Columbia River Sediment Supply and Dredging Volumes

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Critical Points --

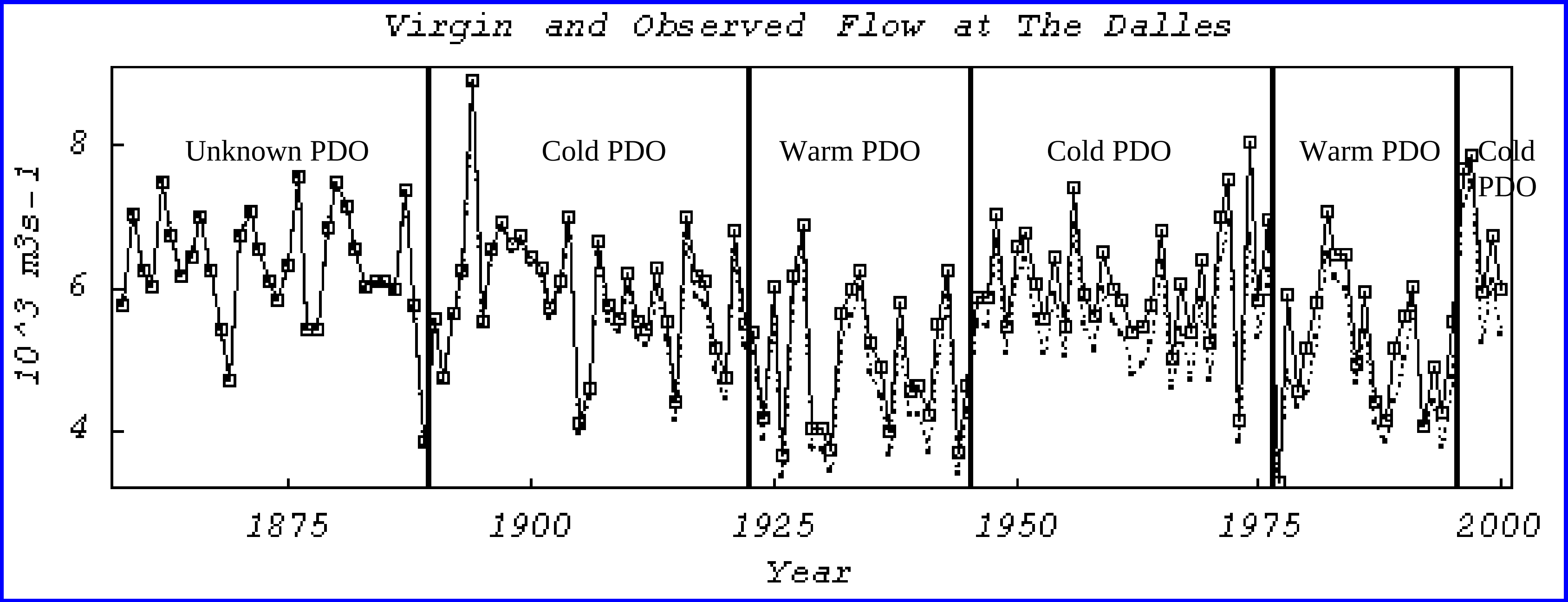
- Columbia River flow varies with the Pacific Decadal Oscillation (PDO) cycle
- Climate-related fluctuations in sand input are larger than those in flow
- Most sand transport occurs as suspended load during freshets
- Dredging volumes are correlated with flow and sand supply
- We are trying to understand a data-poor system

Important Time Scales --

- In inferring changes, it is important to average over an appropriate period:
  - for climate, at least one full PDO cycle
  - for human processes, over the “present” management regime
- One+ full PDO cycles has occurred since ~1946. In climate terms, the “present” in ~1946-date.
- Period since 1970 is the hydrologic “present”, in terms of CR flow regulation. WR is less regulated
- 40-ft channel was finished in the mid-1970s
- 25-30 years is a short time for estimating effects of climate cycles, or determining effects on estuarine habitats

