Beaches and Coastal Environments of Washington

Southern WA Coast – sandy beaches, spits, lagoons, sediment supply from Columbia River, northward longshore transport

Northern WA Coast – headland beaches, cliff erosion, gravel beaches, stacks and island remnants offshore

Straits of Juan de Fuca – headland beaches, cliff erosion, river supply, eastward swell from ocean, large and complex spits

Puget Sound – headland beaches, cliff erosion, rivers with deltas, much local variability due to morphology

Wind patterns affecting WA state

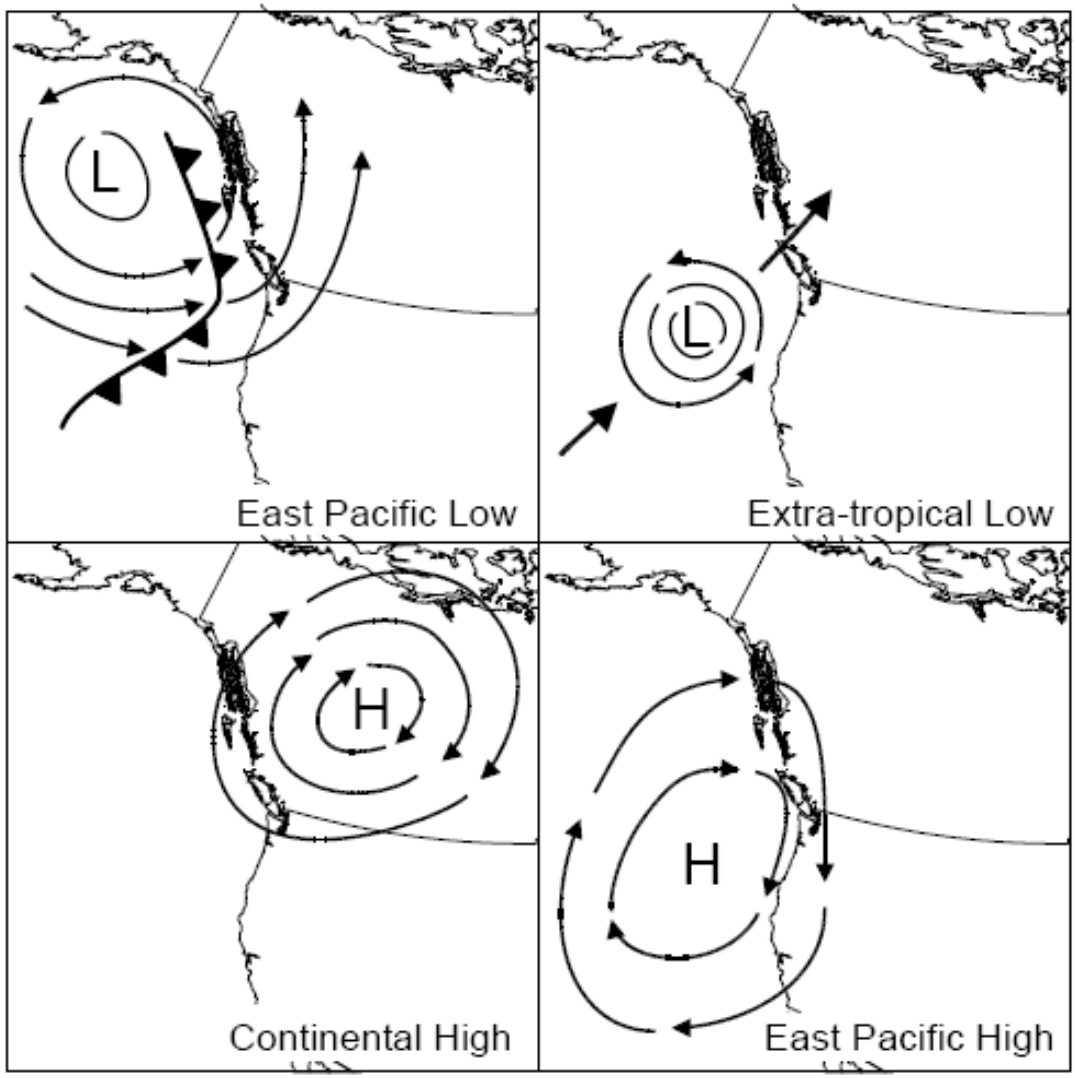
Winter Conditions

Low-pressure systems generate winds from S and SW, which push water against coast – causing storm surge

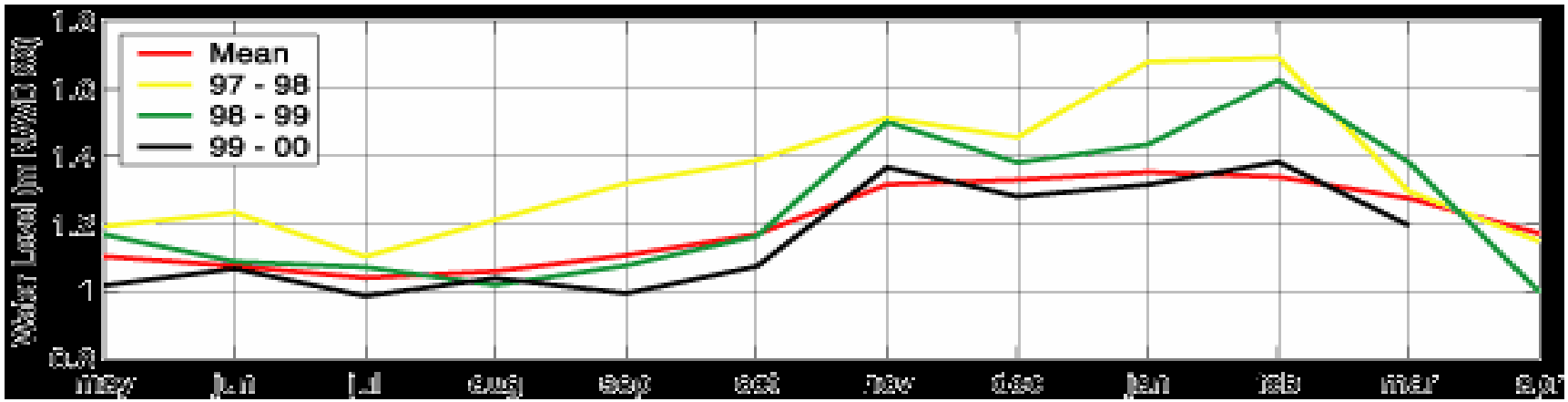
Summer Conditions

High-pressure systems generate winds from N and NE, which pull water away from coast – causing deep water to upwell with nutrients

