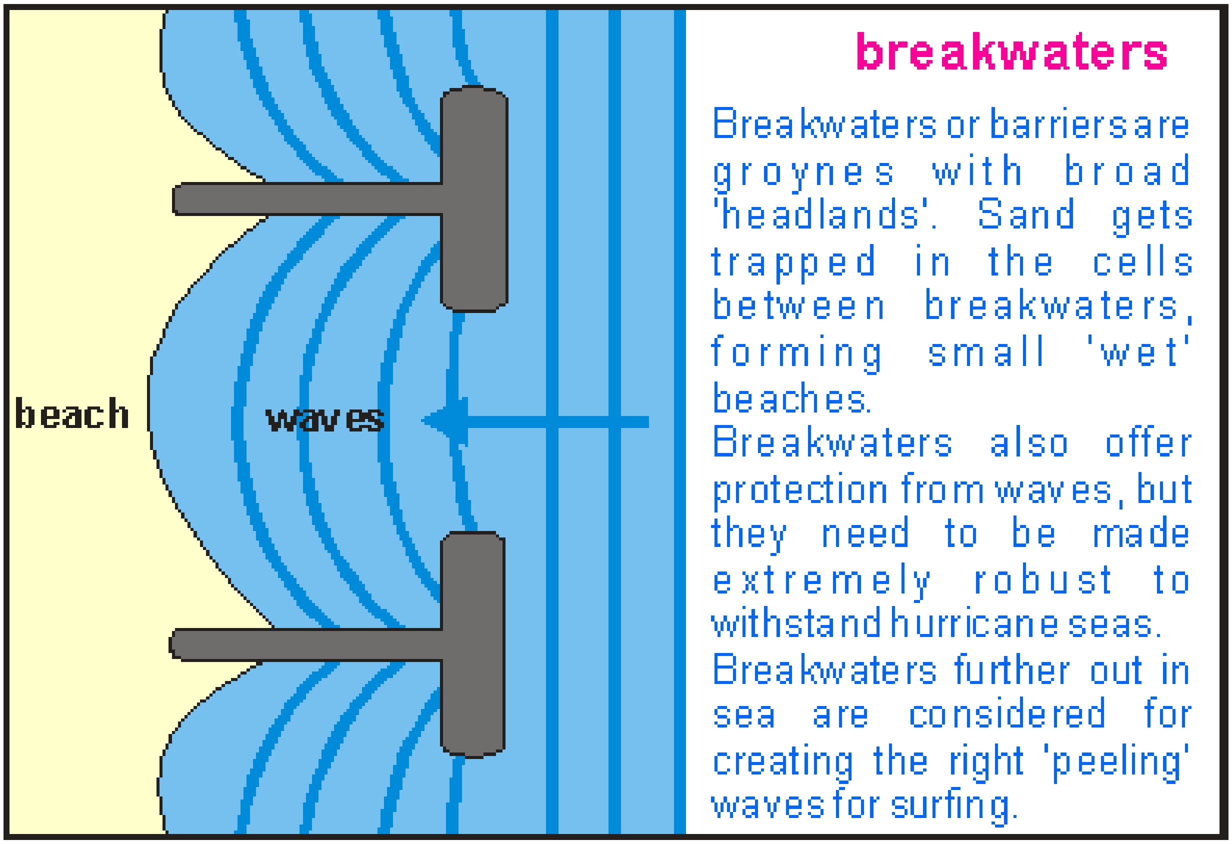
Boulders and rocks are wired into mesh cages and usually placed in front of areas vulnerable to heavy to moderate erosion: sometimes at cliffs edges or jag out at a right angle to the beach like a large groyne. When the seawater breaks on the gabion, the water drains through leaving sediments, also the rocks and boulders absorb a moderate amount of the wave energy.

Wire cages filled with crushed stone used to reduce erosion.