PDO and Columbia R. Flow, 1858-2000 --

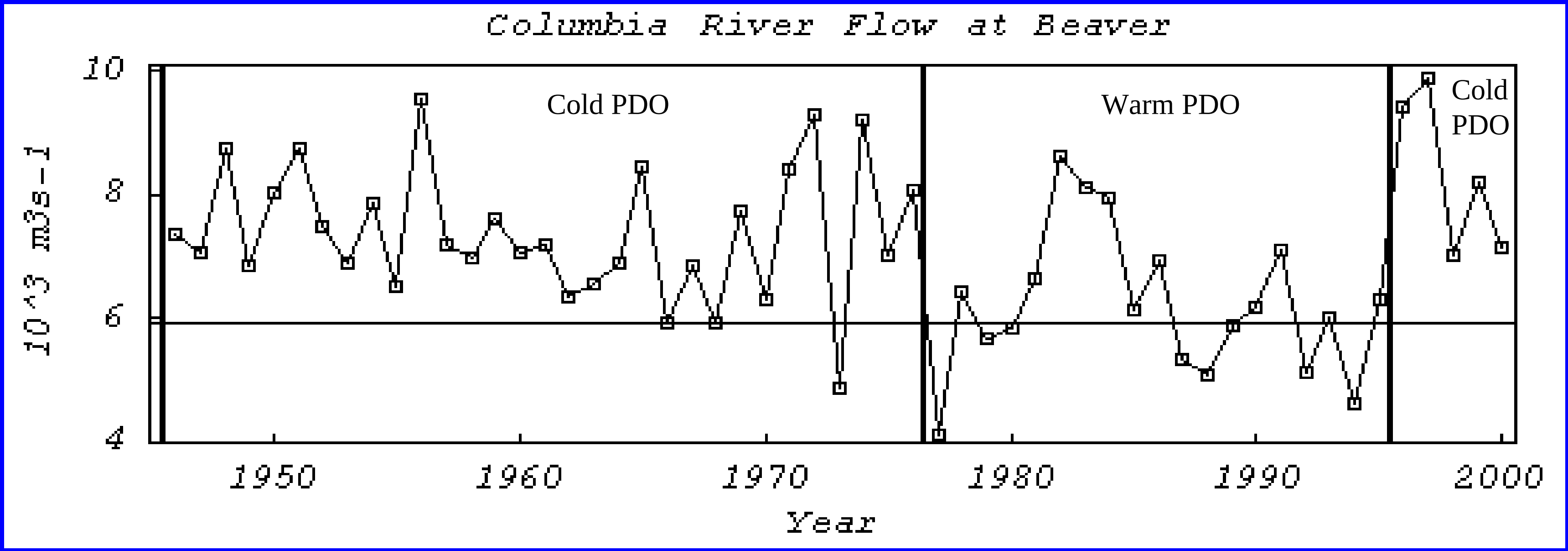
- CR flow exhibits large variability over 20-50 years
- Cold-PDO years since 1946 include very high flows
- Low-flow, warm PDO periods like 1977-95 have occurred for only ~40-45 years since 1890
- The 1980-95 period is not typical of the last 140 years



Dotted = observed annual average flow, solid = virgin annual average flow

PDO and Columbia R. Flow, 1946-2000:

- Cold PDO: 1946-76, mean Beaver flow 7,325 m^3s^{-1}
  1996-00, mean Beaver flow 8,090 m^3s^{-1}
- Warm PDO: 1977-95: mean Beaver flow 6,210 m^3s^{-1}
- Cold/Warm PDO differ by a 20+%
- Ten years during 1980-95 are in the lowest third of all flow years since 1878



Sediment Transport Hindcasts --

- Sediment transport has been hindcast to 1858 using flow records and USGS data --
  - sand transport is usually transport-capacity limited
  - fine sediment transport is supply limited
  - Excludes Mt. St Helens effects, 1980-81
- Our approach is generally conservative --
  - supply from winter freshets is underestimated
  - USGS probably underestimated sand transport
  - Haven’t included tributaries below the Willamette River
- But --
  - overbank flows may transport less sediment (affects pre-1956)
  - cannot account for changes in land use
  - only annual average transport before 1878

