Reading Material

"River Deltas"
from "The Coast of Puget Sound"
J.P. Downing, Puget Sound Books

Field Trip B

Working cruise in Puget Sound on the Thompson, UW's oceanographic research vessel

Wednesday
October 24

All day
(no class)

Puget Sound Cruise

Time: Depart UW 7AM Oceanography Parking Lot
Return UW 9 PM Oceanography Parking Lot

Clothing: foul-weather gear, hat, fleece, good shoes
Prepare for cold, wet, windy and muddy conditions

Food: Lunch and dinner onboard ship
Special dietary needs?

Observations during cruise

Water column

- CTD = chlorinity, temperature, depth
- turbidity (suspended sediment)

Seabed

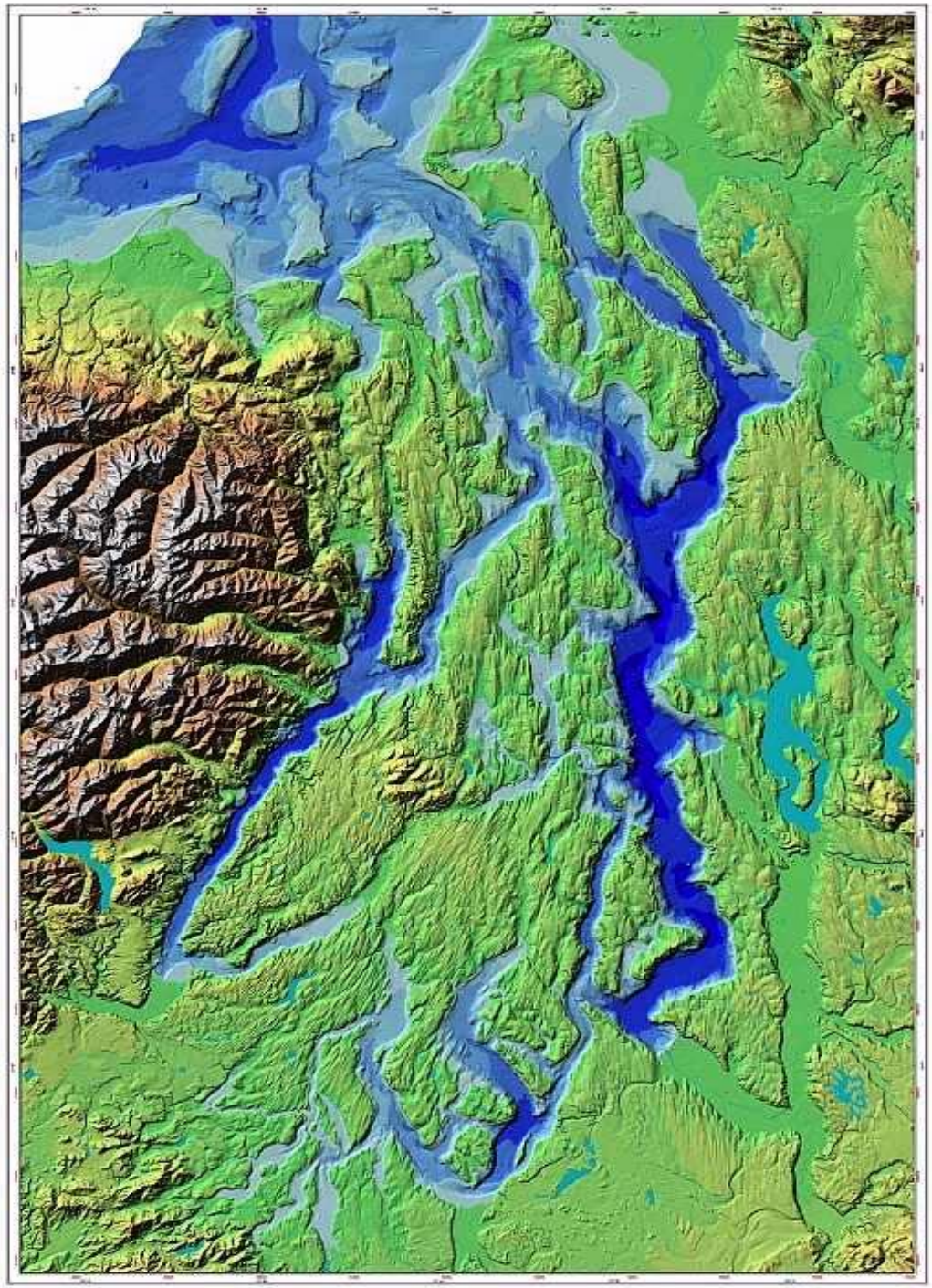
- Grab samples – surface sediment
- box core – 50-cm-long piece of seafloor
- kasten core – 250-cm-long record of sedimentation

Seafloor mapping

- multibeam acoustic profiles

Below seafloor

- seismic profiles



Puget Sound Morphology

Glacial Origin

scour – flow under ice sheet

formed depressions

e.g., Main Basin, Hood Canal, Lake Washington

sedimentary deposits – also raised land surface

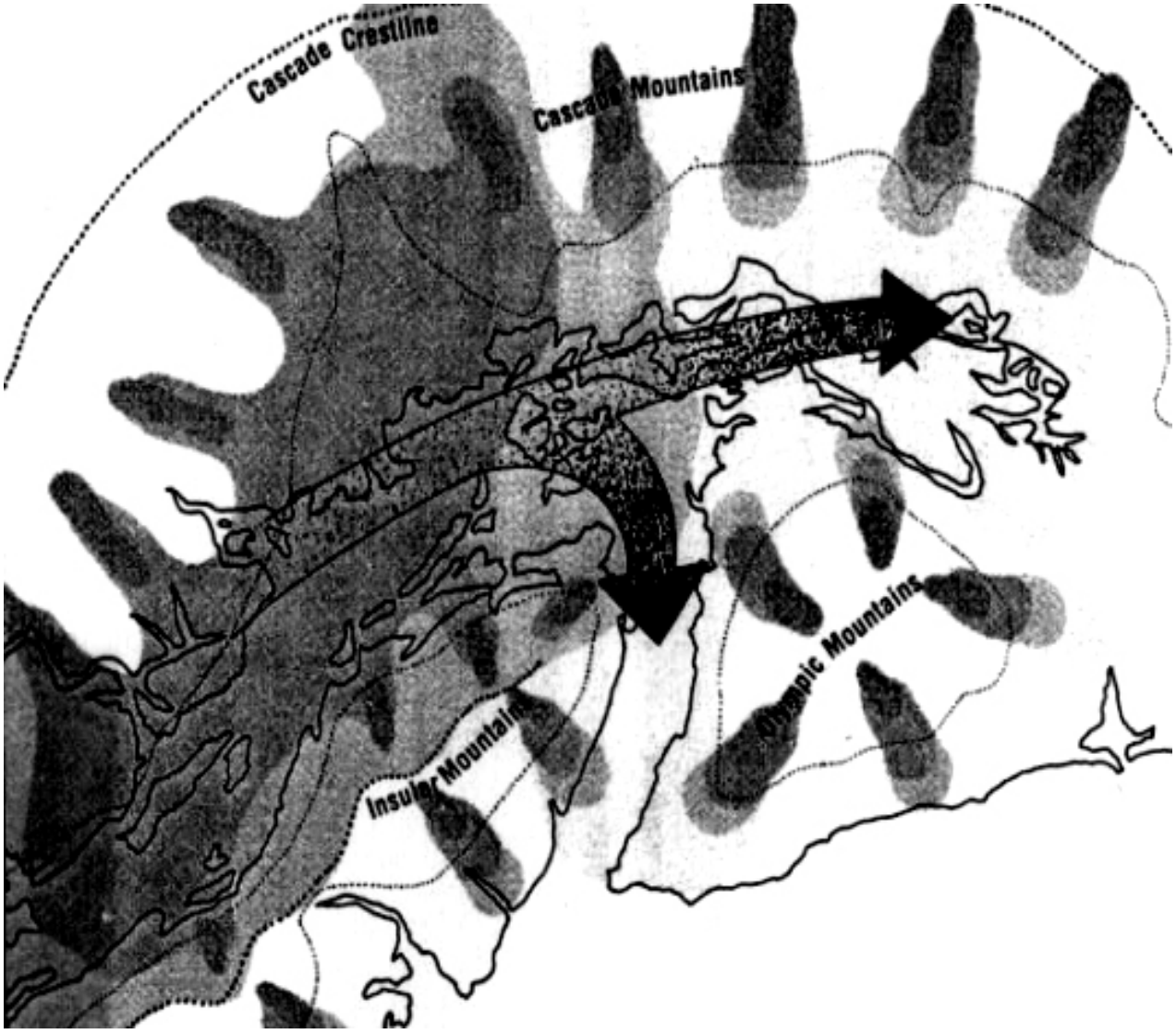
glacial tills, outwash deposits, lake deposits

old glacial sediment now provides new input to PS

cliff erosion

landslides

land surface erosion


Cascade Crestline
Cascade Mountains
Olympic Mountains

Bathymetry (water depth)