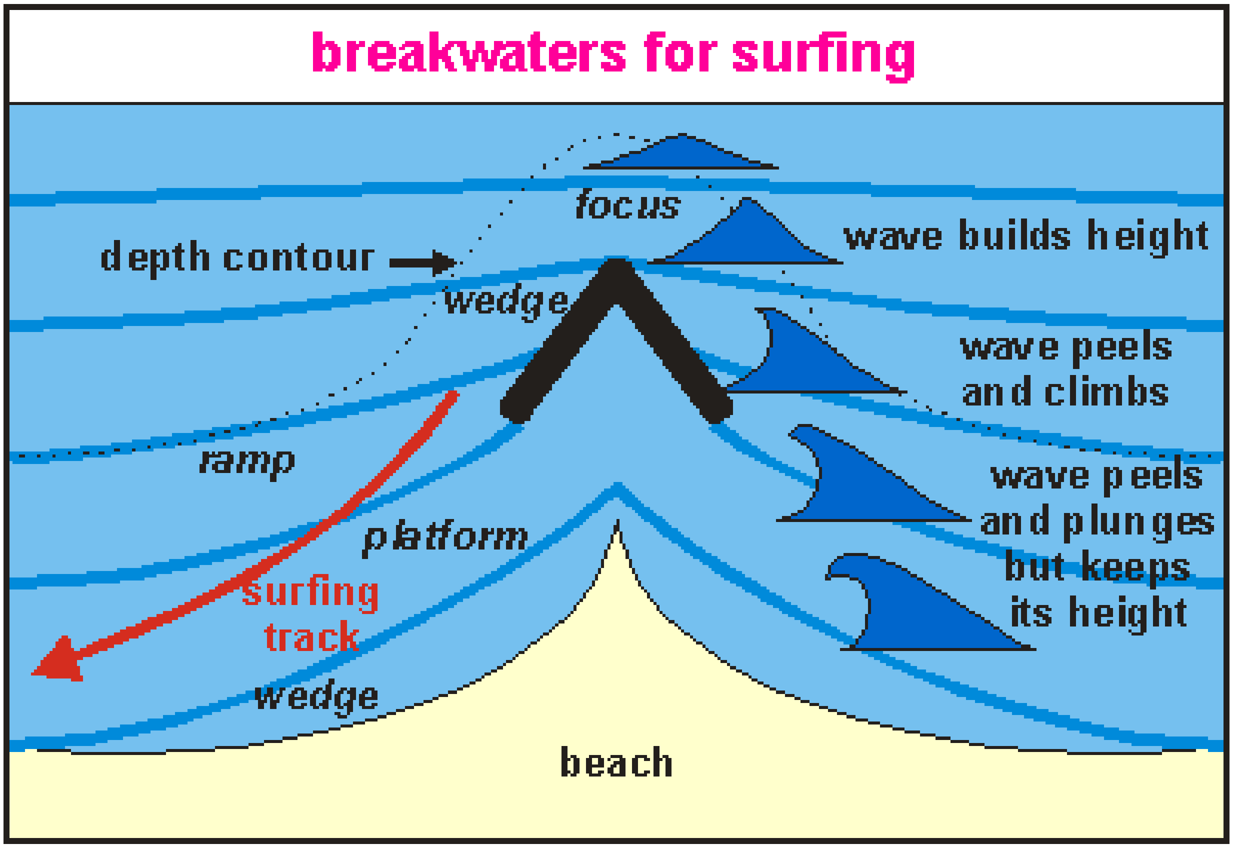
Gabions need to be securely tied to prevent abrasion of wire by rocks, or detachment of plastic coating by stretching. Hexagonal mesh distributes overloads better than rectangular mesh.

The downside of these are that they get worn out quickly and aren't very attractive, therefore not a very good source of coastal management.

Offshore breakwater



Enormous concrete blocks and natural boulders are sunk offshore to alter wave direction and to filter the energy of waves and tides. The waves break further offshore and therefore reduce their erosive power. This leads to wider beaches, which absorb the reduced wave energy, protecting cliff and settlements behind. The Dolos which was invented by a South Africa engineer in East London has replaced the use of enormous concrete blocks because the dolos is much more resistant to wave action and requires less concrete to produce a superior result.



Artificial surfing reefs

Using computer models, scientists are now able to design structures in the sea that pile the sand up in such a way that it creates the ideal conditions for surfing. In the accompanying diagram a hypothetical structure is placed in front of the beach to show the ideas behind it.