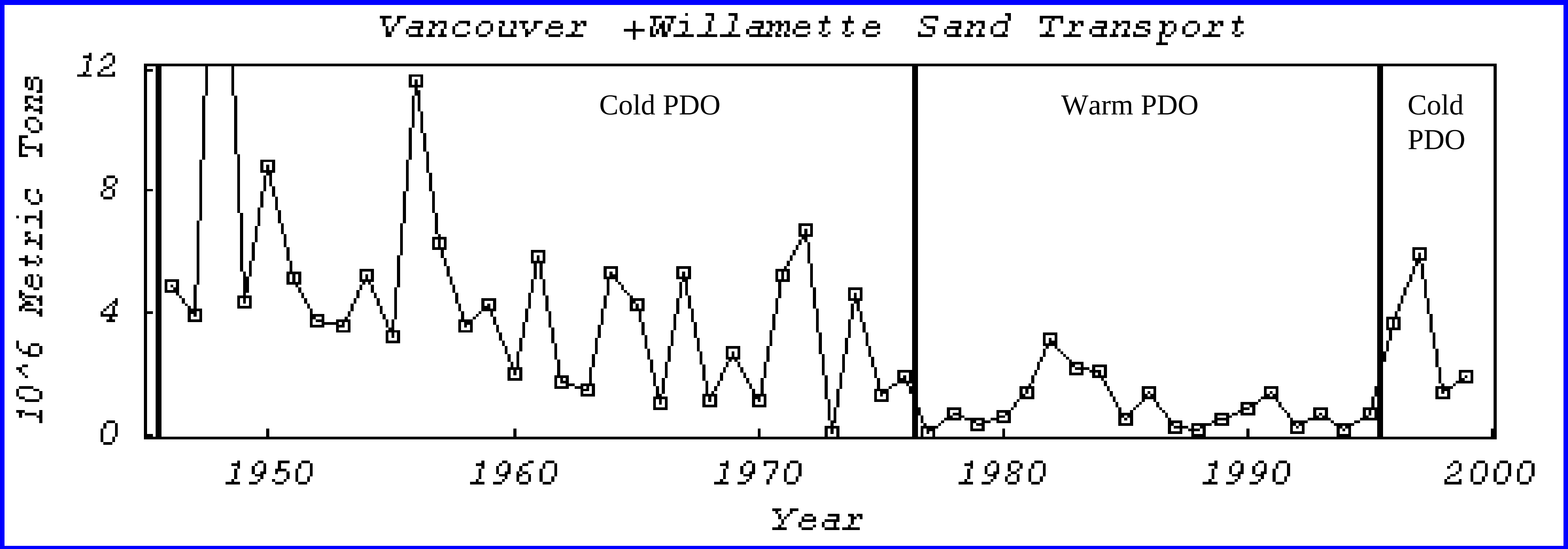
Sediment Transport Amplifies Climate Effects:

- Sediment transport varies with flow Q_R as Q_R^{n}, $n>1$
- For total load, n ~ 2.5; for sand, n ~ 3.5
- There are seasonal changes in SPM quality (e.g., size and organic content that are poorly understood)
- This amplification is an important aspect of how modest climate changes have large ecosystem effects, e.g., on salmonids

Sand Transport, 1946-99

- Cold PDO: 1946-76, CR+WR 4.5 x10^6 mt tons yr^{-1}
  1970-76, 1996-99, CR+WR 3.3 x10^6 mt tons yr^{-1}
- Warm PDO: 1977-95: CR+WR ~1 x10^6 mt tons yr^{-1}*
- Warm/cold PDO sand transports differ by factor of 3-4

