Columbia River Sediment Loads:
Evaluating Historical Changes and Observing the Response of Lower Columbia Wetlands

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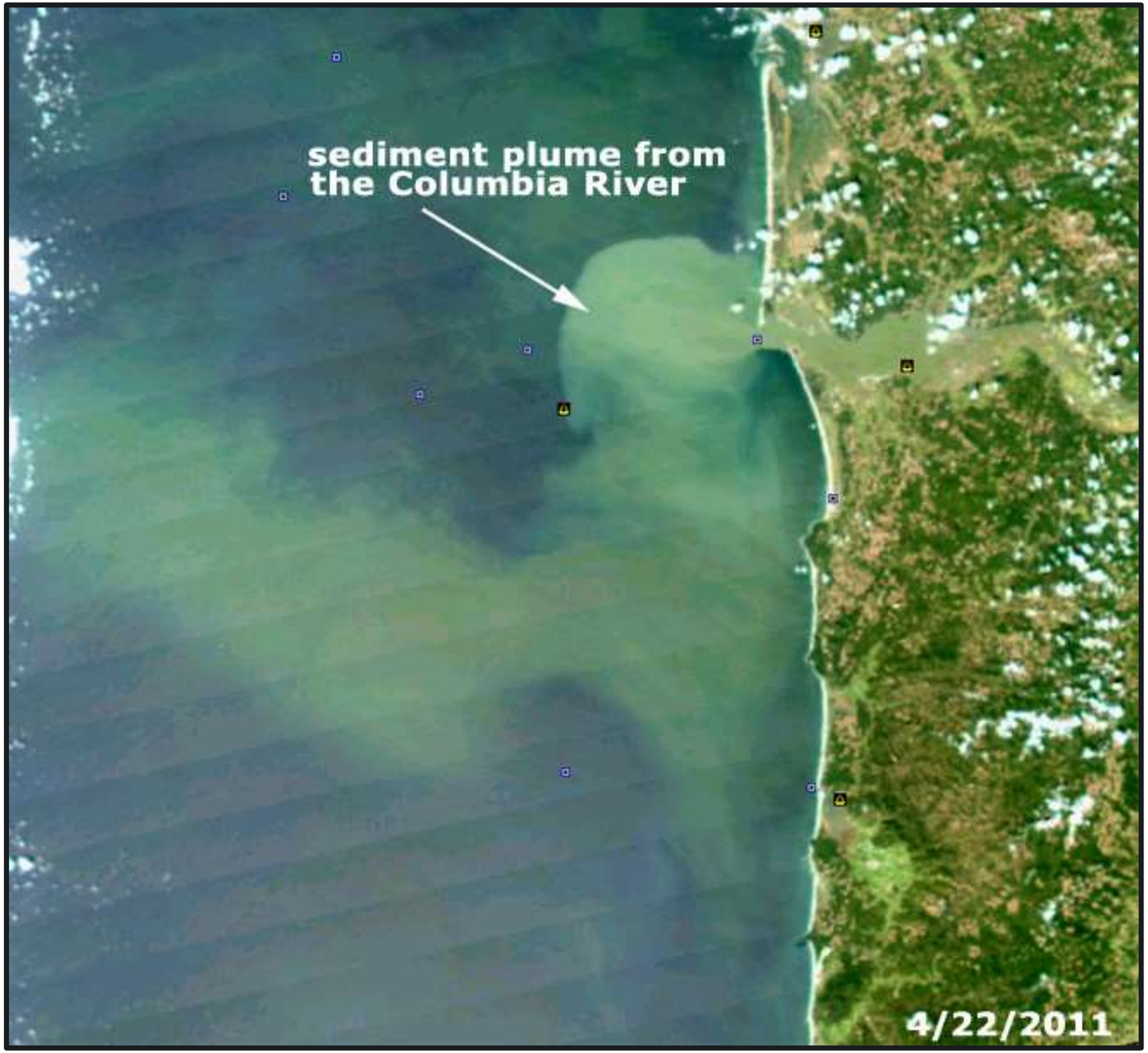
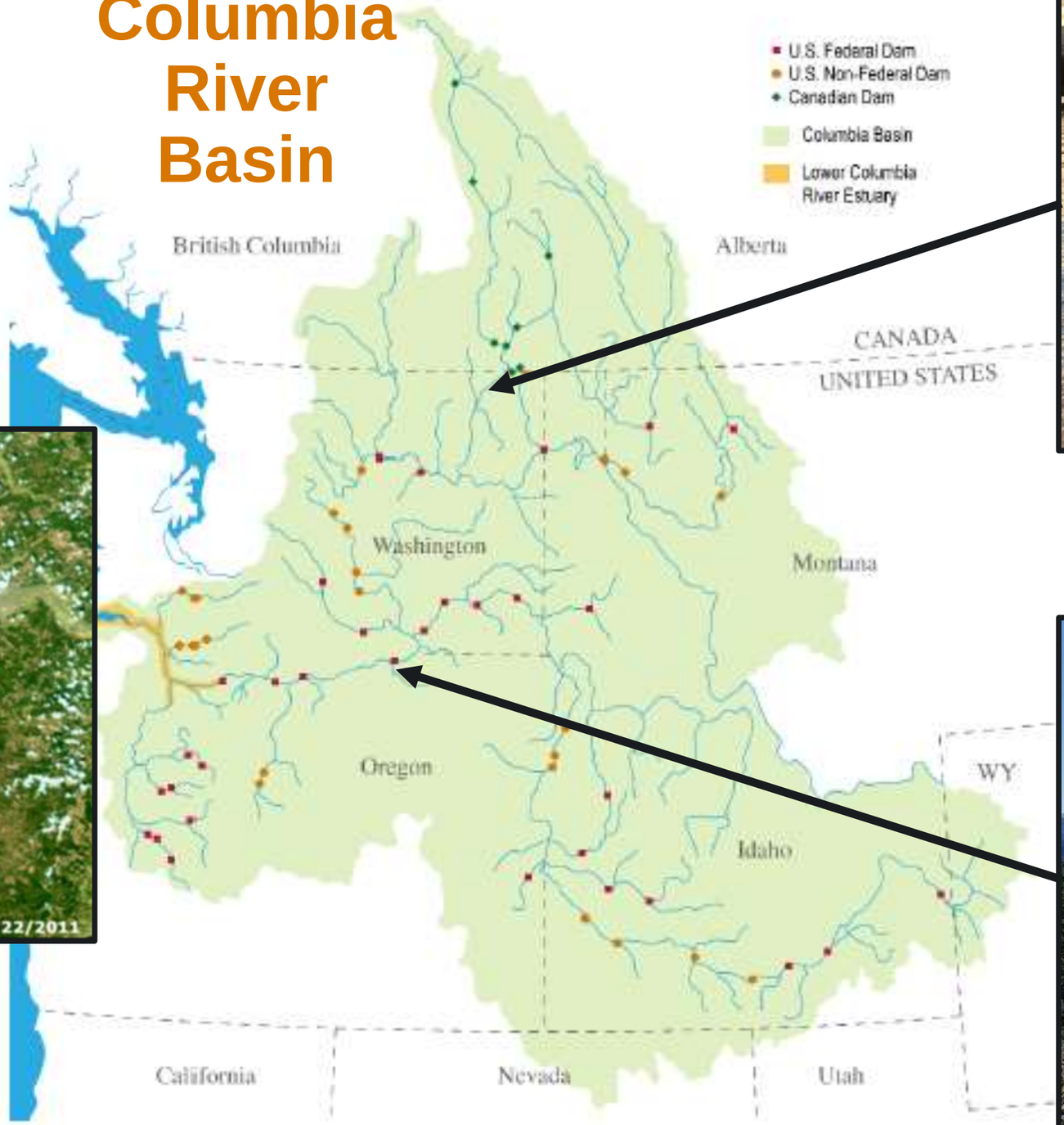
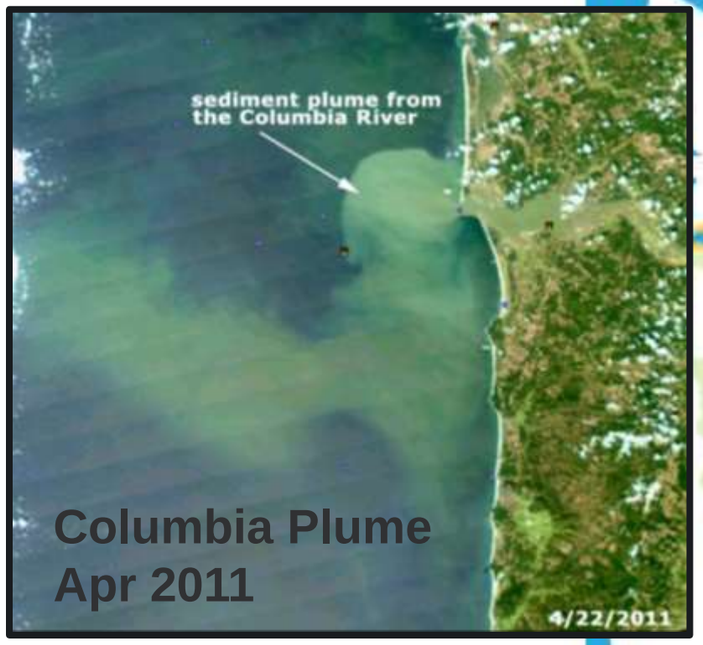


