Beach Profiles

AND CROSS-SHORE TRANSPORT

CE A676 Coastal Engineering
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Topics

- Features of beach and nearshore profiles
- Equilibrium profiles
- Cross-shore transport

References

- Text (Sorensen) Ch. 8
- CEM Part III Ch. 3
- Komar, P., 1998. Beach Processes and Sedimentation, 2nd ed., Prentice-Hall

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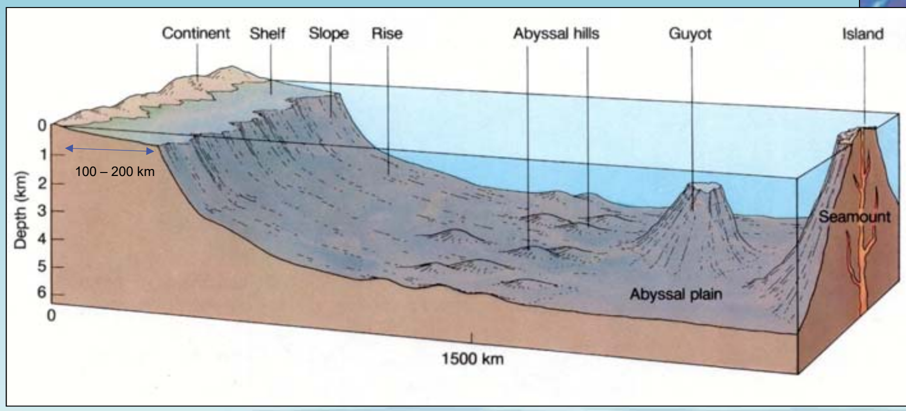
The Big Picture



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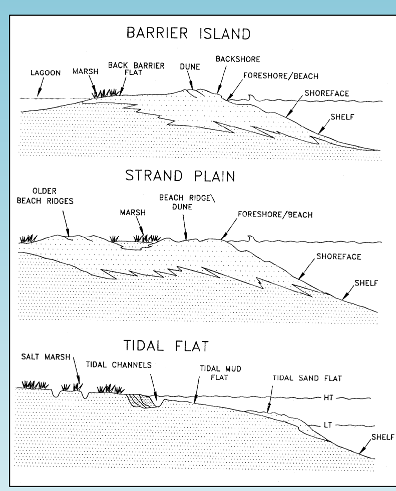
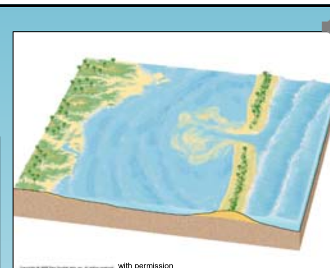
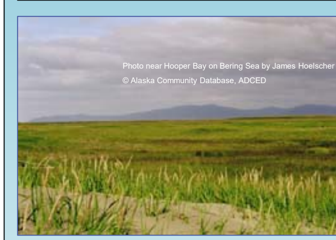
Shore types

- Barrier islands
  - Separated by tidal inlets
  - Dynamic equilibrium
  - Prone to dramatic change by severe storms
- Strand plain
  - Similar to barrier island profile
- Tidal flat
  - Higher tide range







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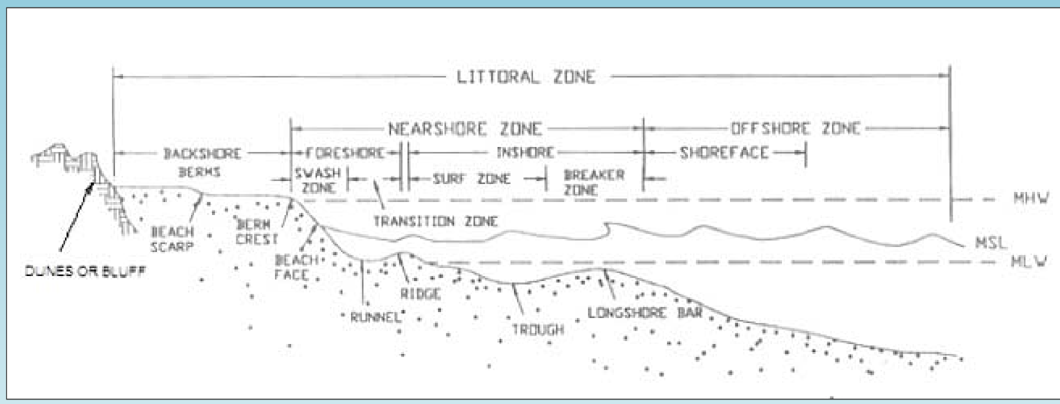
Beach Profile Features