Shallow entrance

- glacial origin – moraine
- oceanographic name – sill
- primary sill is Admiralty Inlet

Several others divide PS into separate basins (>200 m)

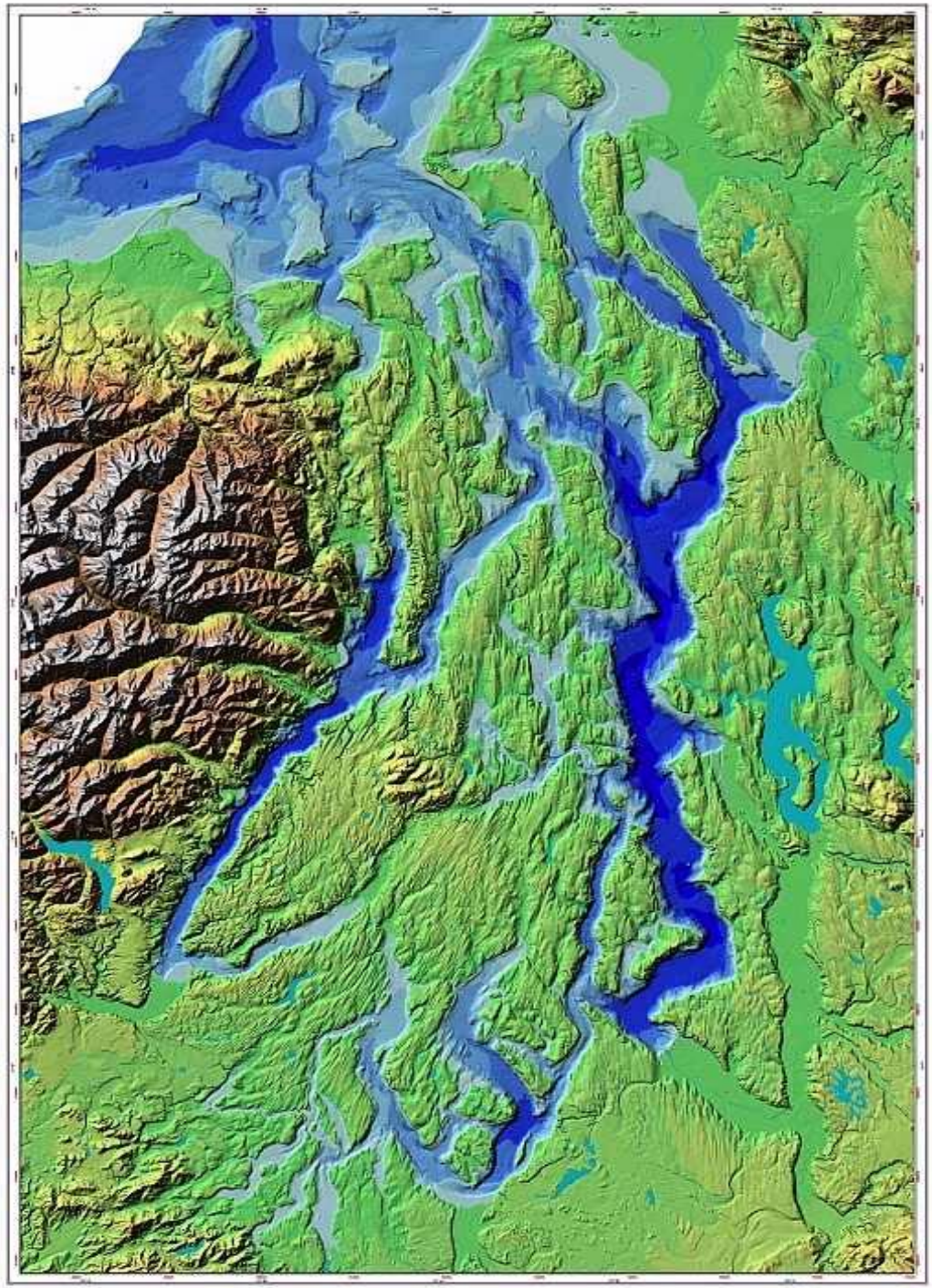
- Main Basin has 46% of water volume

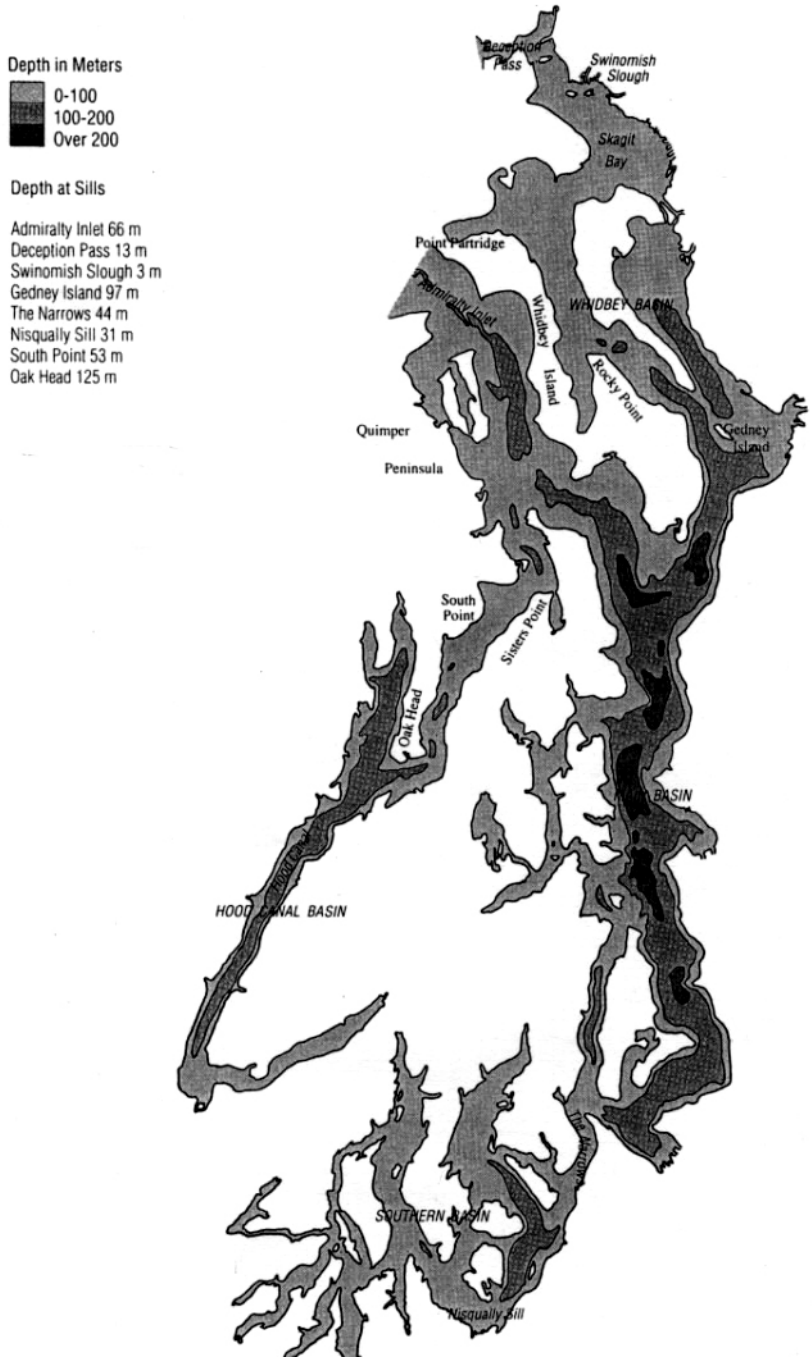
Sinuous shape – result of origin

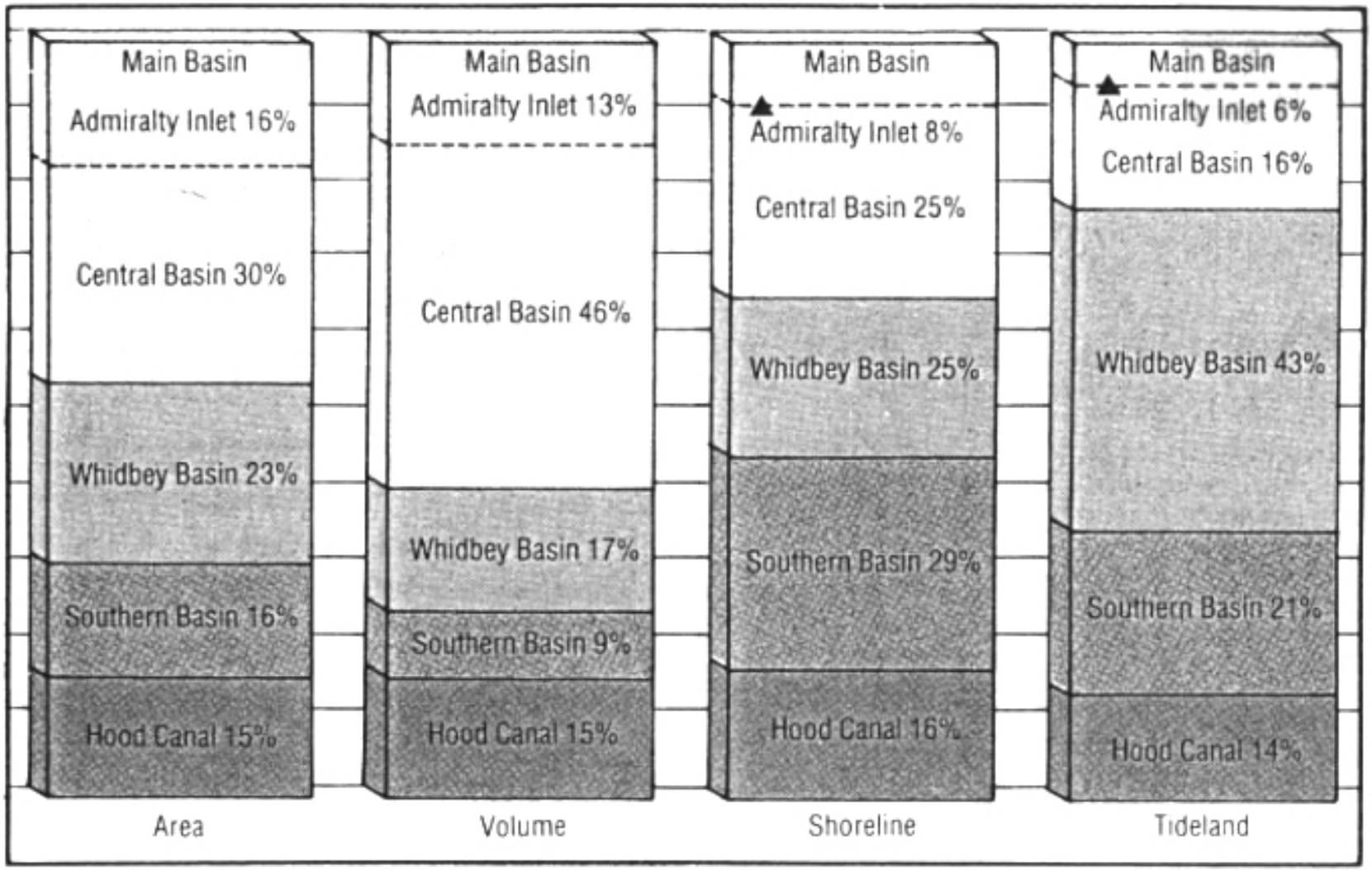
- Southern Basin has 29% of shorelines

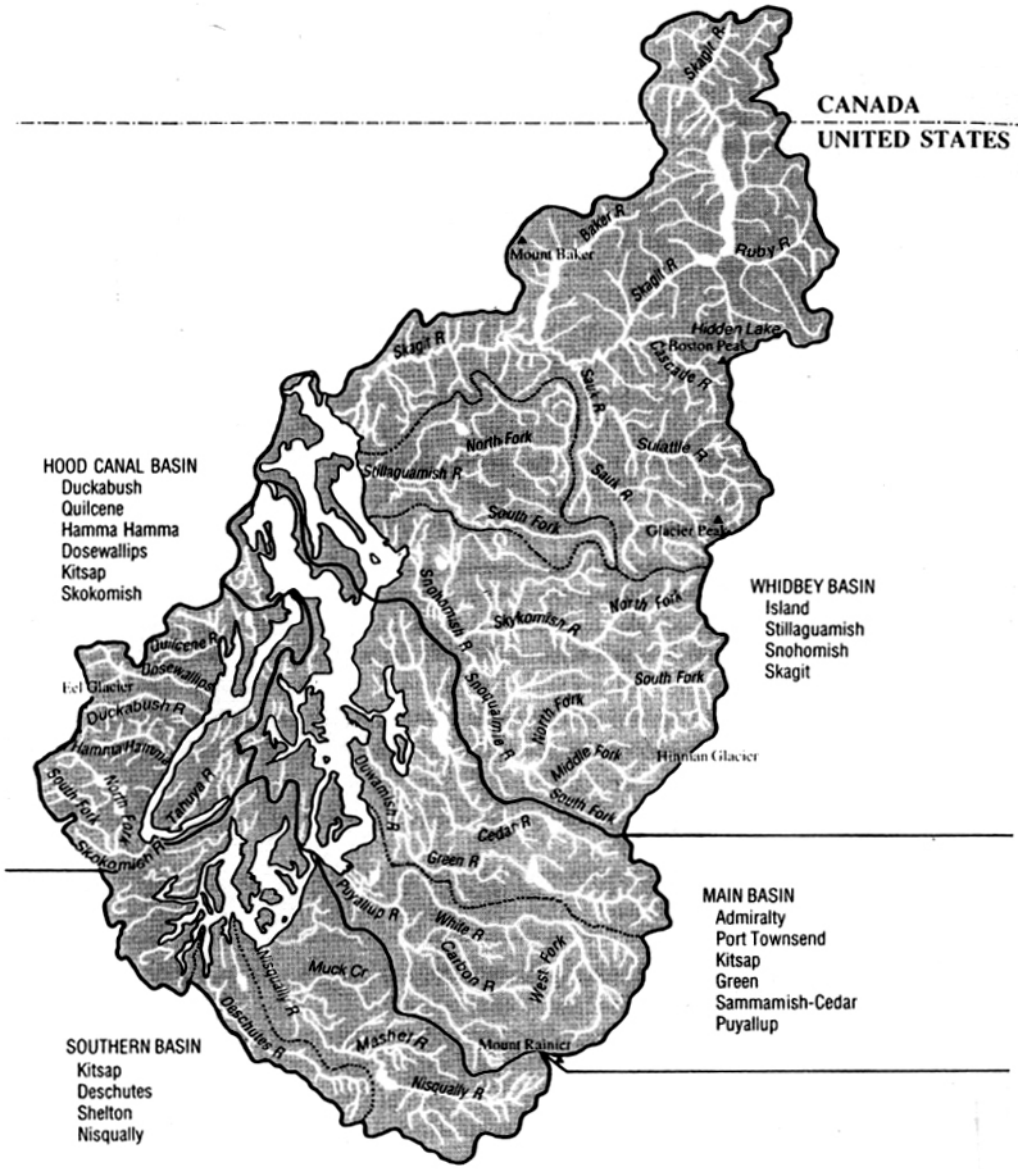
Fluvial (river) sediment supply

- fills PS from shoreline
- Whidbey Basin has 43% of tidelands




Depth in Meters
0-100
100-200
Over 200
Depth at Sills
Admiralty Inlet 66 m
Deception Pass 13 m
Swinomish Slough 3 m
Gedney Island 97 m
The Narrows 44 m
Nisqually Sill 31 m
South Point 53 m
Oak Head 125 m
Deception Pass
Swinomish Slough
Skagit Bay
Point Partridge
Admiralty Inlet
Whidbey Island
WHIDBEY BASIN
Rocky Point
Gedney Island
Quimper Peninsula
South Point
Sisters Point
Oak Head
HOOD CANAL BASIN
SOUTHERN BASIN
Nisqually Sill


Main Basin
Admiralty Inlet 16%
Central Basin 30%
Whidbey Basin 23%
Southern Basin 16%
Hood Canal 15%
Area
2,329 sq km
(899 sq m)
Main Basin
Admiralty Inlet 13%
Central Basin 46%
Whidbey Basin 17%
Southern Basin 9%
Hood Canal 15%