Winter conditions dominate longshore transport

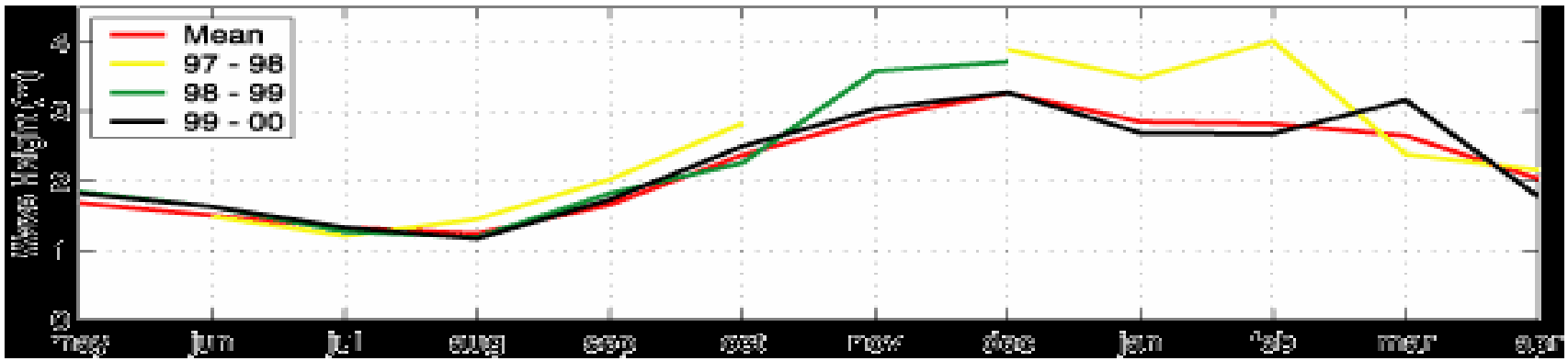


Seasonal changes in water level and wave height



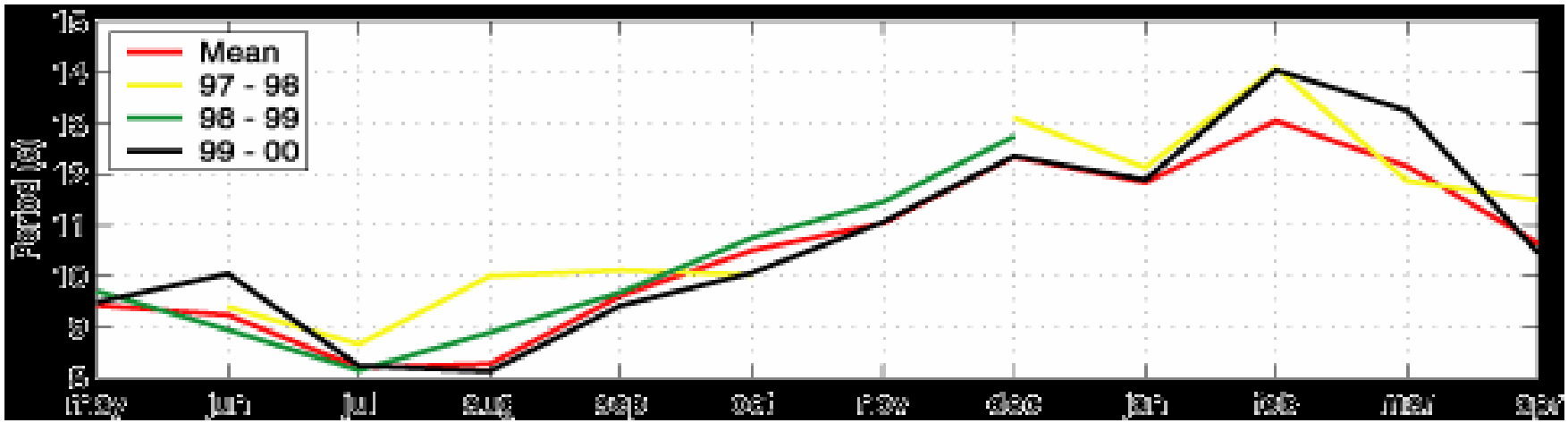
May August December March

Sea level ~0.5 m rise due to winds during winter

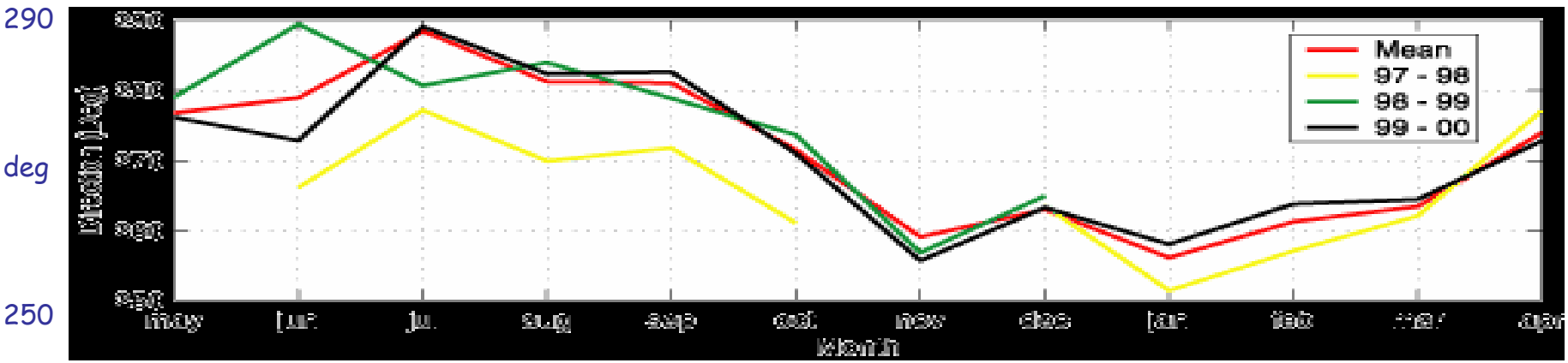


Wave height increases from ~1 m in summer to ~4 m in winter

Seasonal changes in wave period and direction



Wave periods (and wavelengths) reach a maximum in winter



Wave direction from SW during winter, from NW during summer

Pathways for Columbia River sand

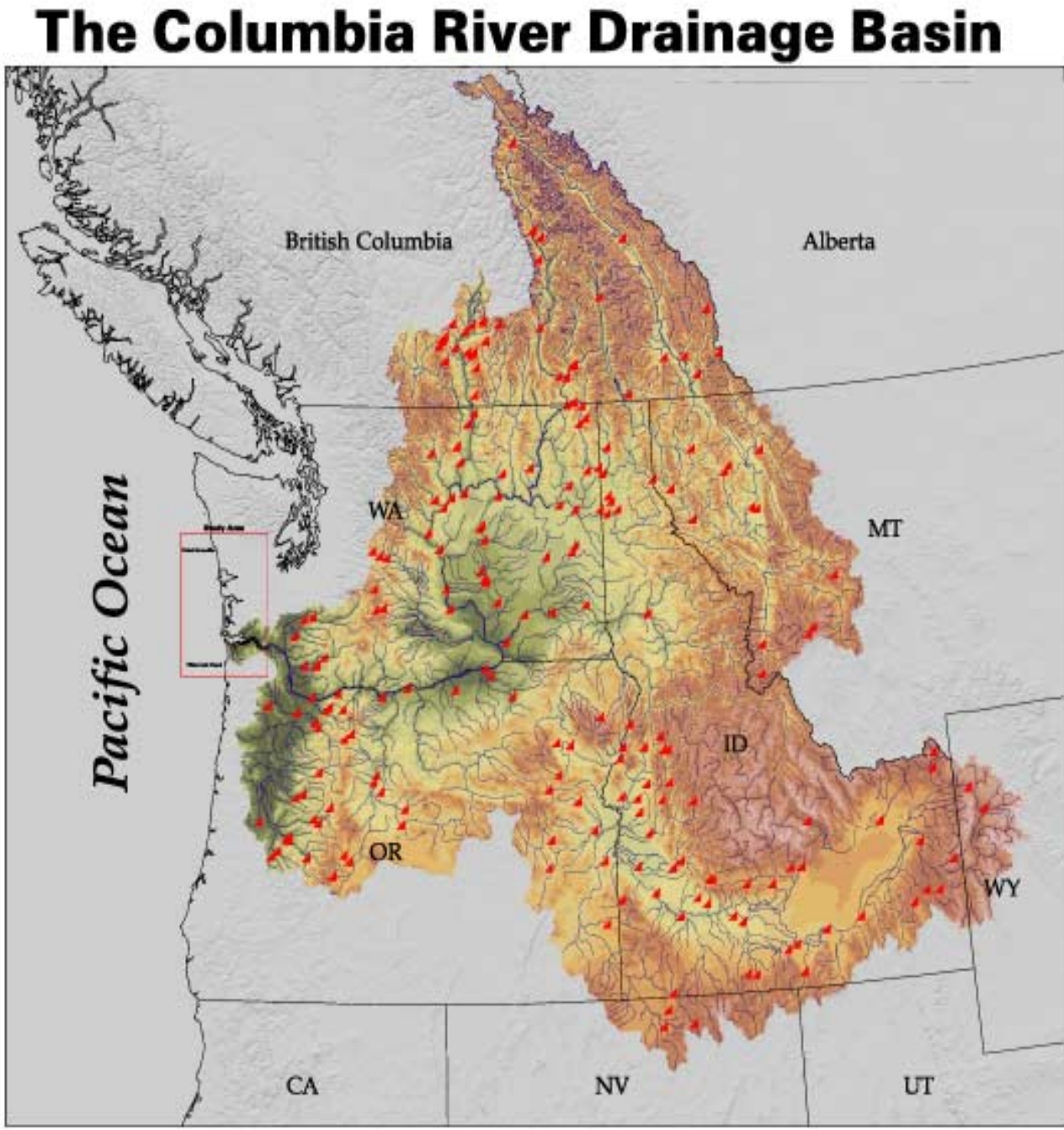
Predominant direction of transport is northward