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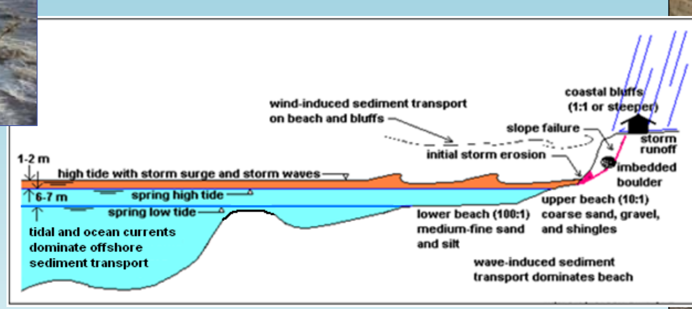
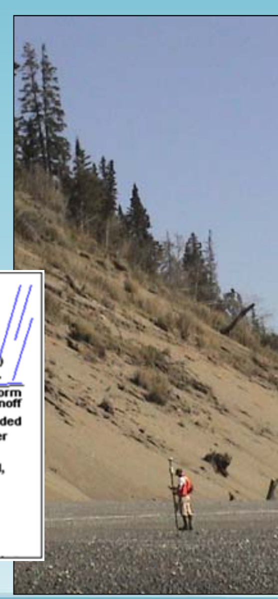
Cook Inlet bluff shoreline





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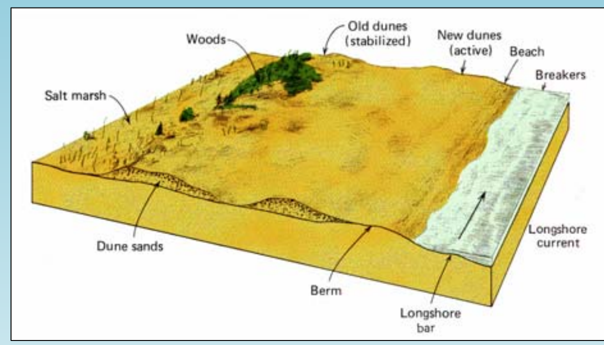
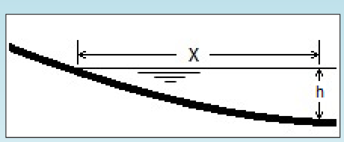
Dunes



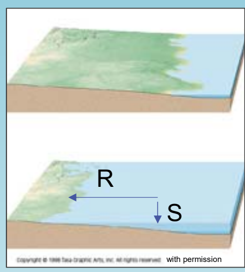
Equilibrium Profile

- Profile of a beach in balance
  - *Source* = *Supply* for longshore and cross-shore sediment transport
  - $h = Ax^n$
    - $n = {}^2/_3$, A has units $m^{1/3}$ (Per Bruun, 1954)
    - $A = 0.21D^{0.48}$, $D = D_{50}$ in mm (R. Dean, 1987)
- Applications
  - Compare actual profile to ideal
    - Steeper → erosion
    - Shallower → accretion
    - Beach fill design



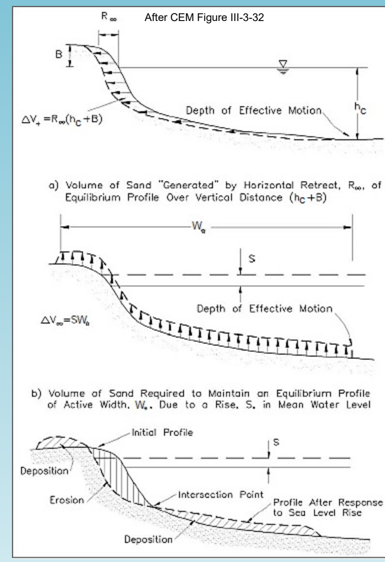
- Issues
  - No tide allowance
  - No Berms
  - No x < 0
  - Problem with slope ($^{dh}/_{dx} = \infty\ at\ x = 0$)
    - Can't use too near waterline
  - No depth of closure (limit of wave-induced sediment transport
    - $h_c \cong 6.75H_s$
    - H_s = an average (seasonal or annual) significant wave height
    - Don't use for $z > h_c$