Volume
(From MLLW)
168 cu km
(26 5 cu m)
Main Basin
Admiralty Inlet 8%
Central Basin 25%
Whidbey Basin 25%
Southern Basin 29%
Hood Canal 16%
Shoreline
2,141 km
(1,330 m)
Main Basin
Admiralty Inlet 6%
Central Basin 16%
Whidbey Basin 43%
Southern Basin 21%
Hood Canal 14%
Tideland
303 sq km
(117 sq m)


CANADA
UNITED STATES
HOOD CANAL BASIN
Duckabush
Quilcene
Hamma Hamma
Dosewallips
Kitsap
Skokomish
WHIDBEY BASIN
Island
Stillaguamish
Snohomish
Skagit
MAIN BASIN
Admiralty
Port Townsend
Kitsap
Green
Sammamish-Cedar
Puyallup
SOUTHERN BASIN
Kitsap
Deschutes
Shelton
Nisqually
Skagit R
Baker R
Mount Baker
Ruby R
Hidden Lake
Boston Peak
Cascade R
Suiattle R
Sauk R
North Fork
South Fork
Glacier Peak
Stillaguamish R
Snohomish R
Skykomish R
North Fork
South Fork
Snoqualmie R
North Fork
Middle Fork
South Fork
Hinman Glacier
Quilcene R
Dosewallips
Eel Glacier
Duckabush R
Hamma Hamma
South Fork
North Fork
Skokomish R
Tahuya R
Duwamish R
Cedar R
Green R
Puyallup R
White R
Carbon R
West Fork
Muck Cr
Mashel R
Nisqually R
Deschutes R
Mount Rainier

Hydrography (water properties)

Salinity (amount of salt dissolved in water)

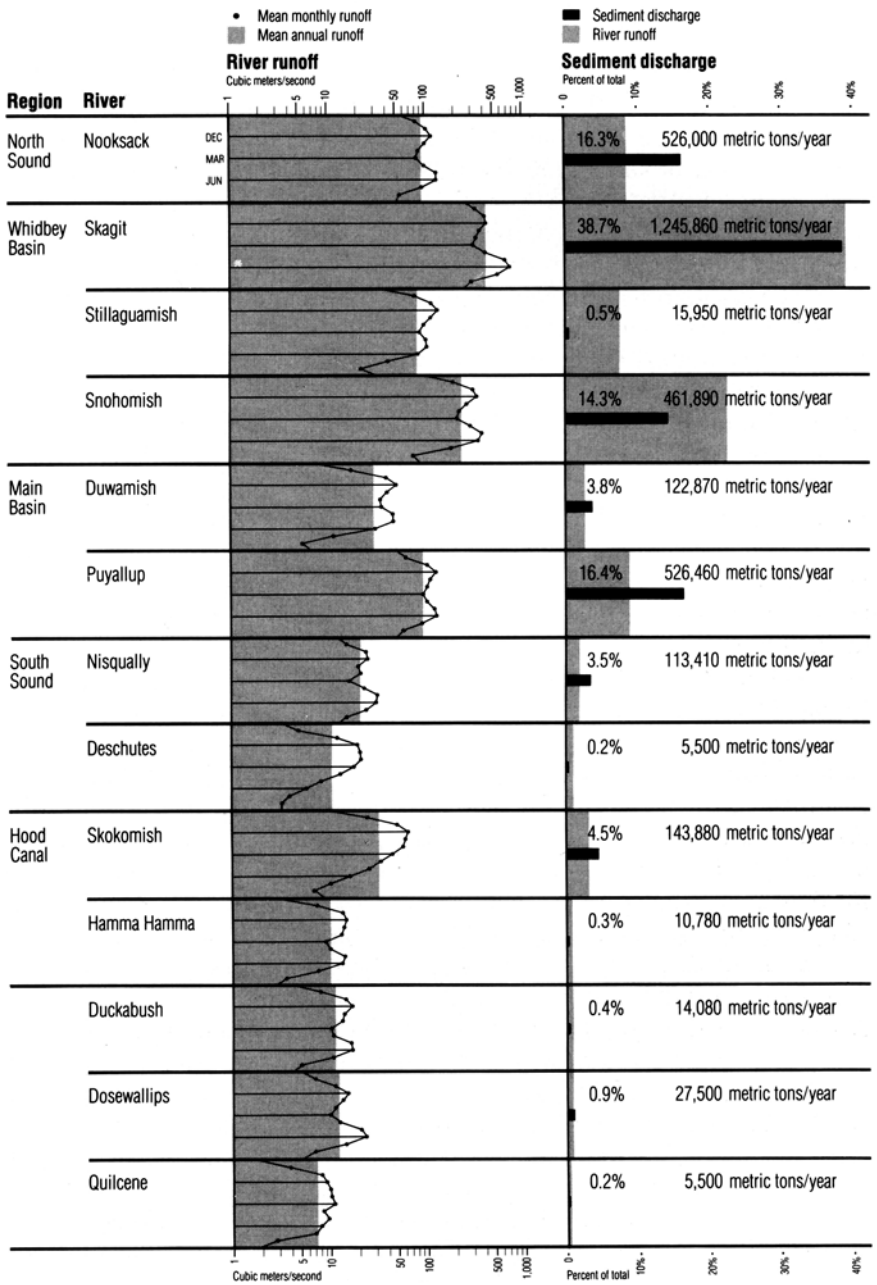
- river water has 0 ppt (parts per thousand)