Sediment exiting to coast = **Supply from basin** − **Lateral flux** − **Dredging** + **Erosion** − **Deposition**

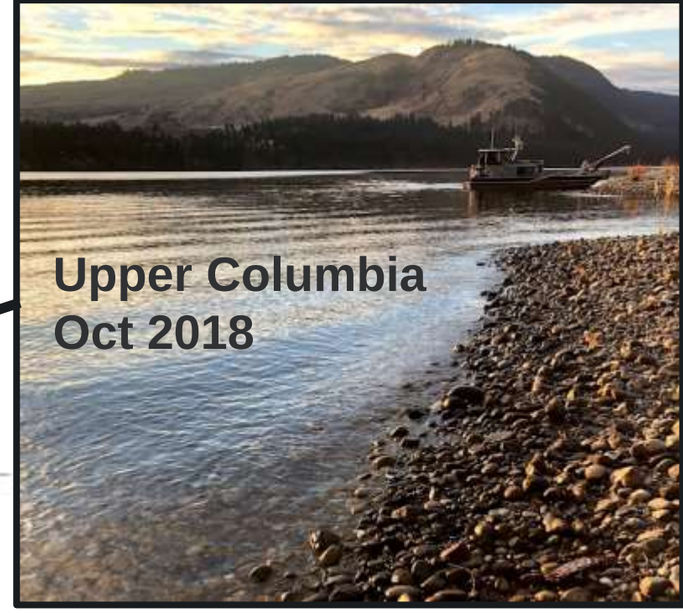
Lateral transport supplies the material to build/maintain/protect existing and future restoration projects