Sand going to beach is small portion of total supply

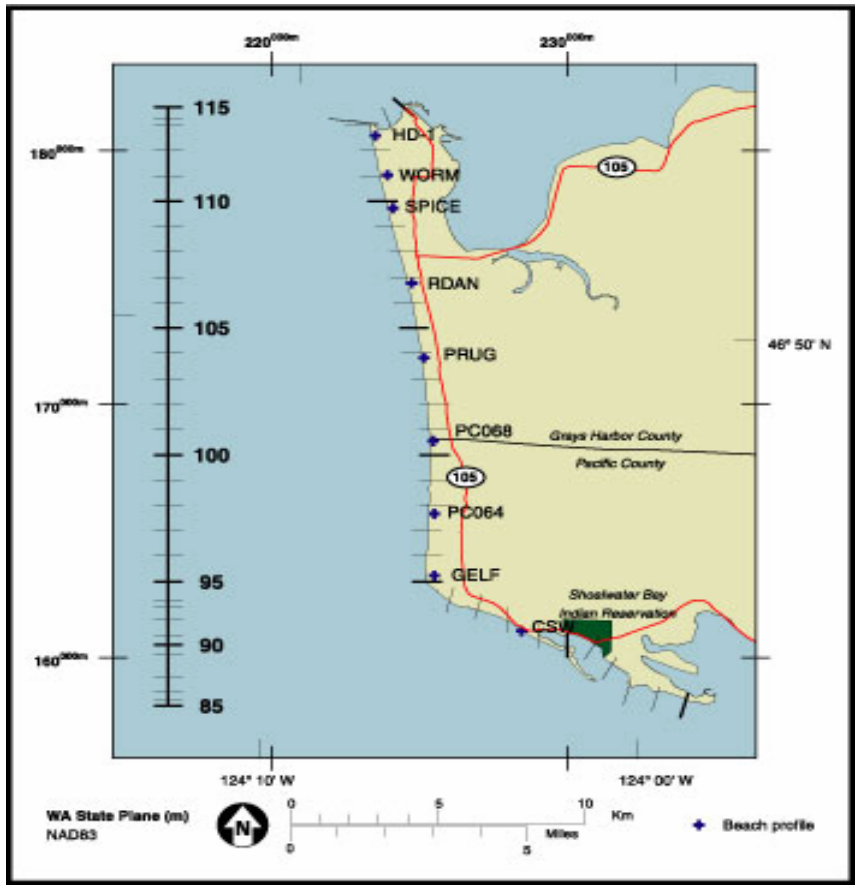
Sediment source for southern WA coast beaches

Dams placed on Columbia River during 20th century likely trapped much of sand supplied to beaches

Columbia discharge
~10 million tons/y
[Mississippi
~200 million tons/y
Amazon
~1000 million tons/y]