- ocean water has ~35 ppt – differs around world
- brackish water at depth in PS – 20-30 ppt

Density (low salinity = low density)

- river plume flows over more dense brackish water

Input of river water - varies with space and time

- northern PS rivers supply the most water
- small input during late summer
- large input during late autumn and winter rains
- large input during spring snowmelt


Mean monthly runoff
Mean annual runoff
Sediment discharge
River runoff
River runoff
Cubic meters/second
Sediment discharge
Percent of total
Region
River
DEC
MAR
JUN
North Sound
Nooksack
16.3%
526,000 metric tons/year
Whidbey Basin
Skagit
38.7%
1,245,860 metric tons/year
Stillaguamish
0.5%
15,950 metric tons/year
Snohomish
14.3%
461,890 metric tons/year
Main Basin
Duwamish
3.8%
122,870 metric tons/year
Puyallup
16.4%
526,460 metric tons/year
South Sound
Nisqually
3.5%
113,410 metric tons/year
Deschutes
0.2%
5,500 metric tons/year
Hood Canal
Skokomish
4.5%
143,880 metric tons/year
Hamma Hamma
0.3%
10,780 metric tons/year
Duckabush
0.4%
14,080 metric tons/year
Dosewallips
0.9%
27,500 metric tons/year
Quilcene
0.2%
5,500 metric tons/year
1
5
10
50
100
500
1,000
0
10%
20%
30%
40%