*1980 and 1981 exclude Mt. St. Helens sand input

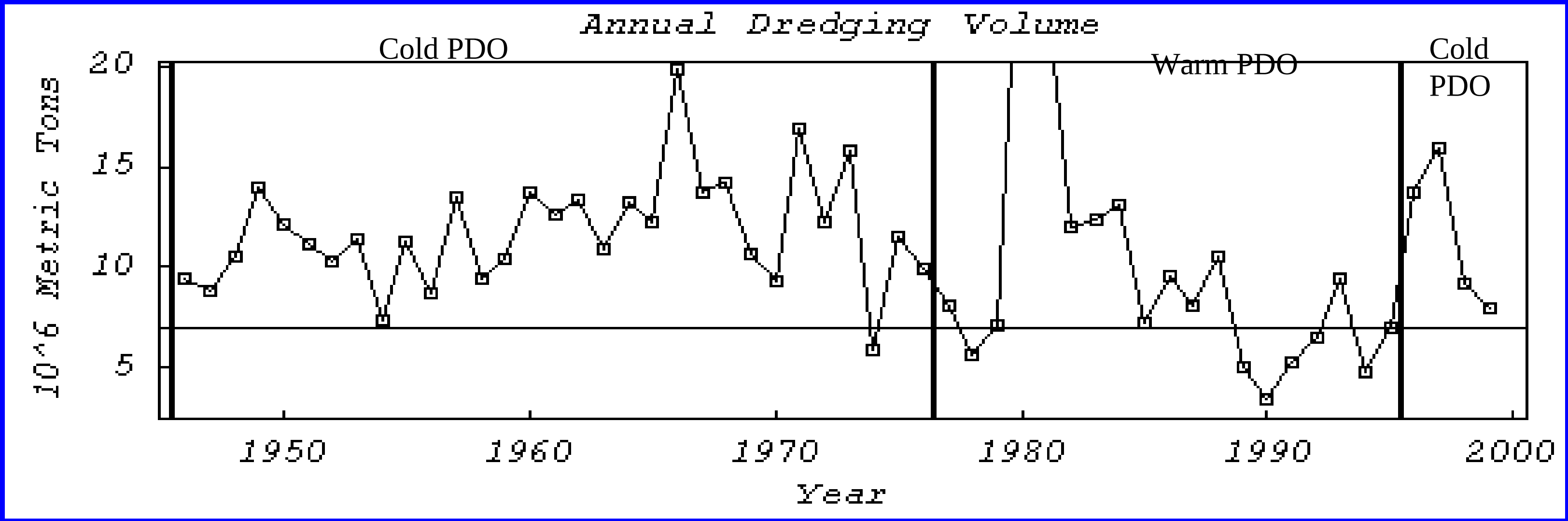


Sand Transport Mechanisms--

- Most bed-material (sand) transport occurs in suspension, during high-flow events
- For flows greater than 15,000 m^3s^{-1}, 50-70% of the total load is sand, mostly in suspension
- Bedload transport is dominant in low-flow years, needs to be considered in all years
- 30-yr study in Fraser River suggest that ~7.5% of sand transport is bedload. 13% of total bed material transport is as bedload (including gravel)