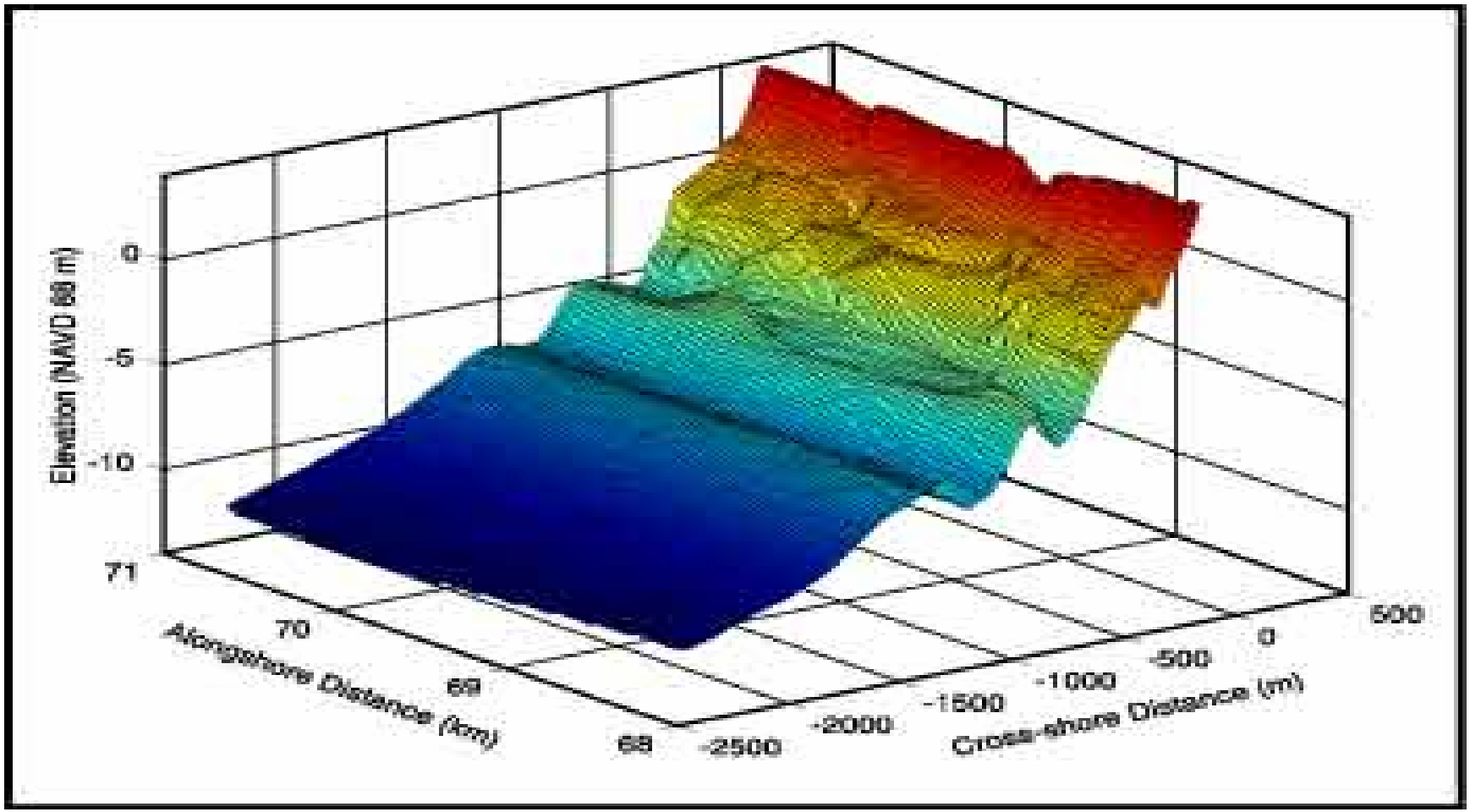


Southwest Washington Coastal Erosion Study



Beach profiles collected seasonal from a number of beach-perpendicular transects

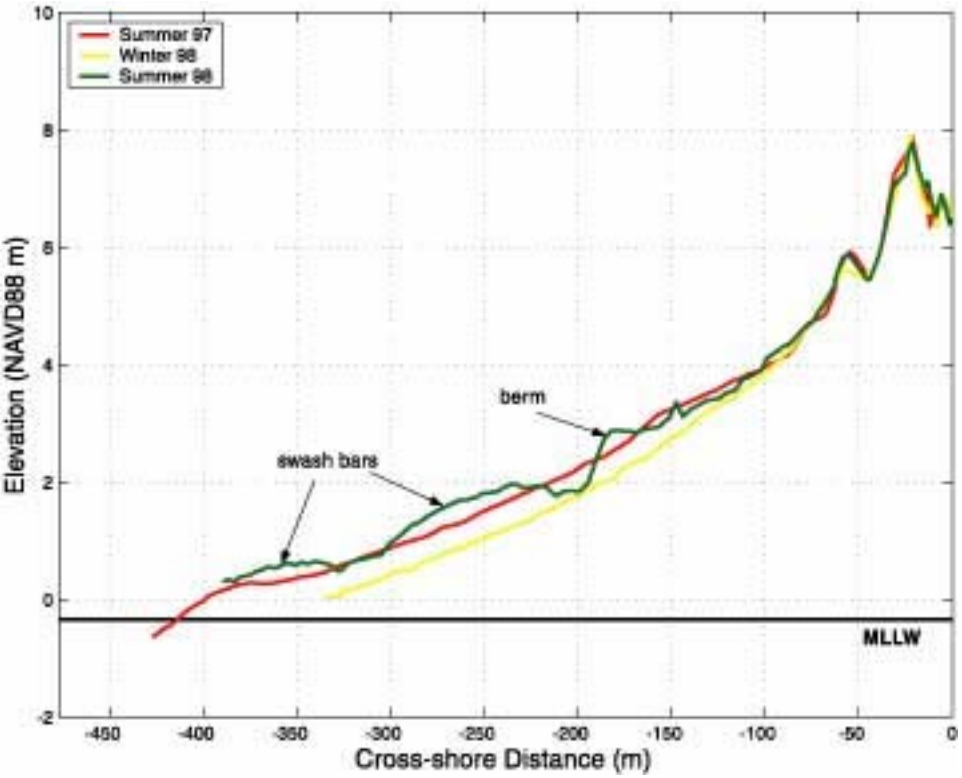
Observations of submarine beach profile

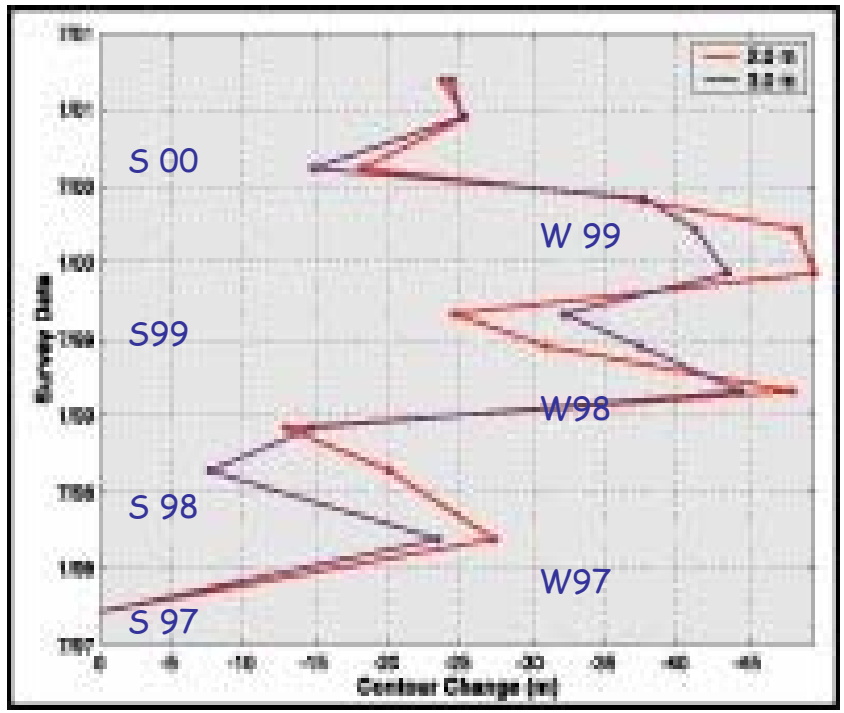


Very difficult to obtain accurately

Data now collected using jet skis with depth recorder and GPS

Changes in beach profiles





Winter 98 profile (yellow) is lower than Summer 97 profile (red) due to seasonal erosion

Summer 98 profile (green) is higher and shows berm and bars moving onto beach

2- and 3-m contours (above MLLW) show erosion during winter (landward migration) and deposition during summer, with a net movement landward between S 97 and S 00

