MAR110 LECTURE #21
Shallow Water Ocean Waves and Beach Erosion

Figure 21.2 Shoaling Waves
As wave shoal, the depth of the water depth decreases, causing the wave speeds slow, and wave heights grow. (NH)

Figure 21.1 Ocean Waves and Coastal Erosion
Coastline Erosion Rates. (IO)

EROSION RATES

<table>
<thead>
<tr>
<th>Table 21-1 Sea-cliff recession rates.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cliff composition</td>
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<tr>
<td>--------------------</td>
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<tr>
<td>Granite and crystalline rocks</td>
</tr>
<tr>
<td>Limestone</td>
</tr>
<tr>
<td>Shale and sandstone</td>
</tr>
<tr>
<td>Unconsolidated sediment</td>
</tr>
<tr>
<td>New England: crystalline rocks</td>
</tr>
<tr>
<td>Cape Cod, Massachusetts:</td>
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<tr>
<td>glacial deposits</td>
</tr>
<tr>
<td>New Jersey: gravel, sand, and clay</td>
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<tr>
<td>Louisiana: sand and clay</td>
</tr>
<tr>
<td>Southern California: alluvium</td>
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</tbody>
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Source: Compiled by D. F. Rising, Process Geomorphology (Orographs, Iowa); William C. Brown, 1988.
Figure 21.3 Wave Refraction
Waves that approach a beach at an angle (like the above) are refracted so that they align with the local bathymetry wave crest. The wave front is bent because the inshore end of the wave encounters shallower water depths earlier than the part of the wave front in deeper water.

Figure 21.4 Wave Refraction and Energy Concentration
As wave approach the shore they align with the isobaths, via changing wave speeds. In deep water, equally-spaced orthogonals to the wave crests define equal amounts of wave energy. The orthogonals are refracted with the waves as they approach the near-shore bathymetry, showing energy concentration (i.e., erosion power) at the headlands.
Figure 21.6 Alongshore Sand Transport & Breakwaters I
Breakwaters (like the offshore, horizontal white line above) block some of the incoming wave energy. With reduced wave energy there is reduced longshore sand transport along that section of the beach leading to accumulation (i.e., a wider beach) due to sand fed by alongshore transport from the left. However, the beach to the right that is unprotected by the breakwater longshore and thus subject to erosion (i.e., a narrower beach). (LEiO)

Figure 21.5 Longshore Current (or Drift) and Sand Transport
Waves that approach the shore at an angle form an longshore current (left-to-right here) that carries with it sand grains that have been suspended by the turbulent action in the surf zone. Further, as the water from the breaking waves wash up and down the beach face, sand particles migrate in zig-zag patterns in the direction of the alongshore current. (LEiO)
Groins are breakwaters perpendicular to the shore that are intended to trap sand that is being transported by the longshore current in order to widen the beach in certain places. (LEiO)

Here the longshore current and sand transport is going from left to right along and around the end of a breakwater that is attached to the shore. Over time the sand has been deposited – creating a sand bar beyond the jetty – threatening to close off the harbor mouth. (LEiO)
Wave Refraction East of Cape Cod

Concentrates Wave Energy

Figure 21.9 “Deep Ocean” Wave Refraction
Wave refraction over Georges Bank and east of Cape Cod concentrates wave energy at the southeastern tip of Cape Cod. (ItO)

Figure 21.10 Cape Cod Sand Transport
Waves, that hit Cape Cod north of Wellfleet-by-the-Sea are generally from the southeast, thus producing a northward longshore sand transport

Waves, that hit Cape Cod south of Wellfleet-by-the-Sea are generally from the northeast, thus producing a southward longshore current. (ItO)
Summer Onshore Sand Transport

Breaking Swell
Erode Bar Sand....
& Build the Summer Berm

Figure 21.12 Beach Evolution – Summer Onshore Transport
Winter Offshore Sand Transport

Winter Storm Wave Currents Erode Beach Sand...

to form sandbars

Figure 21.13 Beach Evolution – Winter Offshore Transport

Storm-Induced Extreme Beach Erosion
Extreme cases of erosion can occur over very short periods of time, especially during large storms such as hurricanes. The maps show Little Narragansett Bay beaches before (left) and after (right) the Hurricane of 1938.
Storm Surge Raises the Platform

.....enabling Extreme Damage

Figure 21.17 Extreme Storm-Induced Coastal Erosion IV
Figure 21.18  Extreme Storm-Induced Coastal Erosion V