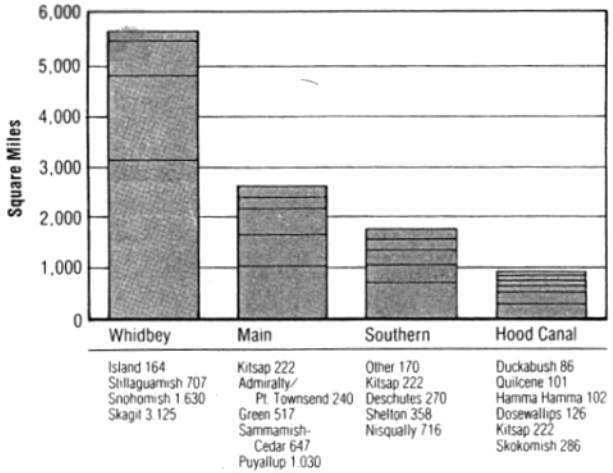


Figure 7.4 Drainage basin areas by river.

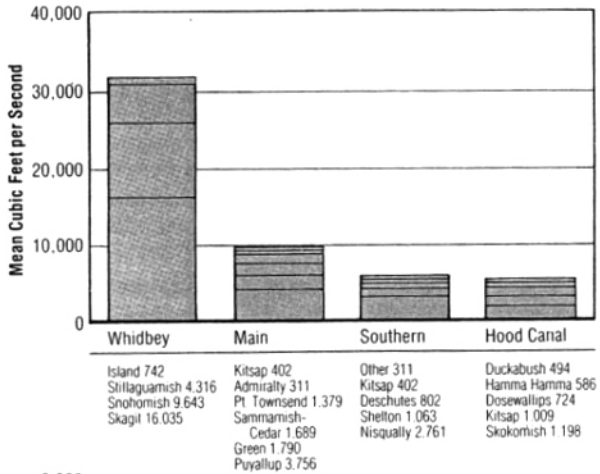


Figure 7.5 Annual average freshwater discharge of the major rivers draining into Puget Sound.

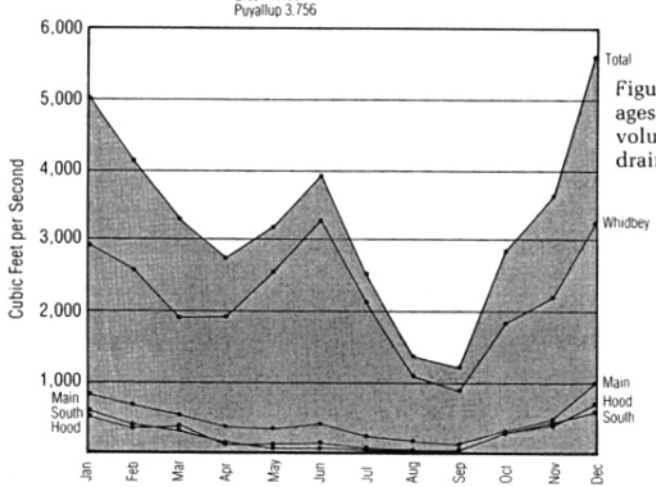


Figure 7.6 Monthly averages of freshwater discharge volume of the major rivers draining into Puget Sound.

Types of river-mouth environments

estuary – semi-enclosed setting
river and salt water meet and mix

fjord – estuary with glacial origin
deep, with shallow sill near mouth

delta – river mouth receiving much sediment
estuary filled with sediment
shoreline growing seaward

Puget Sound Sedimentation

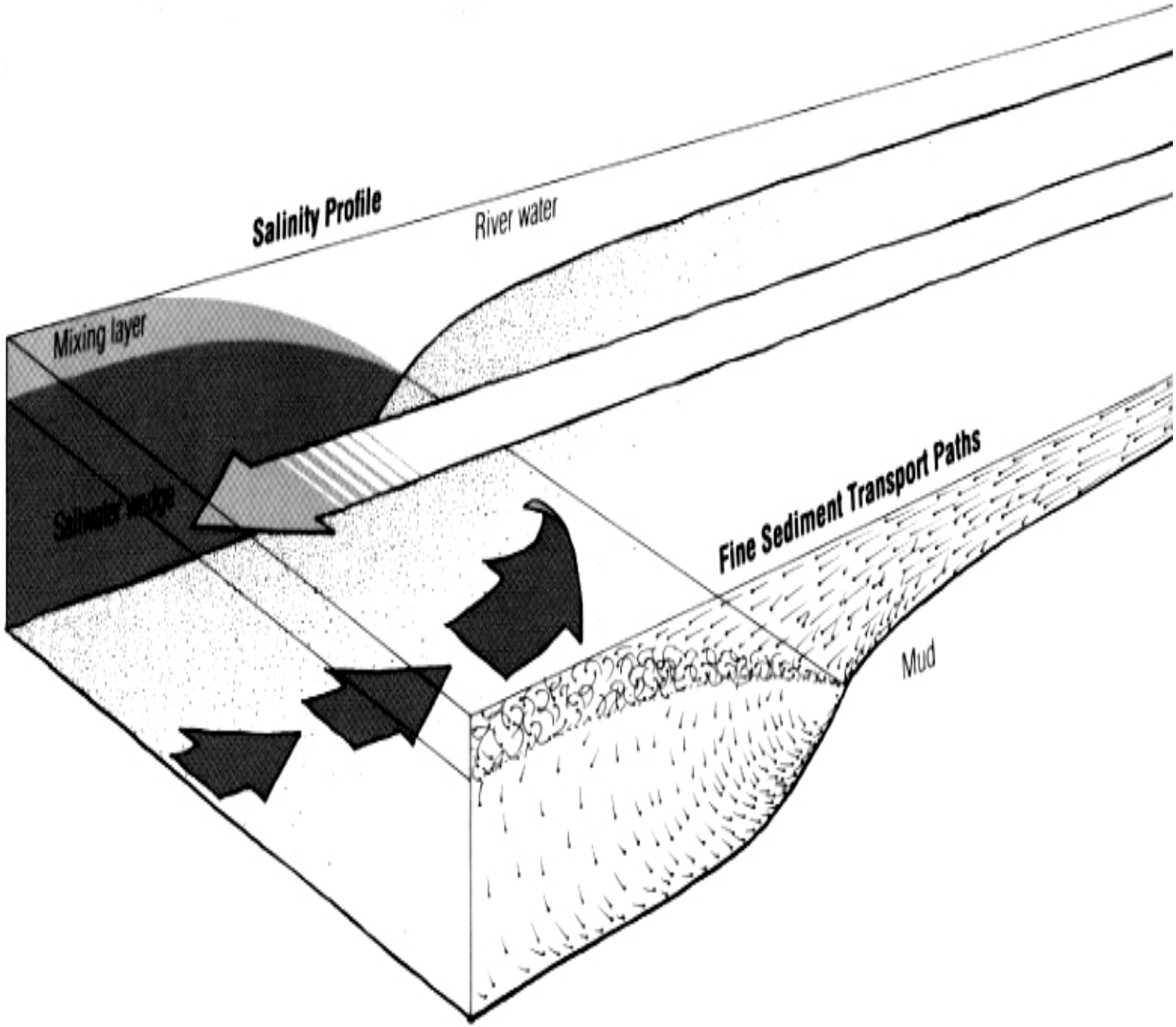
Sources of sediment

shallow – shoreline erosion, landslides

deep – biological productivity, algal debris
much carbon decomposes,
forming methane gas

all depths – river discharge
deltas form near river mouths
river plume carries sediment deeper

near sill – inflow with deep ocean water


Salinity Profile
River water
Mixing layer
Saltwater wedge
Fine Sediment Transport Paths
Mud