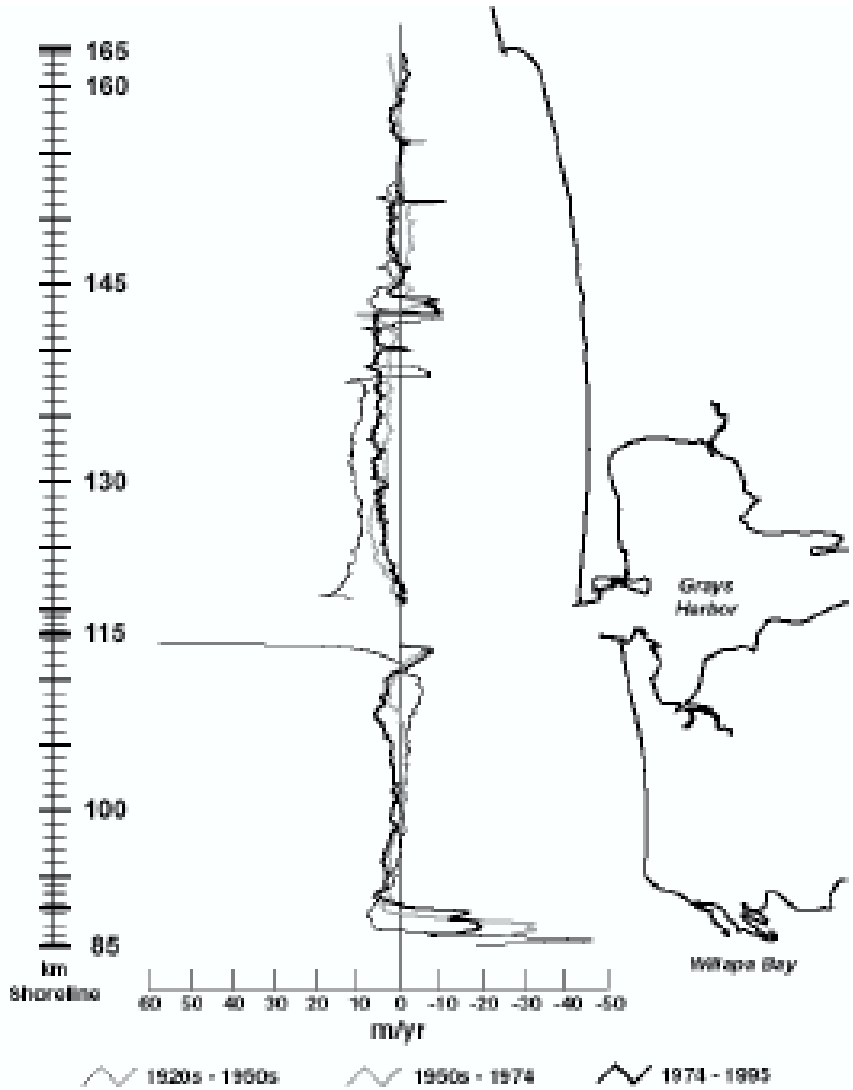
Shoreline changes over many decades

Sand accumulation occurred before 1950

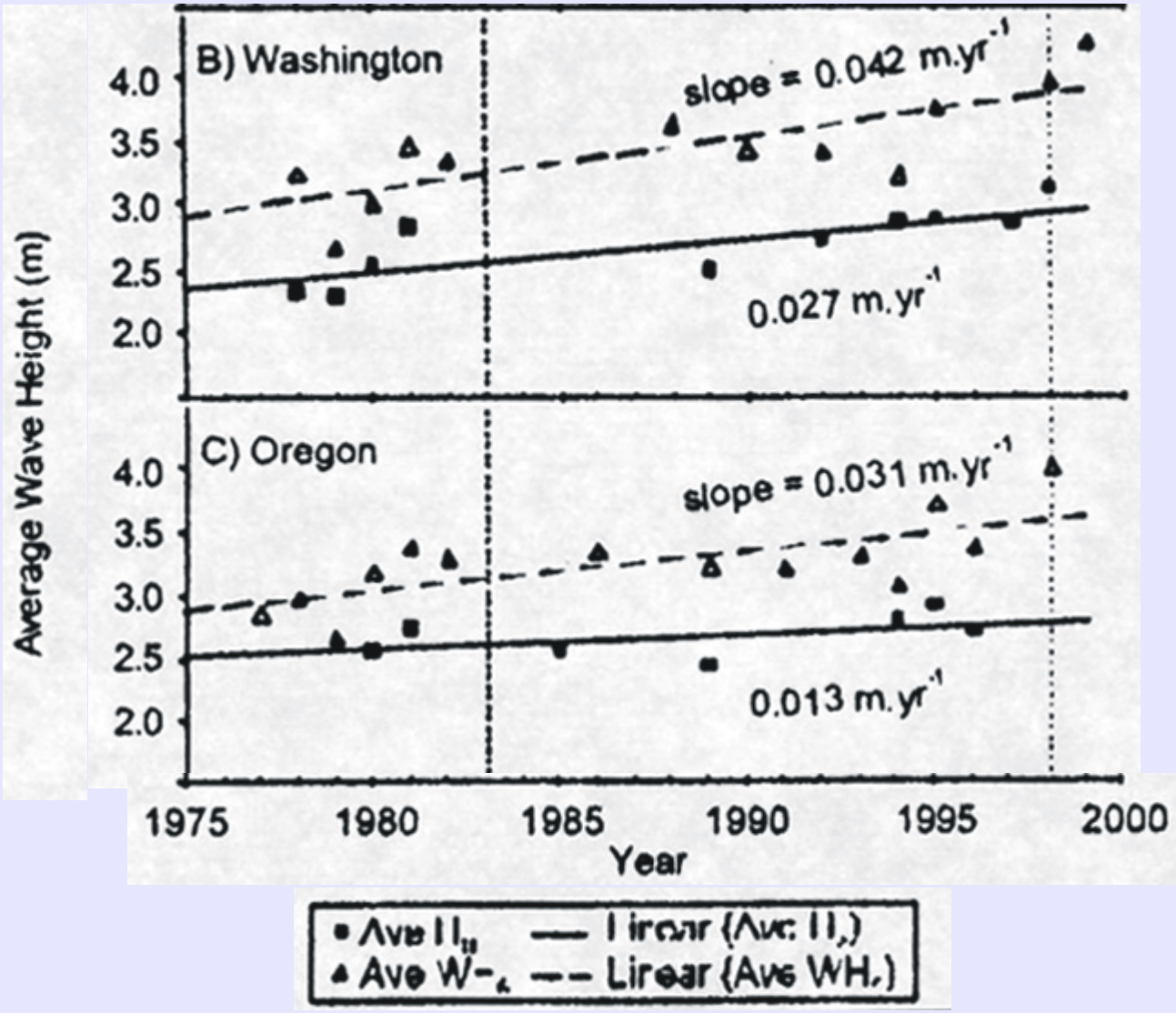
Rate of accumulation slowed since then

Severe erosion on north side of Willapa Bay Inlet has continued through period

South side of Grays Harbor Inlet accumulated much sediment before 1950, but has eroded since building jetty

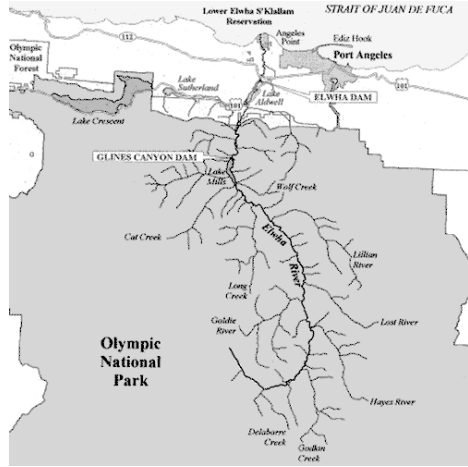


Changes in Wave Climate




Strait of Juan de Fuca
Pacific Ocean
Neah Bay
112
Seiku
Clallam Bay
113
112
Port Angeles
Sequim
Port Townsend
5
Lake Ozette
Elwha
101
Port Hadlock
Everett
Rialto Beach
Sol Duc Hot Springs
Hurricane Ridge
Forks
La Push
Port Ludlow
104
Kingston
OLYMPIC
Quilcene
Edmonds
Hoh Rain Forest
3
101
NATIONAL
Brinnon
Poulsbo
Kalaloch
PARK
Seattle
Winslow
Queets
101
Lake Quinault
Lake Cushman
Neilton
Hoodsport
5
Moclips
Shelton
Pacific Beach
Copalis Beach
101
Kamiche
Tacoma
108
McCleary
Ocean City
8
8
101
109
Ocean Shores
Hoquiam
12
Elma
Olympia
Aberdeen
105
Westport
5
Grayland
101
12