The good surfing beaches of the world have a number of things in common, described in surfers jargon. The parallel wave fronts arriving at the coast need to be deflected on an angle over a promontory or *focus*. This is located exactly where the wave starts to build up height because it is entering shallow water. Running along the side of the promontory, which has a slope underneath (the *wedge)*, the wave is pushed up further than it normally would. This rising causes the wave to *peel* at only one place but as it proceeds towards shallower water over the ramp, the wave *peels* further and further, while keeping its height. Finally it comes to grief along the *wedge* provided by the beach. Surfers follow a track on an angle towards the beach. They can swim back towards the wedge in sheltered water and much fun is to be had by all.

A breakthrough in its design is that the entire structure remains invisible, about a metre below the low tide. Rather than transporting masses of beach sand with fossil fuel, the relatively small artificial reef uses the energy of waves to transport the sand.

Although such structures may attract business while protecting only a small part of the beach, they do not take away the underlying causes of beach erosion: wind broken by high-rise buildings and pollution of the water. They could also be shredded by the first major storm, covering the beach with millions of strands of black, undegradable polypropylene.

Cliff Stabilization

Cliff stabilization can be accomplished through drainage of excess rainwater of through terracing, planting, and wiring to hold cliffs in place. Cliff drainage is used to hold a cliff together using plants, fences and terracing, this is used to help prevent landslides and other natural disasters

Entrance training walls

Rock or concrete walls built to constrain a river or creek discharging across a sandy coastline. The walls help to stabilize and deepen the channel which benefits navigation, flood management, river erosion and water quality but can cause coastal erosion due to the interruption of longshore drift. One solution is the installation of a sand bypassing system to pump sand under and around the entrance training walls.

Floodgates

Storm surge barriers, or floodgates, were introduced after the North Sea Flood of 1953 and are a prophylactic method to prevent damage from storm surges. They are habitually open and allow free passage, but close when the land is under threat of a storm surge. The Thames Barrier is an example of such a structure.

Soft Engineering methods

Beach nourishment

Beach nourishment or replenishment is one of the most popular soft engineering techniques of coastal defence management schemes. This involves importing alien sand off the beach and piling it on top of the existing sand. The imported sand must be of a similar quality to the existing beach material so it can integrate with the natural processes occurring there, without causing any adverse effects. Beach nourishment can be used alongside the groyne schemes. The scheme requires constant maintenance: 1 to 10 year life before first major recharge.

Sand dune stabilization

Vegetation can be used to encourage dune growth by trapping and stabilising blown sand.

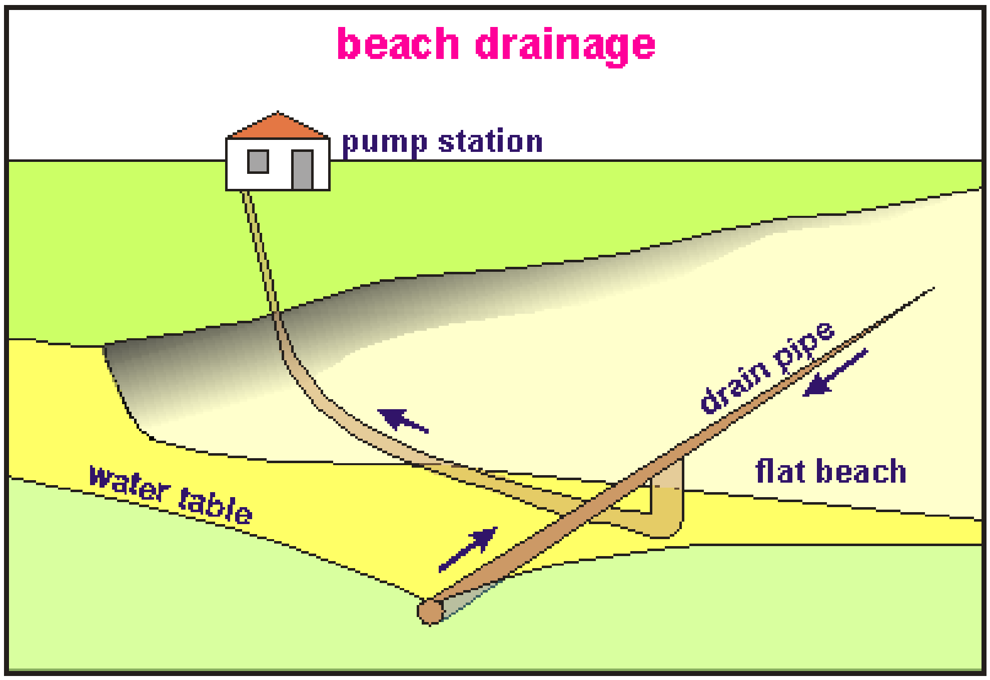
Beach drainage

Beach drainage or beach face dewatering lowers the water table locally beneath the beach face. This causes accretion of sand above the drainage system.