Mechanisms associated with Sedimentation

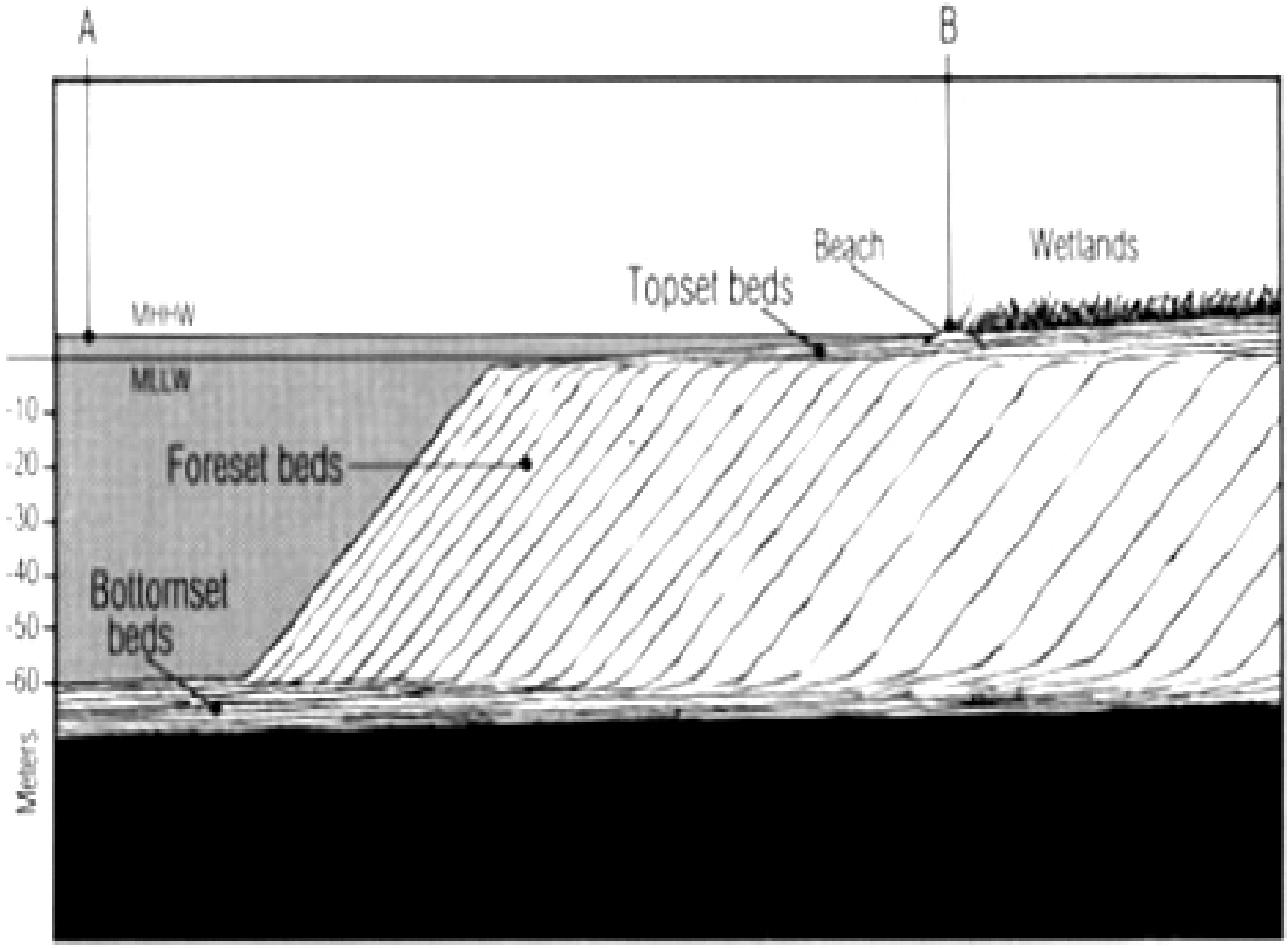
plume transport – turbid surface water
river momentum, tides, wind

flocculation – silt and clay particles form larger aggregates, which sink quickly

landward bottom flow – traps sediment near river

delta formation – thick deposits near river mouth

- topset = tidelands
- foreset = steep surface, rapid accumulation
- bottomset = deep deposits, escape seaward

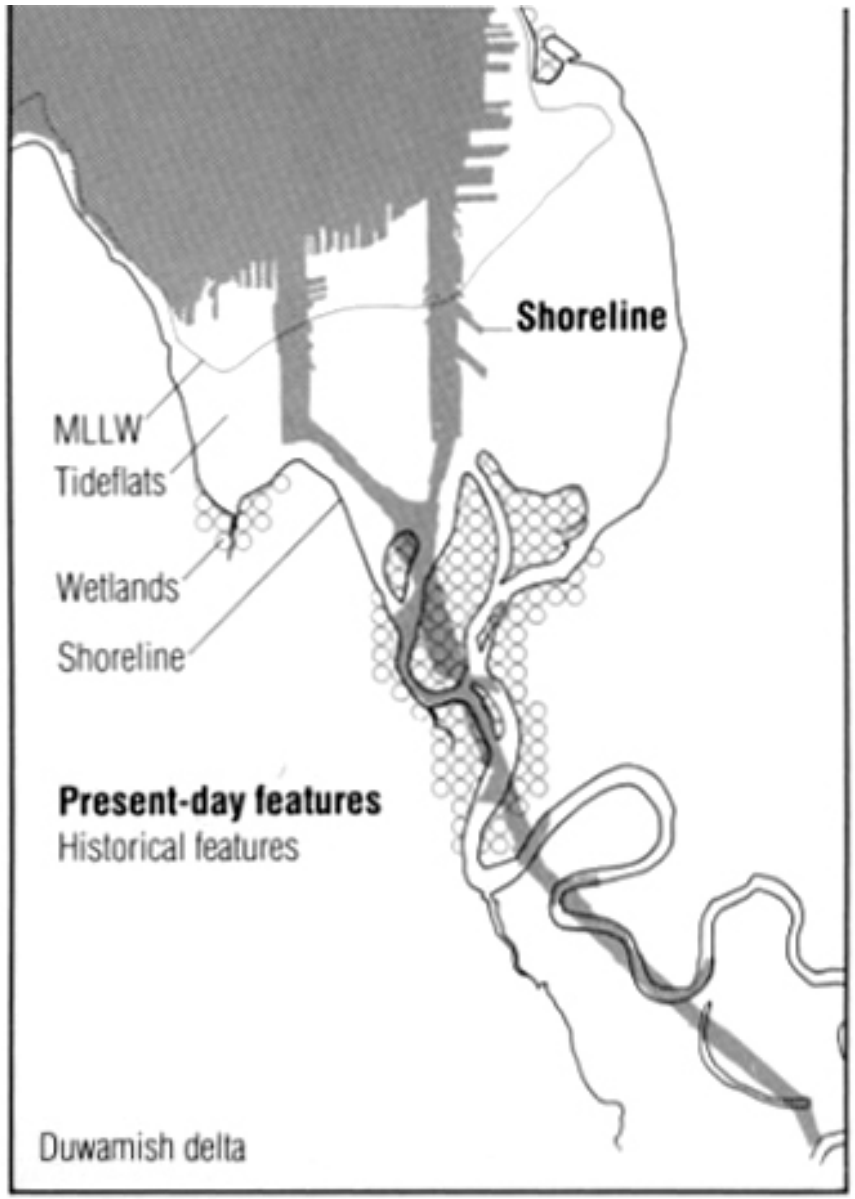

A
B
Beach
Wetlands
Topset beds
MHHW
MLLW
-10
-20
-30
-40
-50
-60
Meters
Foreset beds
Bottomset beds