Elwha River



Drainage basin within Olympic Mountains, supplies sediment to Straits JdF

Two dams have trapped sediment since 1912 and 1926, nearly eliminating supply

Scheduled for removal

Puget Sound

Predominant north-south orientation

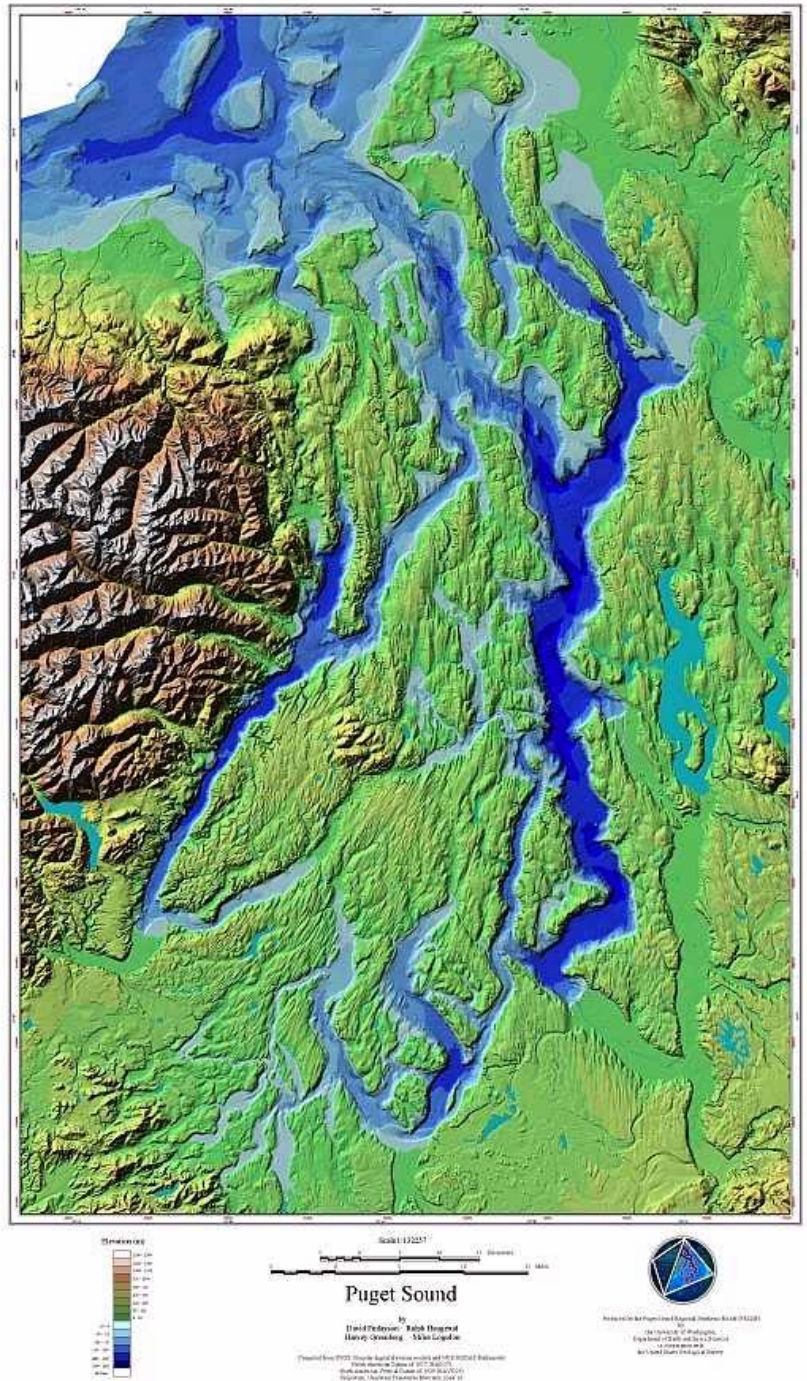
Complex morphology

Glacial history

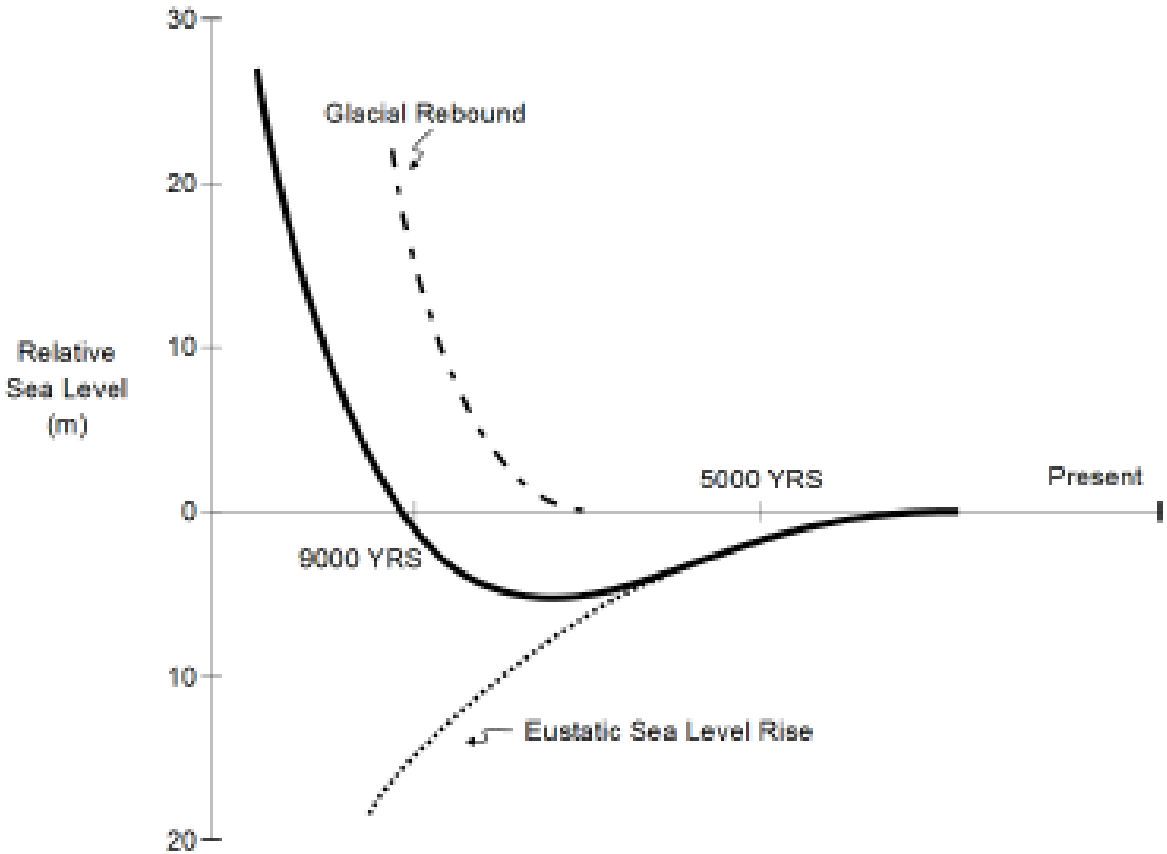
Cliff erosion and river supply

Energetic, but variable wave activity

Strong tidal currents

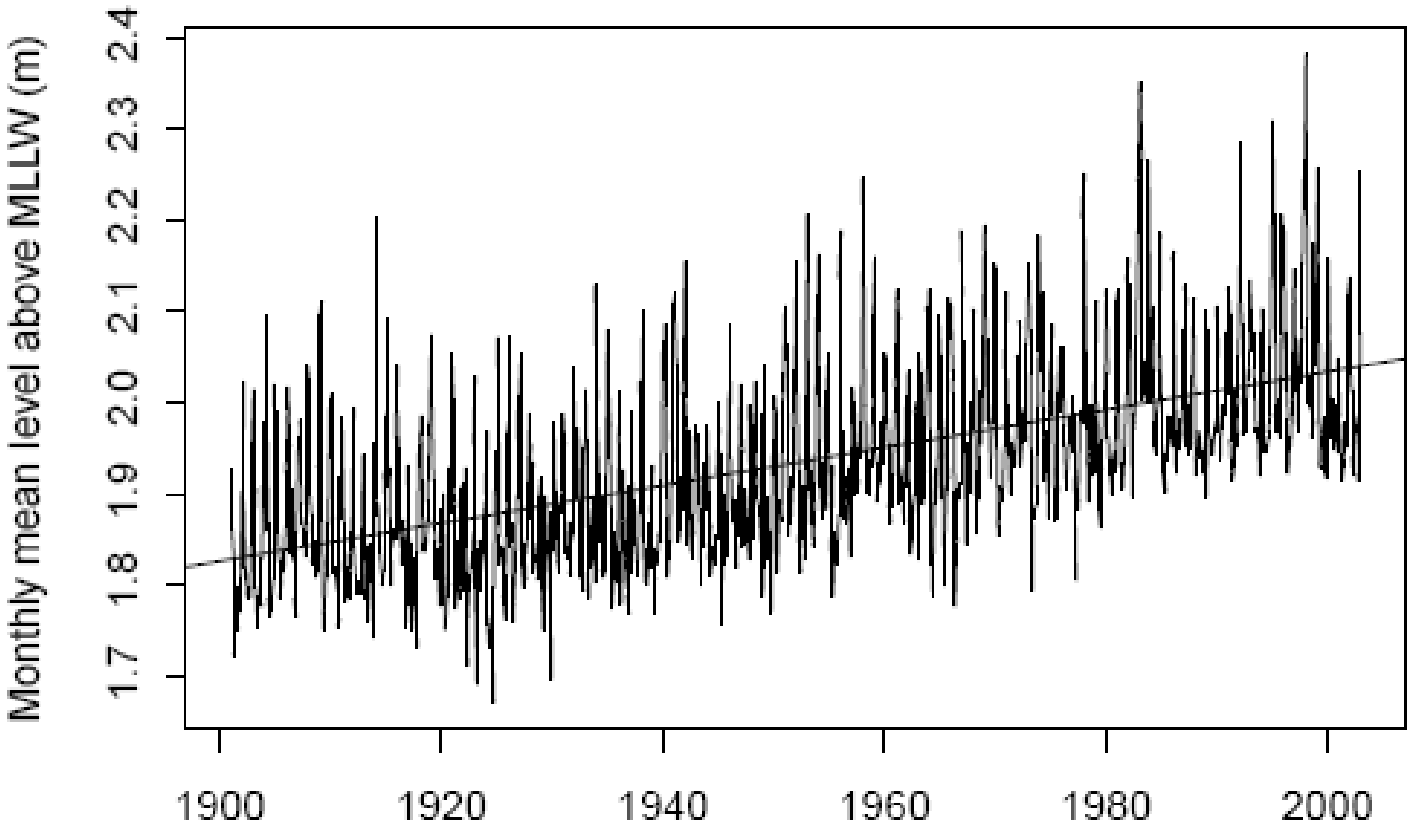


Holocene sea-level rise



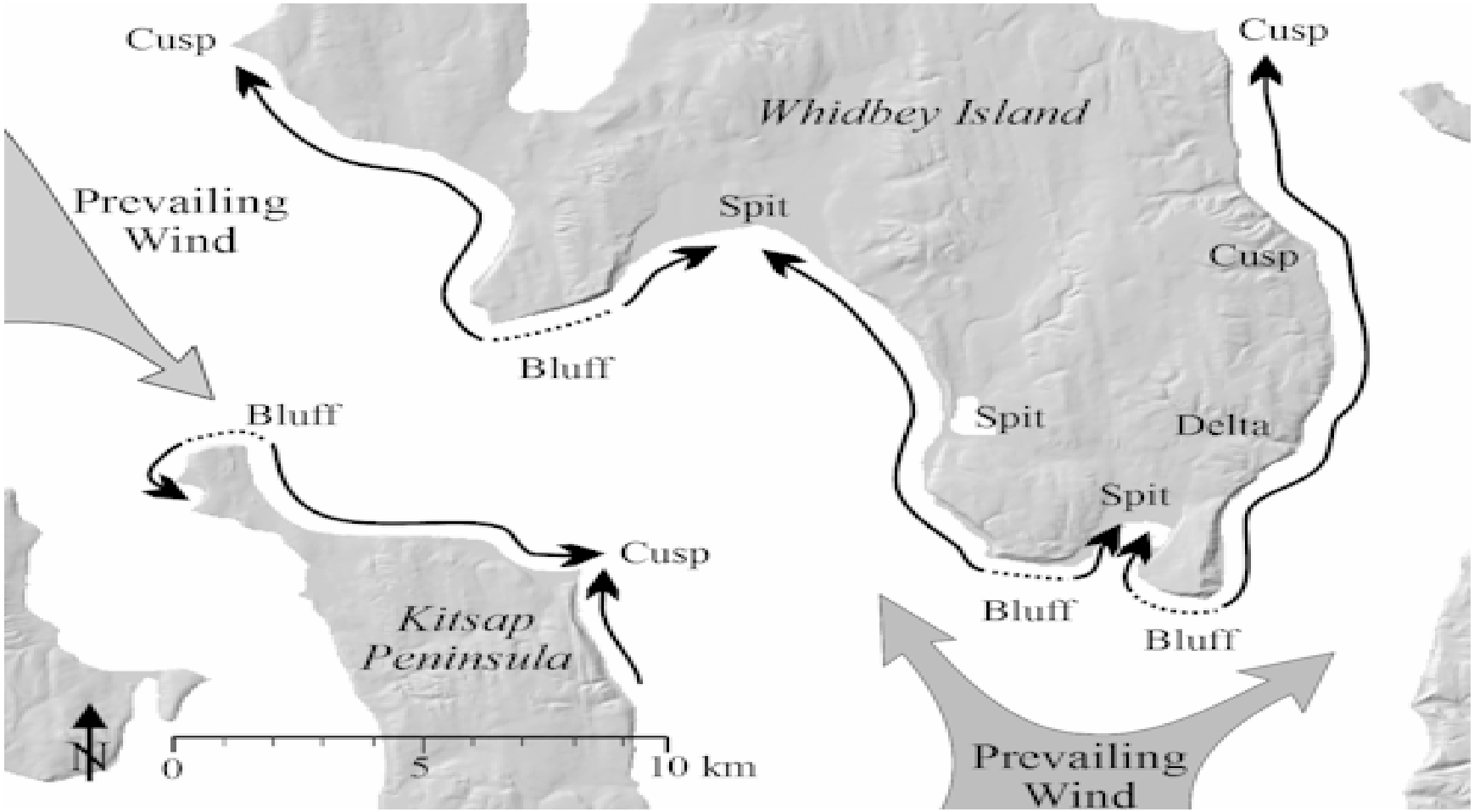
Glacial rebound had strong impact on local sea level during early Holocene, especially in northern Puget sound – sea level fell