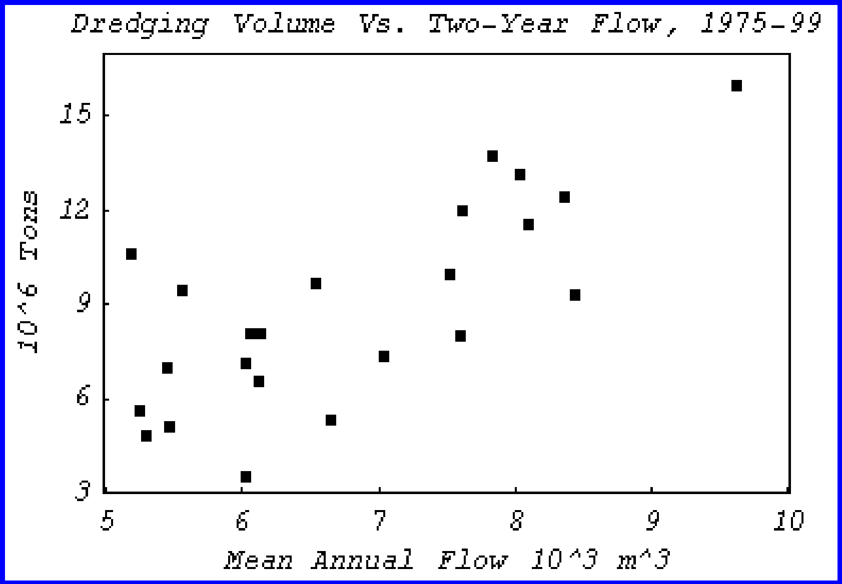
Dredging Volumes --

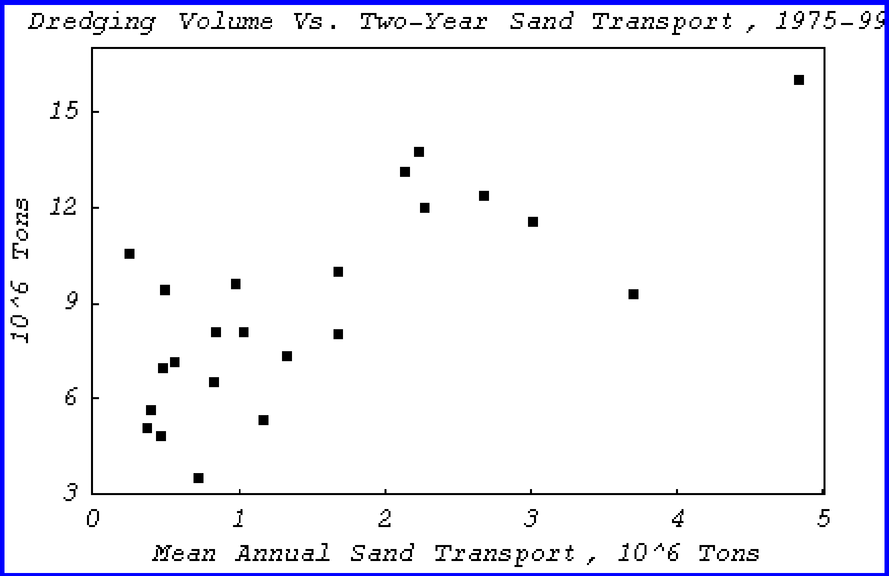
- Seven high-flow years since 1976:
  $12.2 \pm 2.3 \times 10^6$ mt tons yr^{-1} ($\pm$95% conf limits)
- Sixteen low-flow years since 1976:
  $7.4 \pm 1.2 \times 10^6$ mt tons yr^{-1} ($\pm$95% conf limits)
- Ratio for highflow years to lowflow years is 1.65
- EIS Projected dredging is 6.3×10^6 mt tons yr^{-1}



Dredging and Hydrology:

- Dredging is correlated with flow, R^2 ~0.3- 0.5 (depending on the model used) and with sand transport, R^2 ~0.3- 0.6
- Best results obtained when current year of dredging is compared to the past two years of flow or sand transport
- There appears to be a base dredging level of ~2-3 x 10^6 yd^3





Dredging Impacts on Habitat --

- Average dredging: 1975-99 ~8.9 $x10^6$ mt tons yr^{-1}
  1946-99 ~10.4 $x10^6$ mt tons yr^{-1}
  (Not all of this is removed from system)
- Sand supply: 1975-99 ~2.5 $x10^6$ mt tons yr^{-1}
  1946-99 ~4.6 $x10^6$ mt tons yr^{-1}
  There was long-term accumulation of sand, 1868-1958
- Above imbalance raises a question regarding effect of sand removal on habitat since 1958
- Has the long-term trend toward accumulation reversed? (The data are not available to answer this question)

Conclusions --

- Dredging estimates based on 1982-95 understate likely volumes --
  - disposal impacts will likely also exceed projections.
- Even if dredging volumes are correct --
  - long-term mining of sand from the channel through land disposal could be a major impact on fluvial and estuarine habitats

Recommendations --

- A range of dredging volume estimates need to be based on multiple climate scenarios
- Project impacts on salmonids need to be determined in relation to other impacts -- e.g., diking, loss of peripheral wetlands and flow regulation
- Systematic monitoring and research regarding sediment processes are needed
- Historic changes in in-water, wetland and flood-plain habitat need to be determined

Necessary monitoring and research:

- Map habitat changes and analyze w.r.t. to changes in sediment supply
- Long-term monitoring of suspended and bed load, quantity and quality
- Understand effects of land-use on supply/export and accumulation of coarse and fine sediment
- Understand quality and quantity of POC input in relation to freshet styles
- Manage and model sediment as a system-critical resource