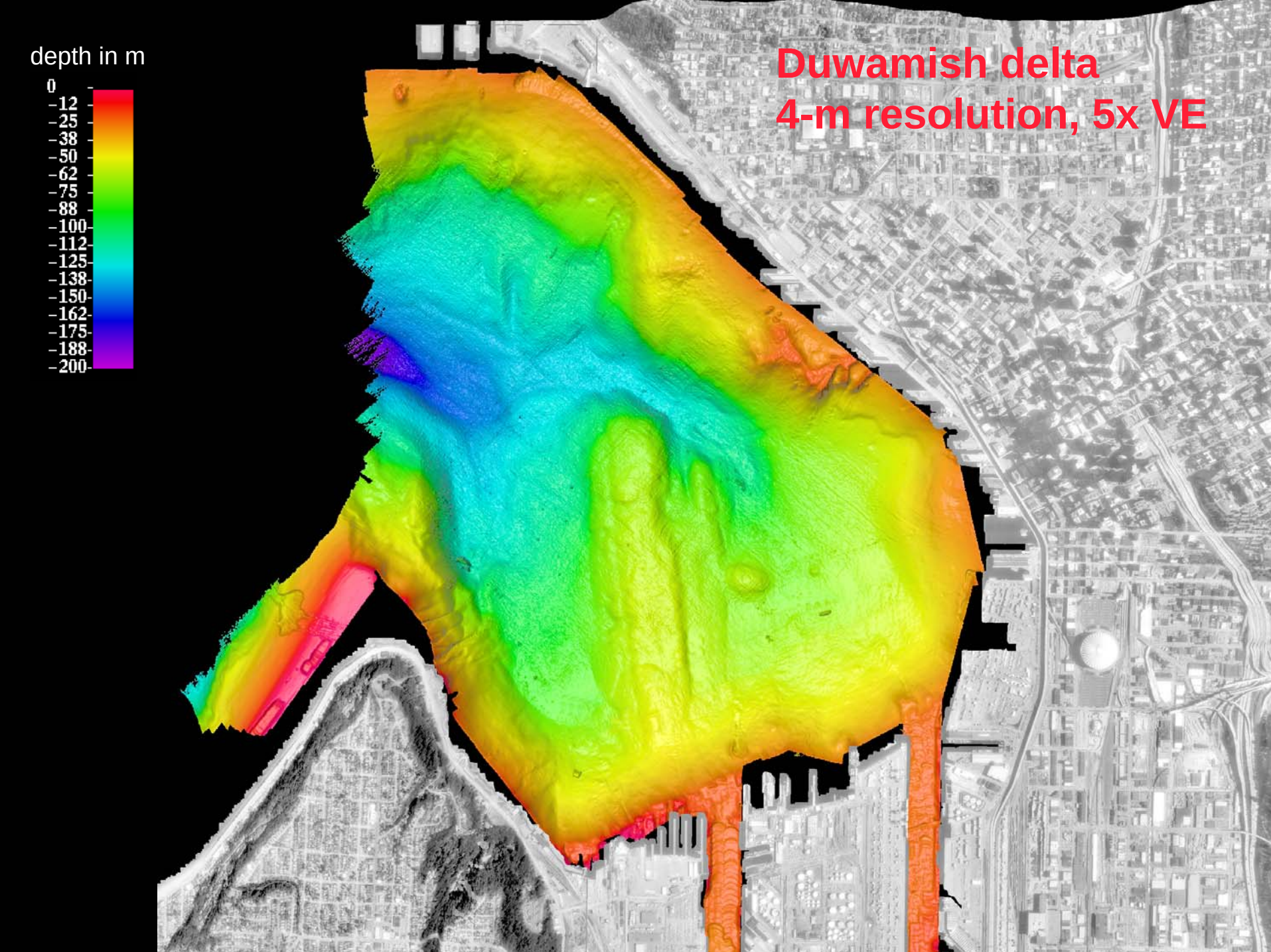
Duwamish delta

Intensely impacted by humans

Wetlands hardened (landfill, roads, parking lots, buildings)