Recent rise in Puget Sound sea level



For past century, sea-level rise has been ~2 mm/y, similar to global sea-level rise

Local variability in longshore transport



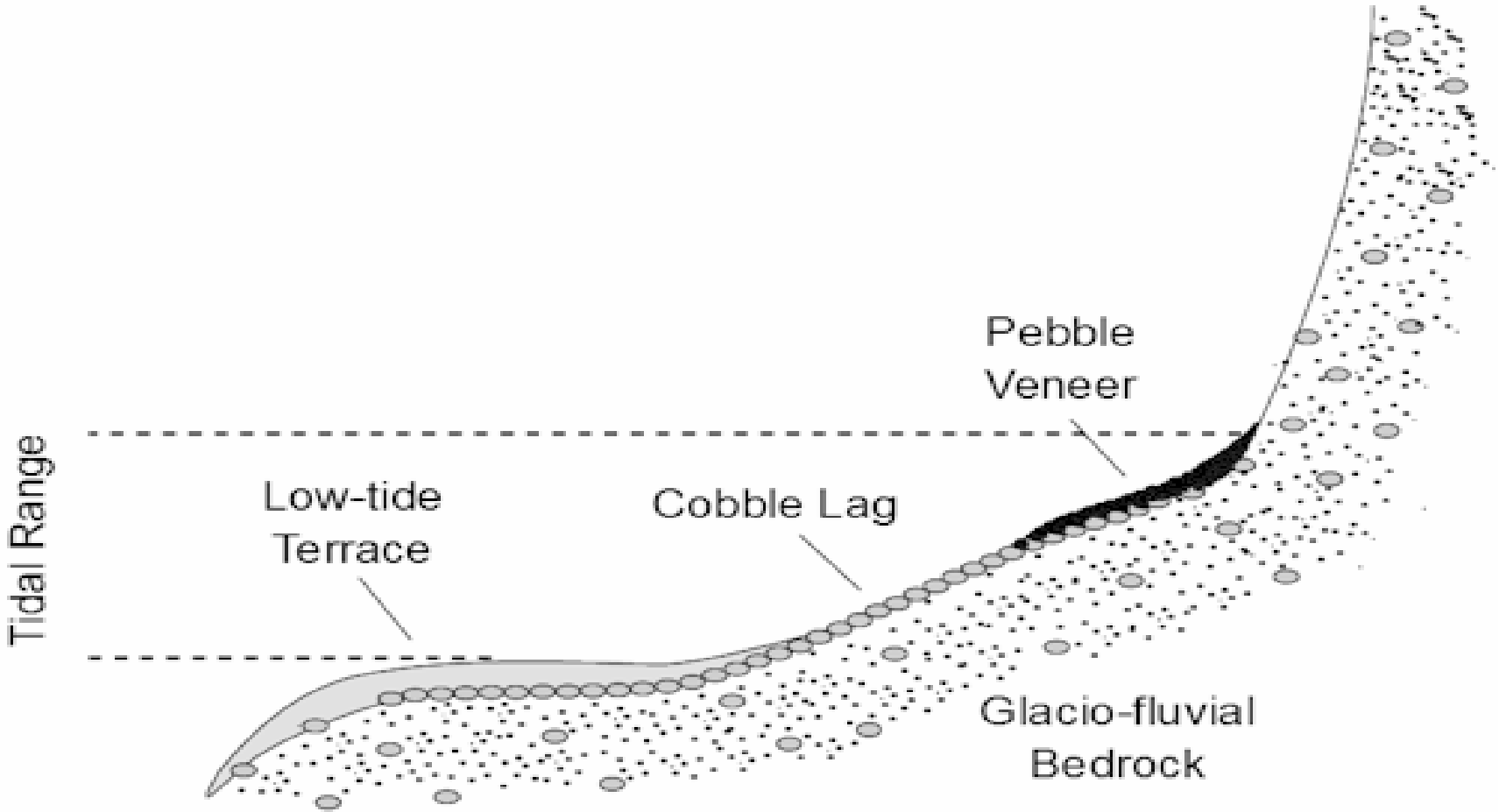
Due to orientation of land masses and direction of winds

Results in dramatic heterogeneity of transport processes: convergent and divergent transport causes deposition and erosion differences over small scales

Typical Puget Sound Beach

Gravel foreshore and sandy low-tide terrace

Common profile for Puget Sound beaches



Impact of waves and tides

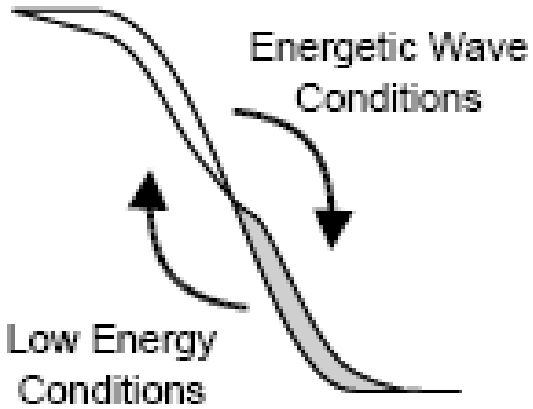
Water level rises, exposing higher areas (including cliffs) to erosion