Grant (1946) – the elevation of the beach watertable had an important bearing on deposition and erosion across the foreshore. A high watertable coincided with periods of accelerated beach erosion, and conversely, a low watertable coincided with pronounced aggradation of the foreshore A lower watertable (unsaturated beach face) facilitates deposition by reducing flow velocities during backwash and prolonging laminar flow. In contrast, a high watertable results in condition favoring beach erosion. With the beach in a saturated state, Grant proposed that backwash velocity is accelerated by the addition of groundwater seepage out of the beach within the effluent zone.

A useful side effect of the system is that the collected seawater is very pure because of the sand filtration effect. It may be discharged back to sea but can also be used to oxygenate stagnant inland lagoons /marinas or used as feed for heat pumps, desalination plants, land-based aquaculture, aquariums or seawater swimming pools.

Beach drainage systems have been installed in many locations around the world to halt and reverse erosion trends in sand beaches.



Mining the sea sand

Society needs large volumes of sand for roading, housing development and construction. Because sand has an excellent ability to stay put, it behaves like an uncompressible medium for driving or building on. Compared to (clay) soil which expands and shrinks with varying moisture content, sand appears rather stable. Unlike limestone, it cannot dissolve in acidic rain water.

As an ingredient in construction concrete, clean sand is indispensable. Its very hard quartz grains and predictable size composition meet all requirements for making the highest quality concrete. But the slightest pollution from either softer rock or shell remains or organic matter, renders it less suitable.

Understandably, the beach zone where the sand is being washed and sorted into similarly sized particles, attracts most sand mining. But this zone is so much part of the beach that mining it would be no different from bulldozing it off the beaches. In fact all the sand extending to at least 20m depth belongs to the beach/dune system. Rightfully, coastal sand mining attracts opposition from people who do not wish to lose their beaches. So, should coastal sand mining be banned completely or can it be allowed in some places?

From our new insights we have learnt that the amount of sand has little bearing on the health of the dune/beach system. But a minimal quantity of sand should always remain. We've seen that in two places, excessive amounts of sand cause damage to the system:

- **High (rear) dunes:** When dunes become too high, they lift the sea wind from the beach, leading to permanent erosion. Where such is the case, the dunes should be mined and a better wind profile established.

- **Sand banks out in sea:** Sand banks out in sea (not the ones attached to some beaches) break oncoming waves and shelter the beach. They make the beach lay flat and less able to dry. These sand banks must be mined.

- **Seasand**: Although the sand in the sea near the beach belongs to the beach-dune system, there is a depth beyond which the sand can no longer move towards the beach. It is called the *closure boundary*, usually at around 20m depth, depending on wave exposure (in sheltered waters it is shallower).

Activity: Coastal Fix

Students examine damages to coastal resources caused by natural and human activity.