Columbia River Basin





Columbia Plume
Apr 2011



Upper Columbia
Oct 2018

Mid-Columbia
Feb 2020

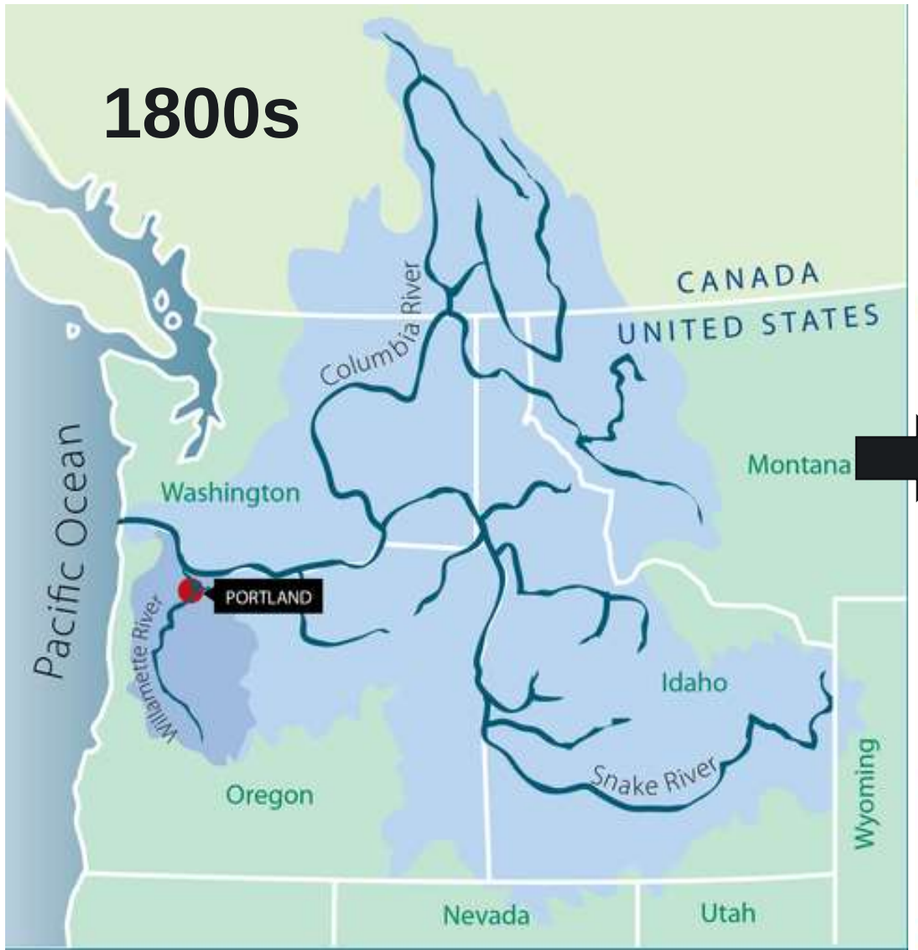
Has sediment supply changed? Probably!

Changes to sediment sources:

- **Land use (logging, farming)**
- **Dams (impound sediment)**
- **Dredging**

Changes to river flows:

- **Dams (flow regulation)**
- **Irrigation withdrawal**
- **Levees, jetties, pile dikes**
- **Channel deepening**
- **Climate change (precipitation patterns)**



Future??

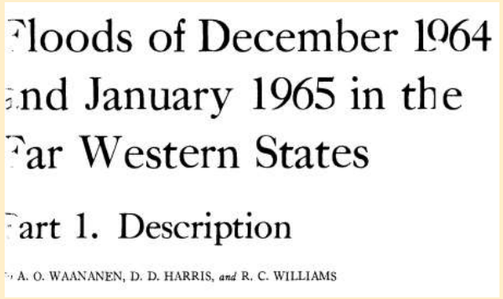
In order to understand how sediment loads in the Columbia will change, let's look at how it has changed.

Modern sources of sediment and flow data

- USGS
- Water Survey of Canada
- B.C. Water Quality Monitoring

- **Waananen et al., 1971**

Floods of December 1964 and January 1965 in the Far Western States. Part I. Description


Floods of December 1964
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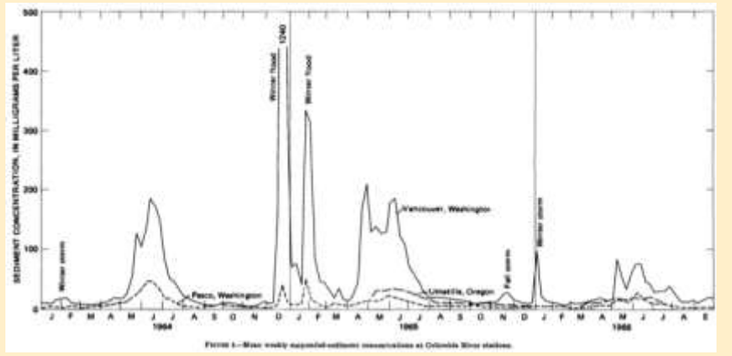
art 1. Description
A. O. WAANANEN, D. D. HARRIS, *and* R. C. WILLIAMS



Historical sources of sediment and flow data

- **Haushild et al., 1966**

Radionuclide transport in the Pasco to Vancouver, Washington Reach of the Columbia River July 1962 to September 1963