Distributary channels altered and stabilized

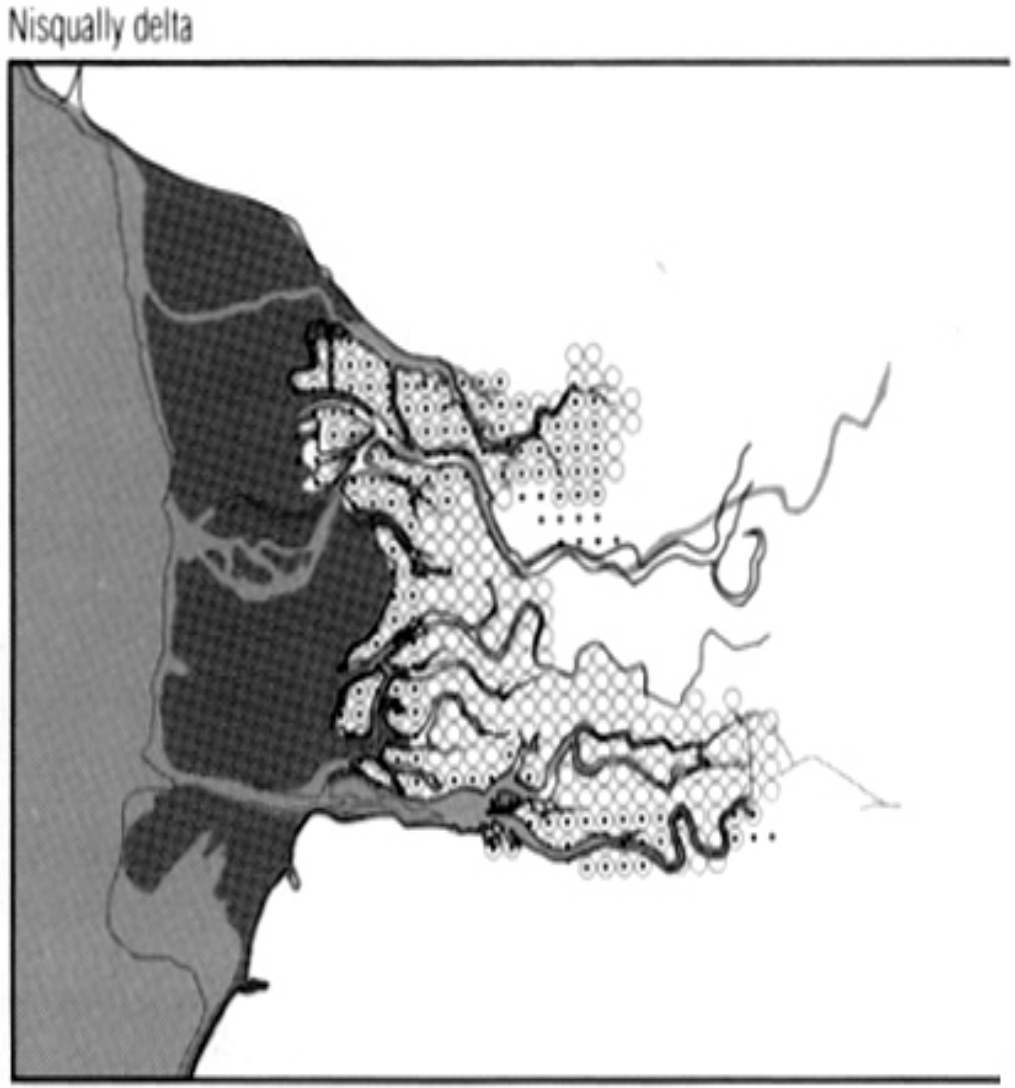


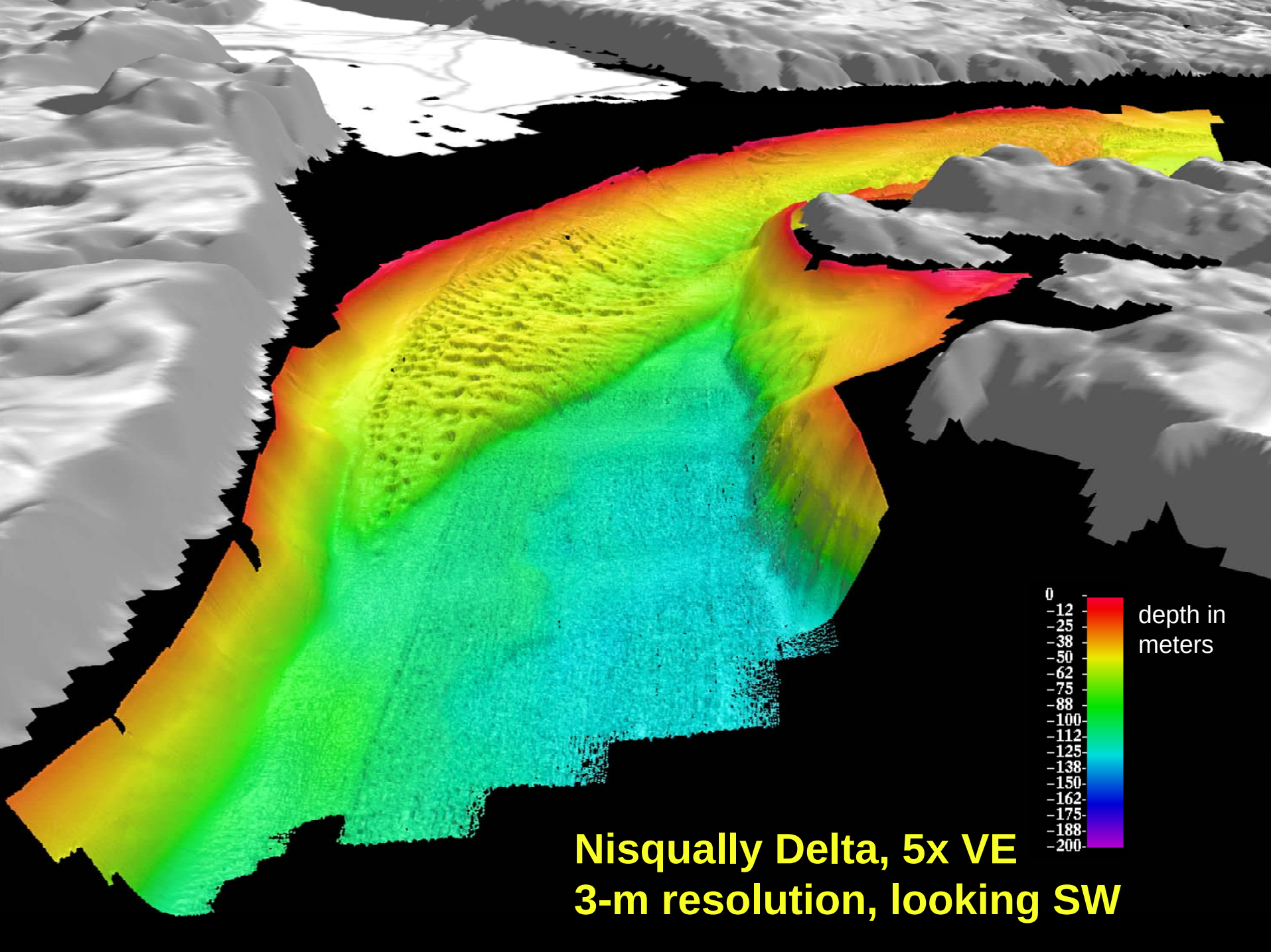

depth in m
0
-12
-25
-38
-50
-62
-75
-88
-100
-112
-125
-138
-150
-162
-175
-188
-200
Duwamish delta
4-m resolution, 5x VE

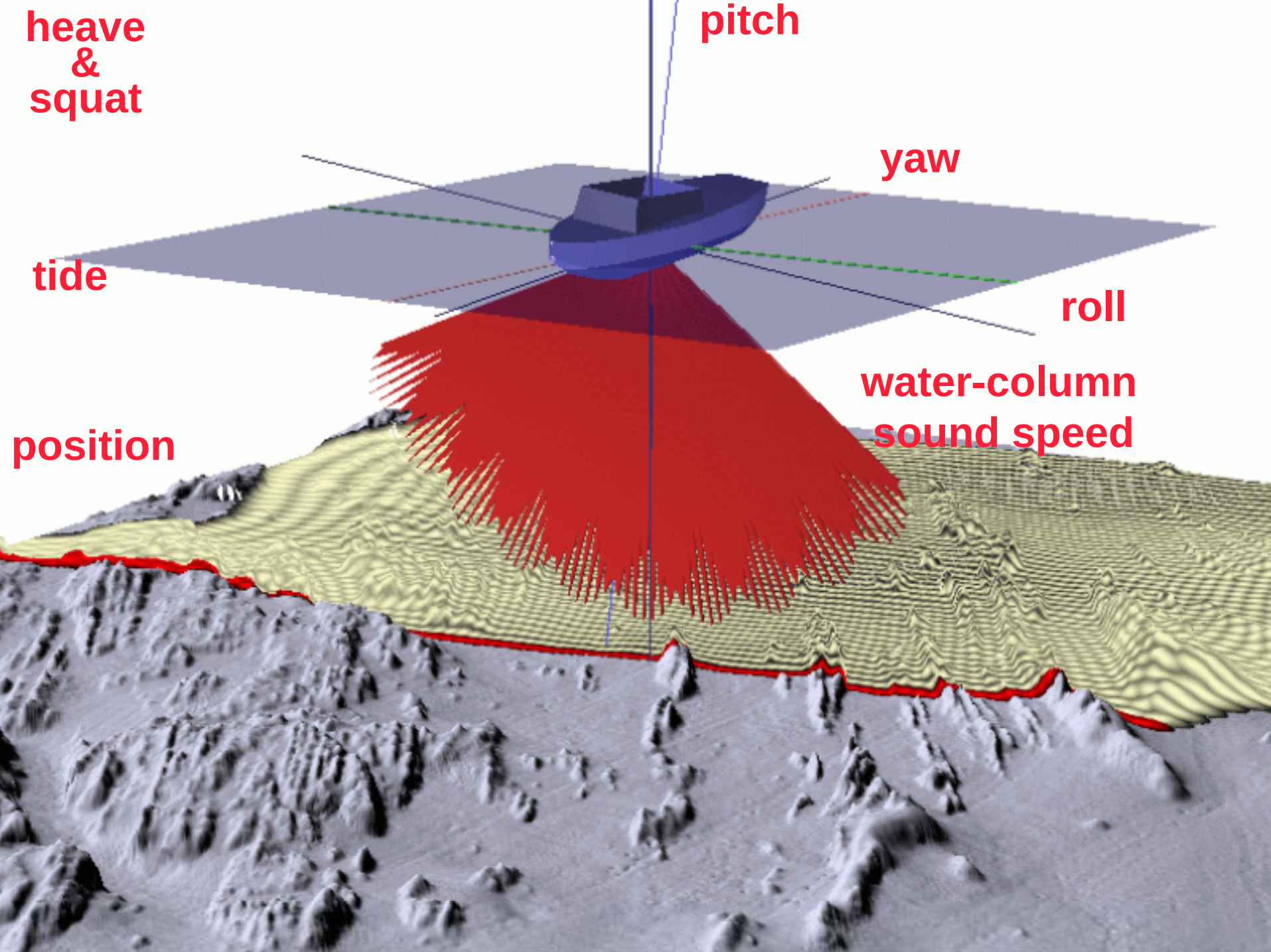
Nisqually delta

nearly natural condition

Several distributary channels bring water and sediment across delta to Puget Sound




0
-12
-25
-38
-50
-62
-75
-88
-100
-112
-125
-138
-150
-162
-175
-188
-200
depth in meters
Nisqually Delta, 5x VE
3-m resolution, looking SW


heave
&
squat
pitch
yaw
tide
roll
water-column
sound speed
position