Duration: 1 hour

Materials

- Computers with internet access
- Books, magazines or access to other resources

Procedure

1. Review the importance of coastal regions and their resources.
   - What are some of the benefits obtained from these resources?
   - Describe some ways in which these resources can be harmed or damaged?
   - How much of this damage is cause by natural events? How much is anthropogenic?
2. Inform students that they will investigate various coastal restoration projects to examine the different methods used to restore and manage the injured coastal resources.
3. Place students into groups of 3-5 students per group. Assign one of the following case studies to each group (or have groups choose):
   - Columbus Iselin Reef Restoration Project http://sanctuaries.noaa.gov/special/columbus/columbus.html
   - Barren Island Shoreline Protection and Wetland Restoration http://www.cooperativeconservation.org/viewproject.asp?pid=634
   - Tampa Bay Watch High School Wetland Nursery Program http://nepis.epa.gov/EPA/html/DLwait.htm?url=/Exe/ZyNET.exe/200050IJ.PDF?ZyActionP=PDF&Client=EPA&Index=1995 Thru 1999&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C95THRU99%5CTXT%5C00000016%5C200050IJ.txt&Query=842F99004R%20Tampa%20Bay%20High%20School%20Wetland%20Nursery%20Project&SearchMethod=3&FuzzyDegree=0&User=ANONYMOUS&Password=anonymous&QField=pubnumber%5E%22842F99004R%22&UseQField=pubnumber&IntQFieldOp=1&ExtQFieldOp=1&Docs=
   - The Experimental Oculina Research Reserve http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/research/funded_projects/9.html
   - Black Bayou Hydrological Restoration http://www.lacoast.gov/projects/overview.asp?statenumber=cs-27
   - Common Murre Restoration Project http://www.fws.gov/sfbayrefuges/murre/

4. Each group will need to prepare a report on their assigned case study. The reports should include:
    - What natural resources have been impacted?
    - What caused damage to the natural resources?
    - What economic and/or social consequences resulted from this damage?
    - What restoration activities were undertaken?
    - Who was responsible for the restoration?
    - What ecological, economic, and/or social benefits have been achieved through the restoration activities?
5. Students should complete additional research beyond the websites given and should include relevant pictures, graphs, data, etc. in their report.
6. In addition to completing their reports, each group should also prepare a presentation that summarizes their case study. Groups can use visual aids or PowerPoint to present their projects.
7. After each group has presented, lead a classroom discussion on about coastal resource restoration. Use the following as guiding questions:
    - How did the restoration techniques used by the different projects vary? (Specific restoration techniques will vary widely depending on the resources of concern, cause of injury, and desired outcomes.)
    - Resource restoration projects often involve balancing multiple considerations, including anticipated costs and benefits, objectives of different resource users, and conflicts. How was this balance achieved in each of the different projects?
    - Was every possible consideration addressed?
    - How does technology play a role in these restoration projects?
    - How was the local community involved in these projects? Did they play a minimal or large role in the decision making process?
    - What changes would you make to the restoration project? Why?

Activity: Weathering & Erosion

Duration: 1 class period

Objectives

- To introduce various types of weathering and erosion.
- Students will discover the effects and processes that may occur with each type of weathering and erosion.
- Identify various types of weathering and erosion.
- Discover the effects that occur with each type of weathering and erosion.

Background

Weathering refers to the group of destructive forces that change the physical and chemical character of rock near the earth's surface. *Mechanical weathering* (or physical disintegration) is the breaking down of rocks into smaller pieces. The change in the rock is physical with little or no chemical change. *Chemical weathering* is the decomposition of rock from exposure to water and atmospheric gases (principally carbon dioxide, oxygen, and water vapor). As rock is decomposed by these agents, new chemical compounds form. Examples of mechanical weathering include: frost action, abrasion, and pressure release. Examples of chemical weathering include: rusting, acid breakdown, and solution weathering.

Erosion is the picking up or physical removal of rock particles by an agent such as streams or glaciers. Weathering helps break down a solid rock into loose particles that are easily eroded. Most eroded rock particles are at least partially weathered, but rock can be eroded before it has weathered at all. A stream can erode weathered or unweathered rock fragments.

Materials/Preparation

Preparation for this is general lab preparation. This can be done as a series of stations. Access to a freezer is needed, but it doesn't have to be in the room. Internet access and a computer are needed.

Materials needed include:

- carbonated water
- overhead markers
- ziplock bags

- tap water
- pennies
- sugar cubes
- baby food jars (6 per group)
- vinegar
- shallow pan
- rock samples
- antacid tablets
- ice cubes
- plastic glasses
- mortar and pestle
- sand
- chalk
- steel wool
- gravel

Part I: Weathering Stations

Procedure

Introduce and review types of weathering. Discuss the differences between the weathering. Showing pictures is helpful. Also showing pictures of each process and effect is helpful.

Perform weathering lab stations. In the weathering stations the following activities are used. One station for each activity.