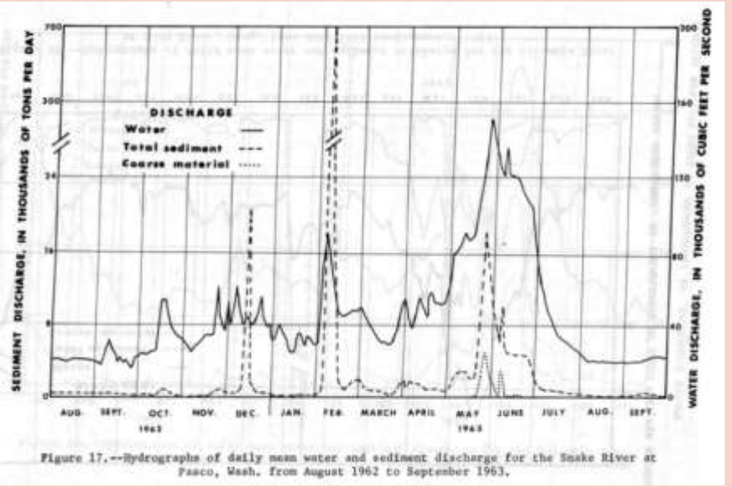
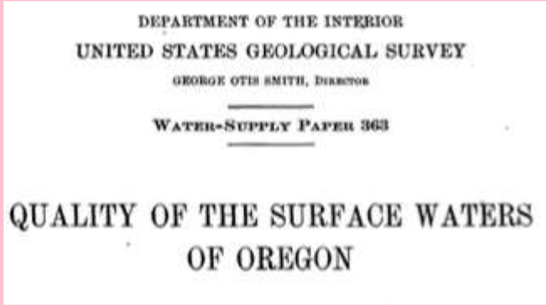


Figure 17.--Hydrographs of daily mean water and sediment discharge for the Snake River at Pasco, Wash. from August 1962 to September 1963.

- **Van Winkle 1914[a,b]**

[a]Quality of the surface waters of Washington
[b]Quality of the surface waters of Oregon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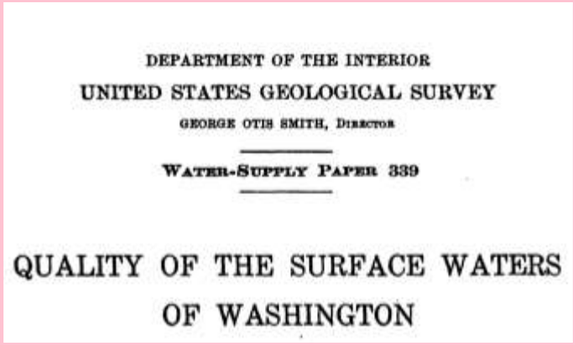
GEORGE OTIS SMITH, DIRECTOR
WATER-SUPPLY PAPER 363
QUALITY OF THE SURFACE WATERS OF OREGON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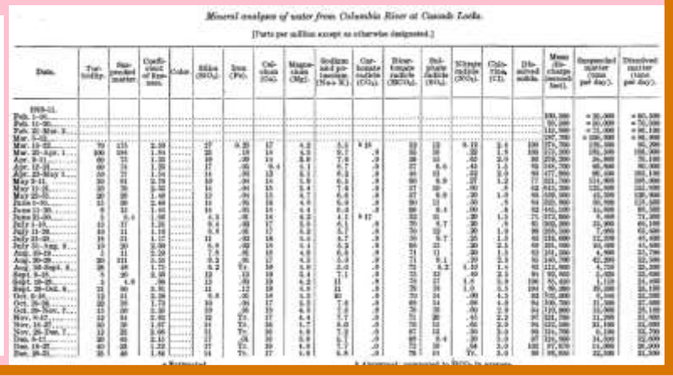
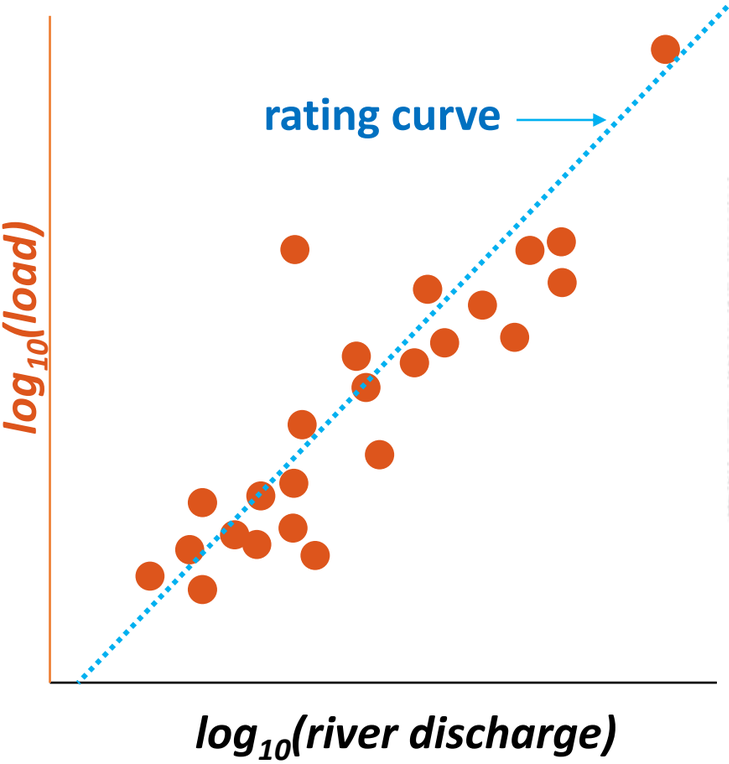
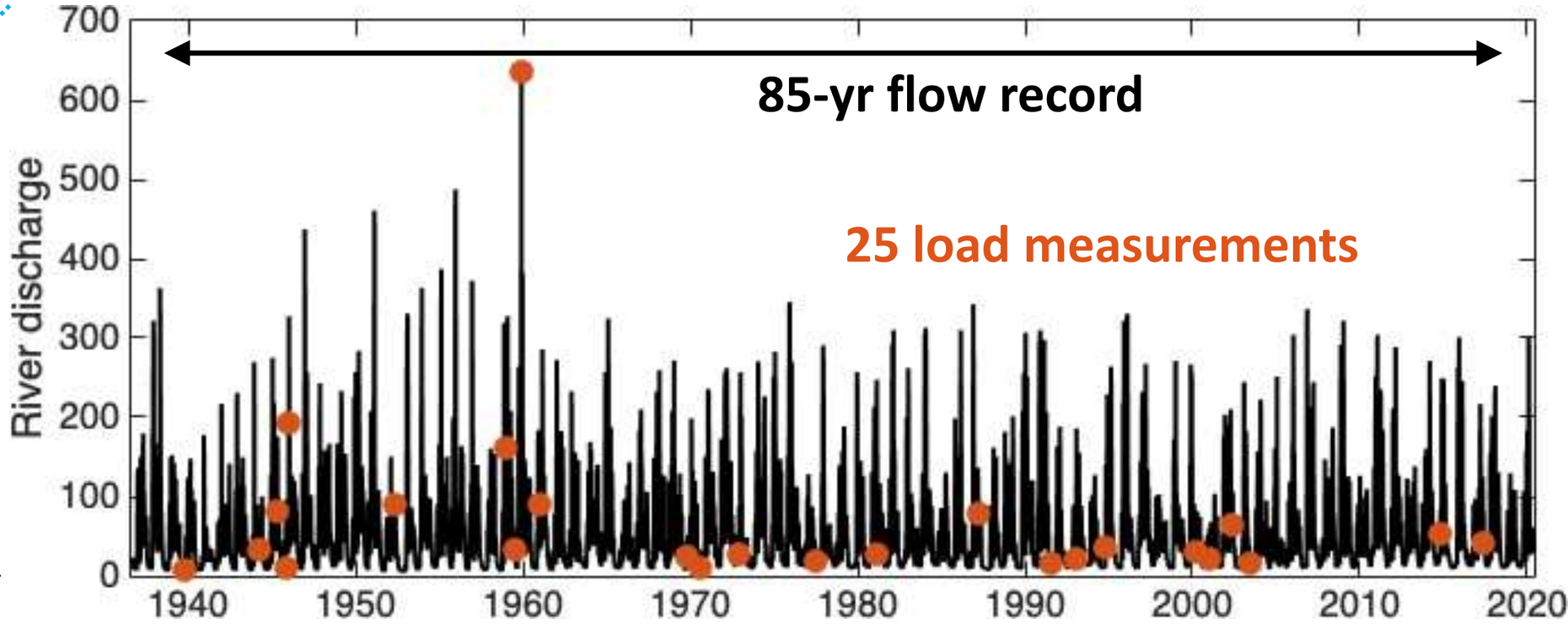
WATER-SUPPLY PAPER 339
QUALITY OF THE SURFACE WATERS OF WASHINGTON