Wave energy increases, moving sediment seaward and alongshore

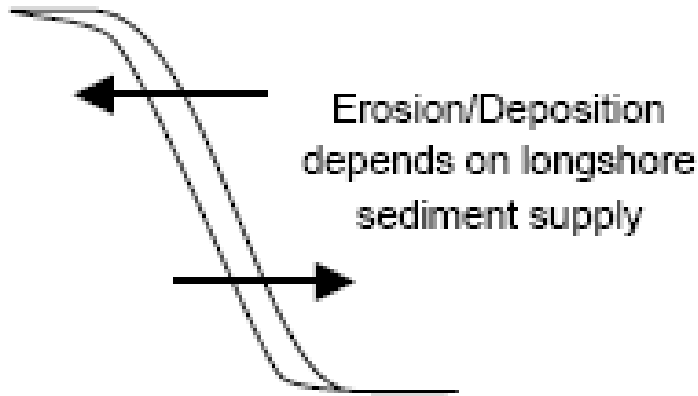
Equilibrium profile develops, depending on importance of across-beach and alongshore transport

Differences in beach profiles

Slope Change
(cross-shore dominate waves)



Parallel Change
(longshore dominate waves)



Where across-beach transport dominates, sediment profile changes depending on wave conditions

Where alongshore transport dominates, profile remains similar but moves landward or seaward

Impacts of biogenic materials

Oyster beds

Drift Wood

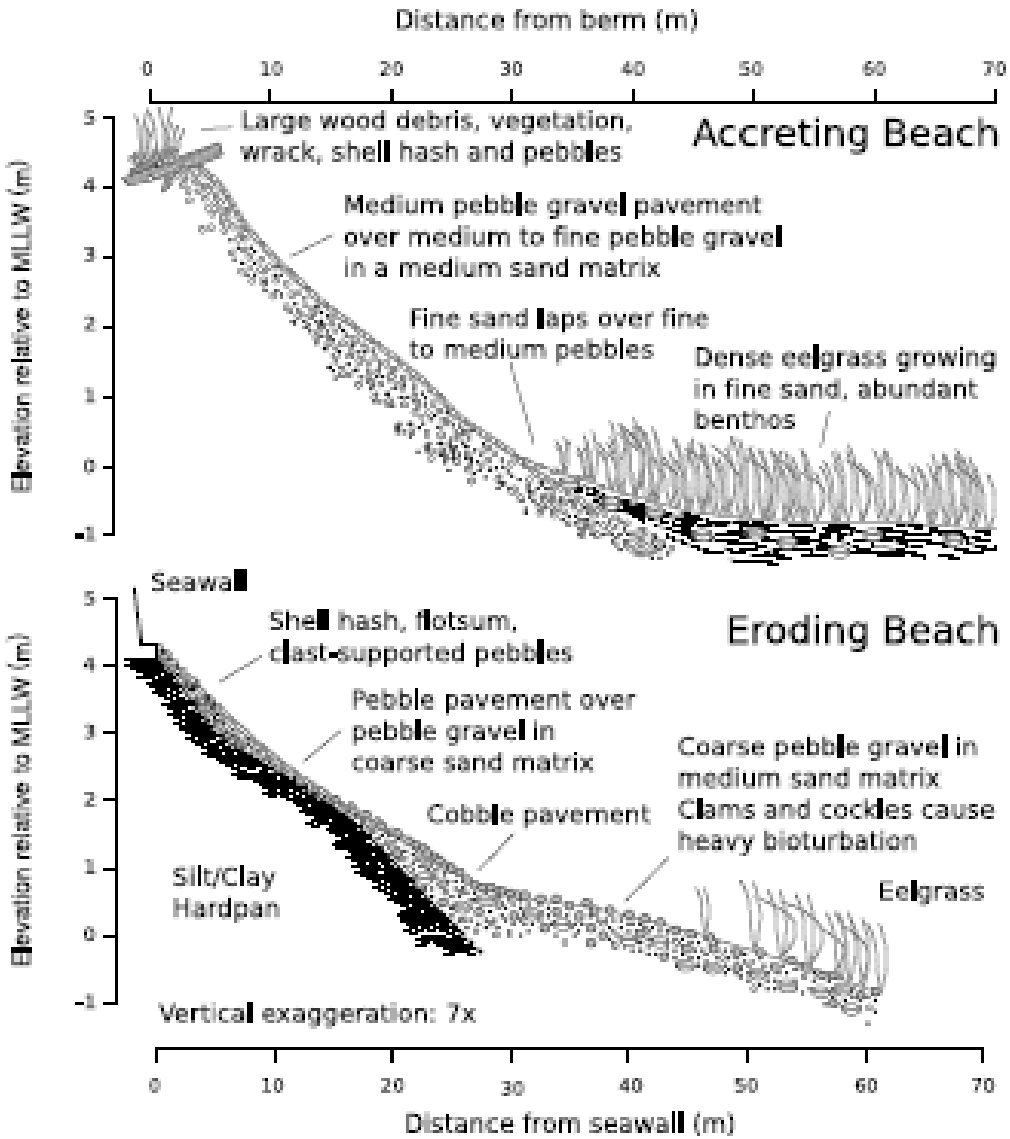
Stabilize intertidal and supratidal regions of beach profile

Impacts of seawalls

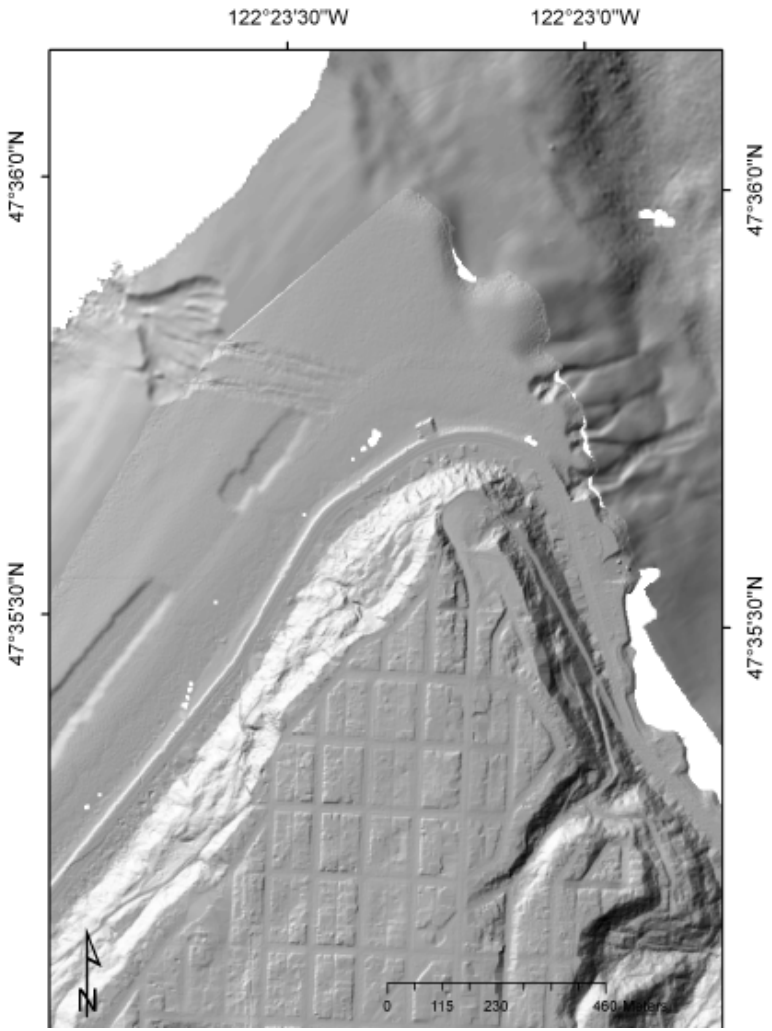
They help stabilize shoreline, but increase wave energy

Waves reflect back, rather than break

Superimposed wave height causes stronger wave motions – coarsens seabed and removes subtidal eelgrass (which is important for stabilizing seabed, and providing biohabitats)



Other Stupid Human Tricks



Sand mining and slope failures destabilize beach profile