Sea Level Rise – Bruun Rule



$$R_\infty = S\frac{W_*}{h_c + B}$$

- R_∞ = static response horizontal shoreline retreat of equilibrium profile
- S = vertical sea level rise
- W_* = width of active profile
  - $W_* = \left(\frac{h_c}{A}\right)^{3/2}$ CEM Eqn. III-3-19
- $h_c + B$ = vertical extent of active profile
- h_c = closure depth
- $R(h_c + B)$ = sediment lost from profile due to sea level rise



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Bruun Rule – Sea Level Rise Example

- After CEM Example Problem III-3-5:
  - h_c = 6 m, B = 2 m, D = 0.2 mm, dS/dt = 3 mm/yr
  - What is rate of shoreline retreat?
  - What rate of beach fill is required to prevent retreat?

$A = 0.21D^{0.48} = 0.1m^{1/3}$ $W_* = \left(\frac{h_c}{A}\right)^{3/2} = 465$ m

$R_\infty = S\frac{W_*}{h_c + B}$ $\frac{dR_\infty}{dt} = \frac{dS}{dt}\left(\frac{W_*}{h_c+B}\right) \cong 0.17$ m/yr

$$\frac{dV}{dt} = W_*\frac{dS}{dt} \cong 1.4\frac{m^3}{m}/yr$$

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Slope at the beach face (shoreline)

- Variety of empirical formulae in literature
  - Response to Bruun/Dean equilibrium profile problem at x = 0
  - For example: $S_0 = 0.25\left(\frac{D}{H_o}\right)^{0.25}\left(\frac{H_o}{L_o}\right)^{-0.15}$
    - S_0 = slope at the shoreline
    - $D = D_{50}$
    - H_o = deep water wave height
    - L_o = deep water wave length
  - Can be applied to a modified Bruun/Dean derivative relationship:
    - $S = \frac{S_0}{1+\frac{3}{2}\left(\frac{S_0}{A^{3/2}}\right)h^{1/2}}$
      - S = slope at depth h

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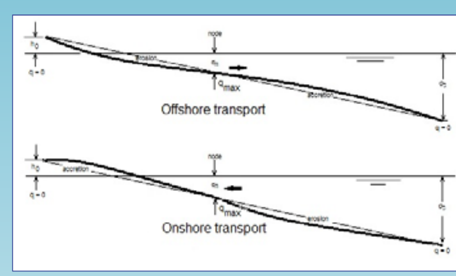
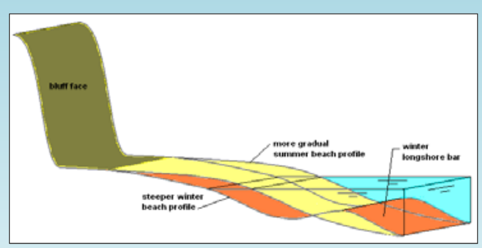
Cross-shore change

- Wave induced sediment transport extends from
  - limit of runup onshore
  - to limit of wave-induced motion offshore (depth of closure)
- Maximum transport in the surf zone is at the node between erosion and accretion
- Winter offshore bar profile is associated with net *offshore transport*
  - High wave conditions
  - Steeper beach face
- Summer "berm-type" profile is associated with net *onshore transport*
  - Low wave conditions
  - Shallower beach face slope





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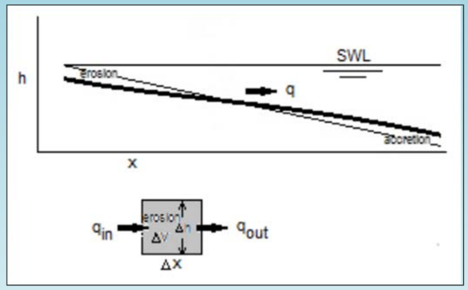
Cross-shore transport prediction

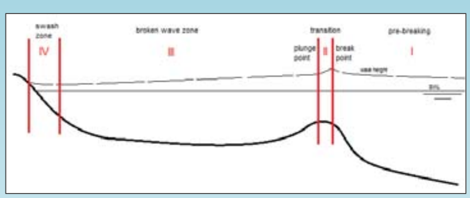
SBEACH model formulation

- Elevation change Δh across Δx (cross-shore increment)
- Uniform conditions in Δy (longshore increment)
- Leads to volume change ΔV
- Sediment transport $q = \frac{dV}{dt}$
- $\frac{\Delta q}{\Delta x} = -\frac{\Delta h}{\Delta t} \rightarrow \frac{dq}{dx} = -\frac{dh}{dt}$