Mineral analyses of water from Columbia River at Cascade Locks.
[Parts per million except as otherwise designated.]

Estimating sediment loads

- Measurements of suspended sediment loads tend to be difficult and **sparse**





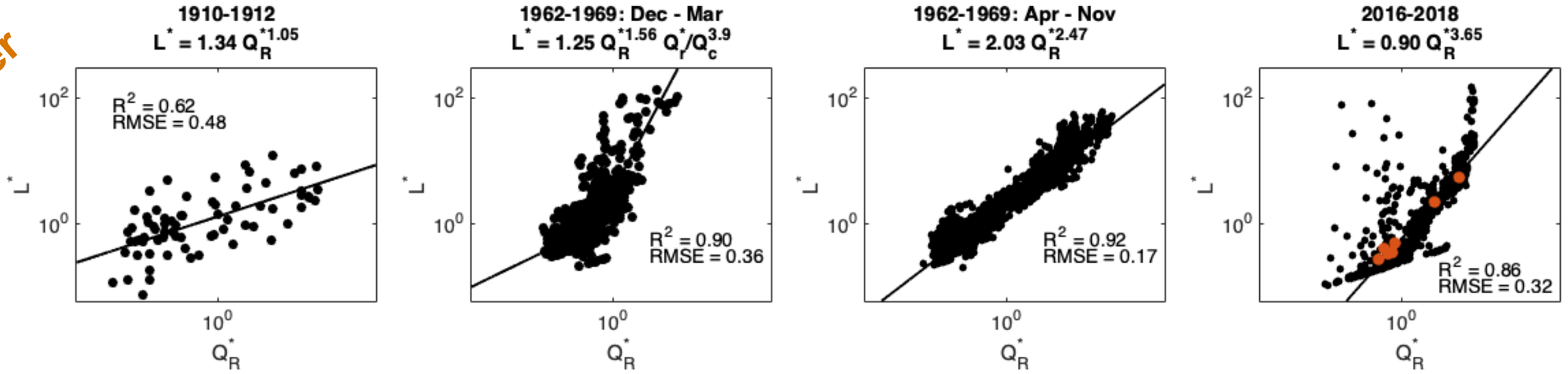
RATING CURVE

a statistical relationship between

flow (Q) *and* ***suspended sediment load (L)***

$L = a\,Q^b$

Example: Vancouver



4 Rating curves

HISTORICAL PRE-1940

- Based on digitized data from Van Winkle (1914)
- Best suited for estimating fines load due to methodology
- Lot of scatter