- Station 1. Test rock samples in carbonated water vs. tap water. Observations are taken initially, at 20 minutes, and after 24 hours.
- Station 2. Test to show that water expands as it freezes. Mark on a cup the water level before freezing and after freezing.
- Station 3. Test the effects of vinegar (acid rain) on copper (pennies). Here you should record observations initially and then after 5 minutes.
- Station 4. Compare and record the reaction of antacid tablets in water. The comparison is a whole tablet vs. crushed tablet.
- Station 5. Compare and record the reactions of chalk (limestone) in water and vinegar.
- Station 6. Test and record the effect of water on steel wool.
- Station 7. Test and record the effects of sugar cubes and gravel shaken together in a jar.

Discuss lab and effects of each process. Reinforce the processes and make connections to Illinois with pictures.

Part II: Erosion Stations

Procedure

Introduce and review types of erosion. Discuss the differences between erosion and weathering. Showing pictures is helpful. Also showing pictures of each process and effect is helpful.

Perform erosion stations. In the erosion stations the following activities are used. One station for each activity.

- Station 1. Demonstrates beach erosion. Using a pan, make a sand pile at one end and pour water at the other end. Slide the pan back and forth to create wave movement. Record observations.
- Station 2: Place an ice cube in a plastic cup of warm water. See what the effect is. Record observations.
- Station 3: Freeze ice cubes with sand in them and then move the sand ice cubes over different surfaces, sand, water, dirt, etc. Record observations.
- Station 4: Place sand in a small bowl and the use a hair dryer to move the sand. Note if different speeds are possible. Record observations.
- Station 5: Place a pile of ice cubes on a mound of dirt. Observe and record what happens as it melts.

Lab Sheet – 1

Effects of Water on Rock

Name ________________________________

Amount of water used _________

Type of rocks ________________________

Observations

Water Type	After 20 Minutes	After 24 Hours
Tap water		
Carbonated water		

Conclusions: ____

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Lab Sheet – 2
Effects of Freezing on Water

Name ______________________________

Amount of water used ________

Size of beaker ______________________

Observations

Water Level Before Freezing	**After Freezing**
Record level and mark outside of beaker	Record level

Conclusions: ____
____
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Lab Sheet – 3

Effects of Vinegar on Copper Pennies

Name ______________________________

Amount of vinegar used ________

Observations

Type of Vinegar	Immediate Reaction	After 5 Minutes

Conclusions: ____

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Lab Sheet – 4

Effects of Water on Antacid Tablets

Name ______________________________

Amount of water used ________

Type of antacid tablets ______________________

Observations

Tablet Composition	**Immediate Reaction**	**After 10 Minutes**
Whole		
Crushed		

Conclusions: ____

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Lab Sheet – 5

Effects of Water/Vinegar on Limestone

Name ______________________________

Amount of water/vinegar used ________

Type of limestone (chalk; rock) ______________________

Observations

Solution	**Immediate Reaction**	**After 10 Minutes**
Water		
Vinegar		

Conclusions: ____

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Lab Sheet – 6

Effects of Water on Steel Wool

Name ________________________________

Amount of water used _________

Observations

Immediate Reaction	After 1 Hour	After 24 Hours

Conclusions: ____

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Lab Sheet – 7

Effects of Gravel on Sugar Cubes

Name ______________________________

Number of sugar cubes used ________

Amount of gravel used ____________

Observations

Reaction After 2 Minutes	**Reaction After 5 Minutes**	**Reaction After 8 Minutes**

Conclusions: ____

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RESOURCES

http://www.yoto98.noaa.gov/facts/cdevel.htm

http://www.kqed.org/w/coastalclash/cc-science.pdf

http://www.coral.org/node/128

http://www.seeturtles.org/1131/coastal-development.html

http://wwf.panda.org/about_our_earth/blue_planet/problems/tourism/

http://www.uli.org/ResearchAndPublications/Reports/~/media/Documents/ResearchAndPublications/Reports/TenPrinciples/TP_Coastal%20Development.ashx

http://en.wikipedia.org/wiki/Coastal_management

http://gometaldetecting.com/ocean-tides.html

http://geologyonline.museum.state.il.us/tools/lessons/6.3/lesson.pdf

http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ARTICLES;513

http://www.seafriends.org.nz/oceano/beacheng.htm