SBEACH cross-shore zones

- Zone I
  - $q = q_b e^{-\gamma x}$
  - q_b = rate at break point
  - x coordinate from break point
  - Spatial decay coefficient
    - $\gamma = 10.3\left(^{D}/_{H_b}\right)^{0.47}$
    - D = grain size
    - H_b = breaking wave height
- Zone II: $q = q_b e^{-\gamma x}$, γ=0.21
- Zone III and IV require calibration measurements (field, physical model, or both)



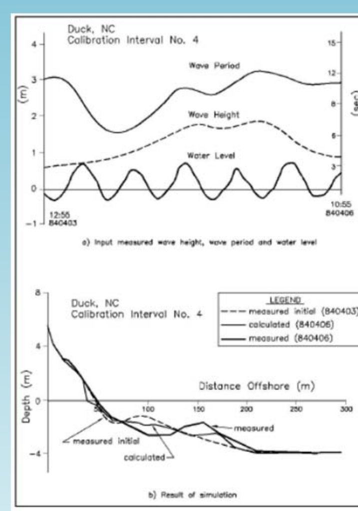
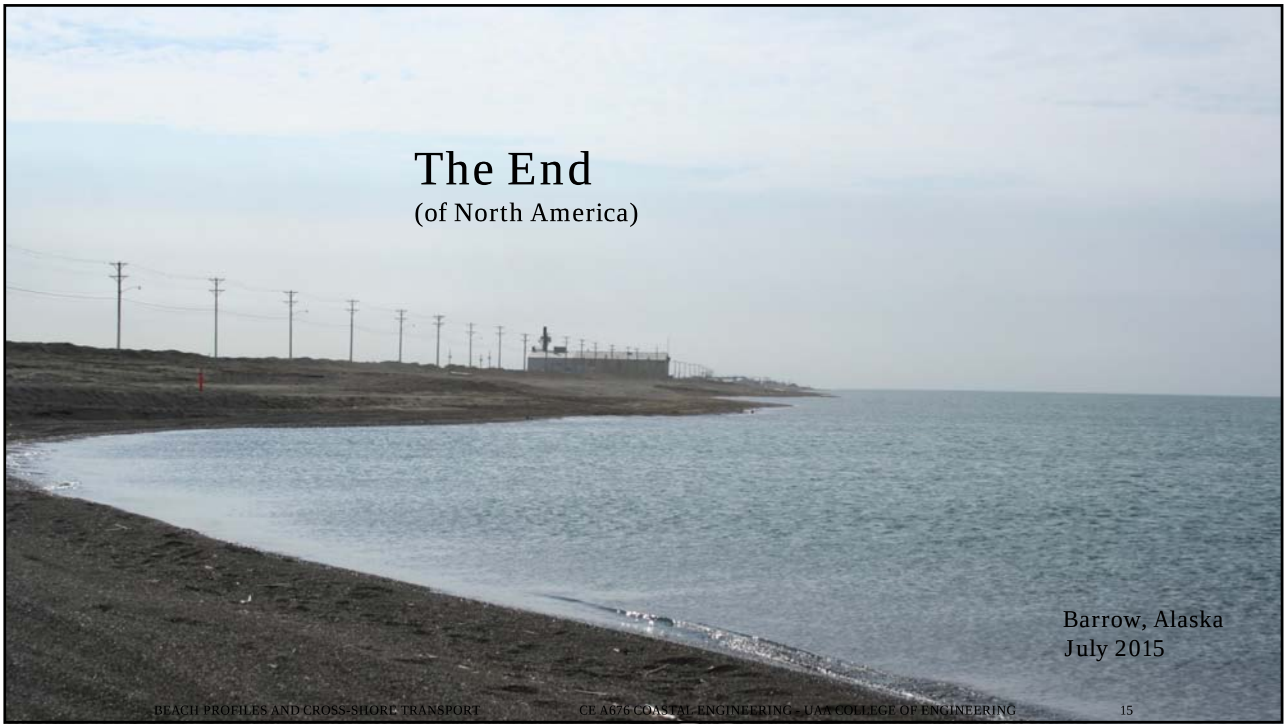


Figure III-3-44. SBEACH tested against profile evolution data from Duck, NC (Larson and Kraus 1989)

Coastal Engineering Manual Part III Ch. 3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