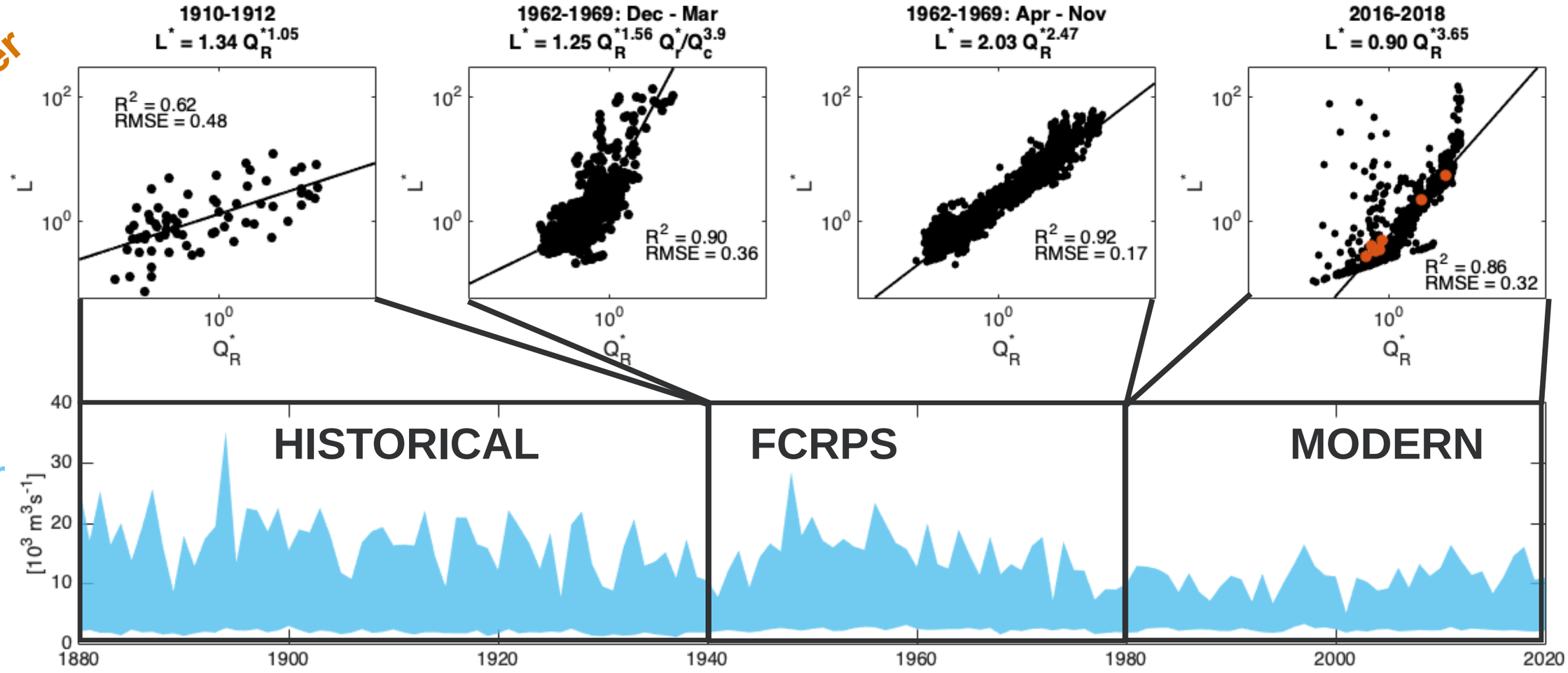
Federal Columbia River Power System (FCRPS) 1940-1980

- Based on digitized data from Haushild (1966) and Waananen (1971).
- Data from Dec-Mar shows much more sensitive response to changes in river discharge, therefore
- Two rating curves for Dec-Mar and Apr-Nov

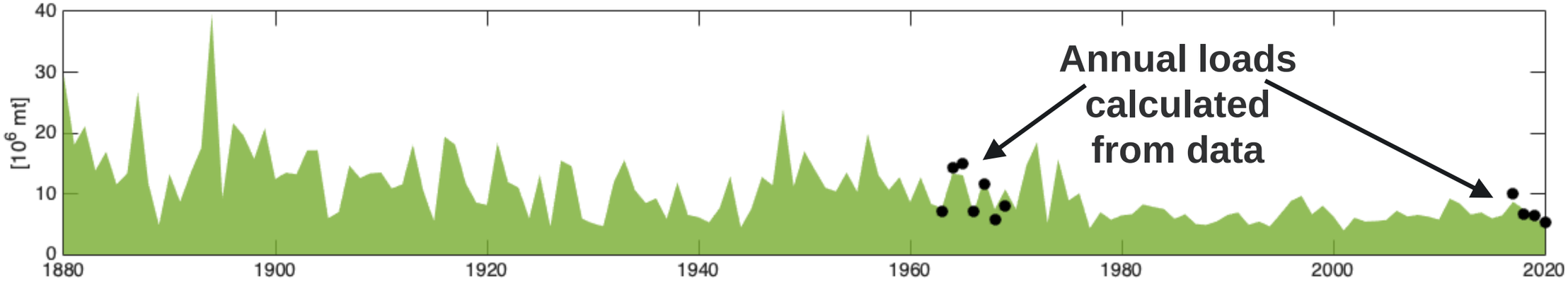
MODERN 1980-NOW

Based on calibrated USGS turbidity data, **heavily weighted** by **sediment load data**

Example: Vancouver



Vancouver river discharge



Annual suspended sediment load estimates

- **7 Mainstem**

Steamboat Rapids, Birchbank, Northport, Pasco, Warrendale, Vancouver, Quincy,

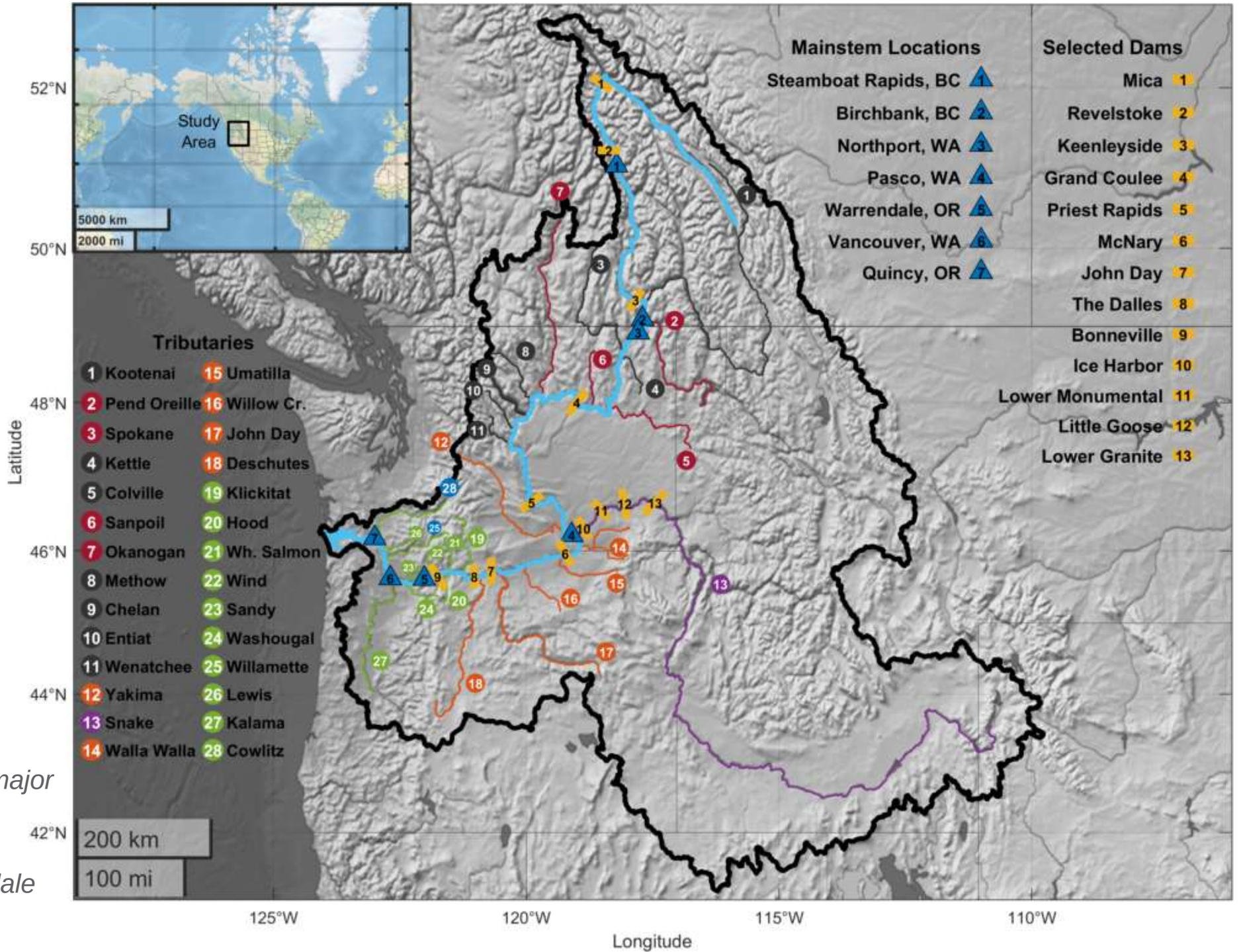
- **21 Tributaries**

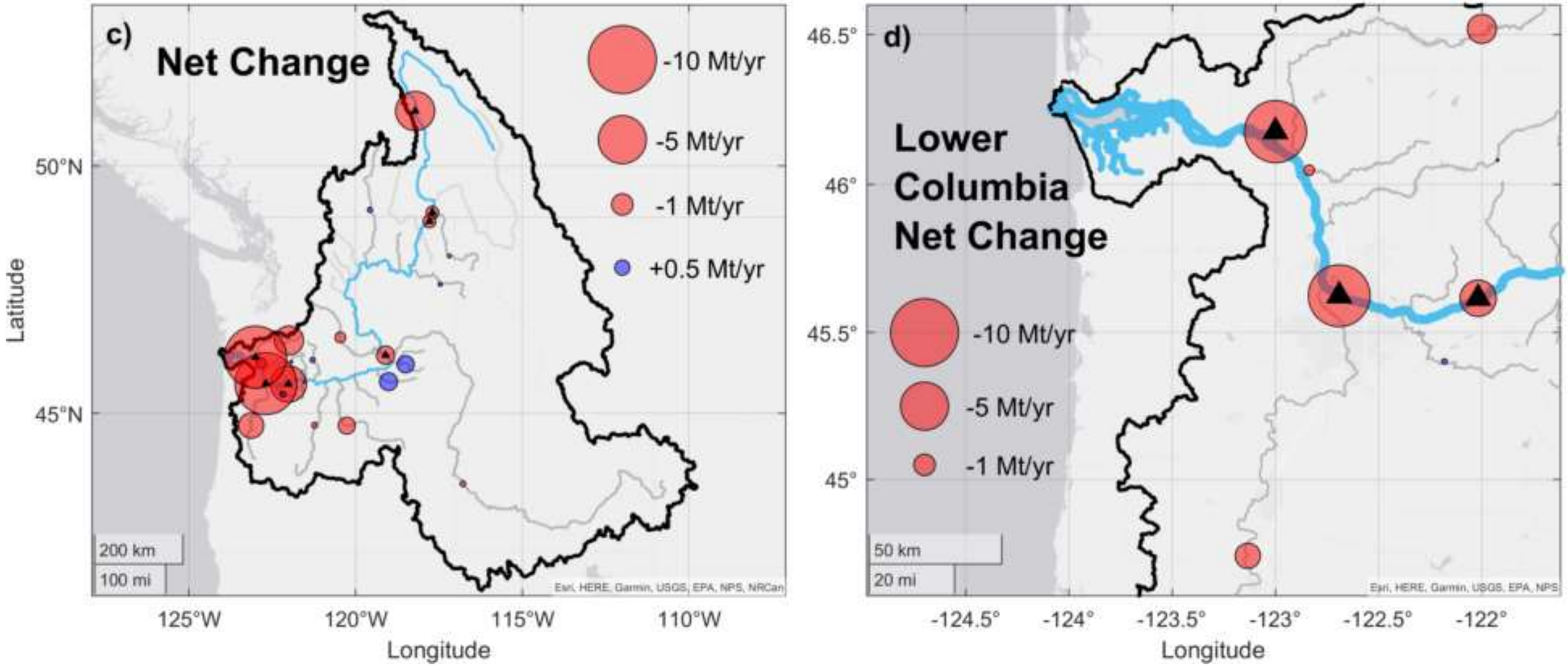
Pend Oreille, Spokane, Sanpoil, Okanogan

Yakima, Snake, Walla Walla, Umatilla, Willow, John Day, Deschutes

Klickitat, White Salmon, Wind, Hood, Sandy, Washougal, Willamette, Kalama, Lewis, Cowlitz

- *Estimates back to 1910s for most major tributaries and mainstem locations*
- *Estimates back to 1878 at Quincy, Willamette R., Vancouver, Warrendale*





- **Biggest losses are in the Lower Columbia**
- **Tributary losses tend to be small (or gains due to rating curve changes)**
- **Quincy, OR (start of estuary)**

  Total: 12→ 3.6 Mt/yr : 70% loss

  Sand: 4.6→1.2 Mt/yr : 75% loss

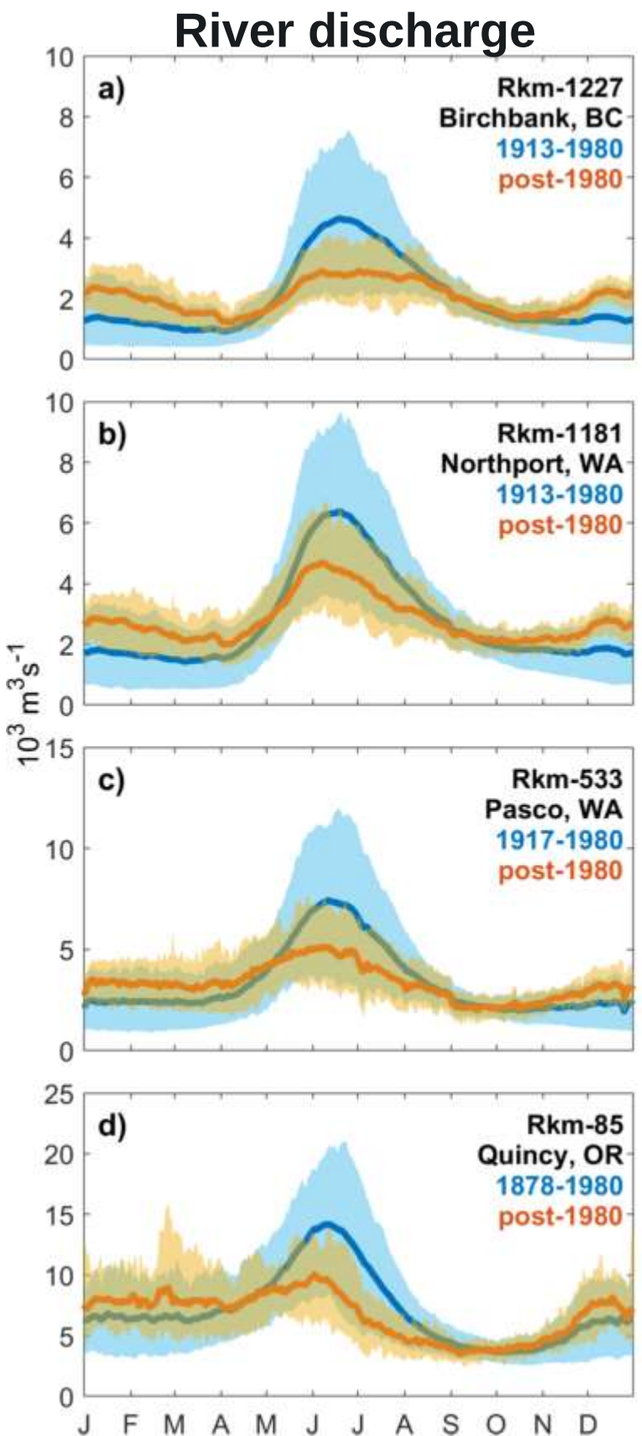
  Fines: 7.3→2.4 Mt/yr: 69% loss

Mainstem flows

- River flows have decreased, both in magnitude and variability
- Timing of freshet has shifted earlier

Mainstem loads

- Loads have decreased more than flows ($L = aQ^b$)
- Timing of peak sediment loads has shifted earlier
- In the Lower Columbia, there's more of an extended winter plateau rather than a spring peak



Upper Columbia (BC)

Upper Columbia (US)

Mid Columbia

Lower Columbia

Mainstem flows

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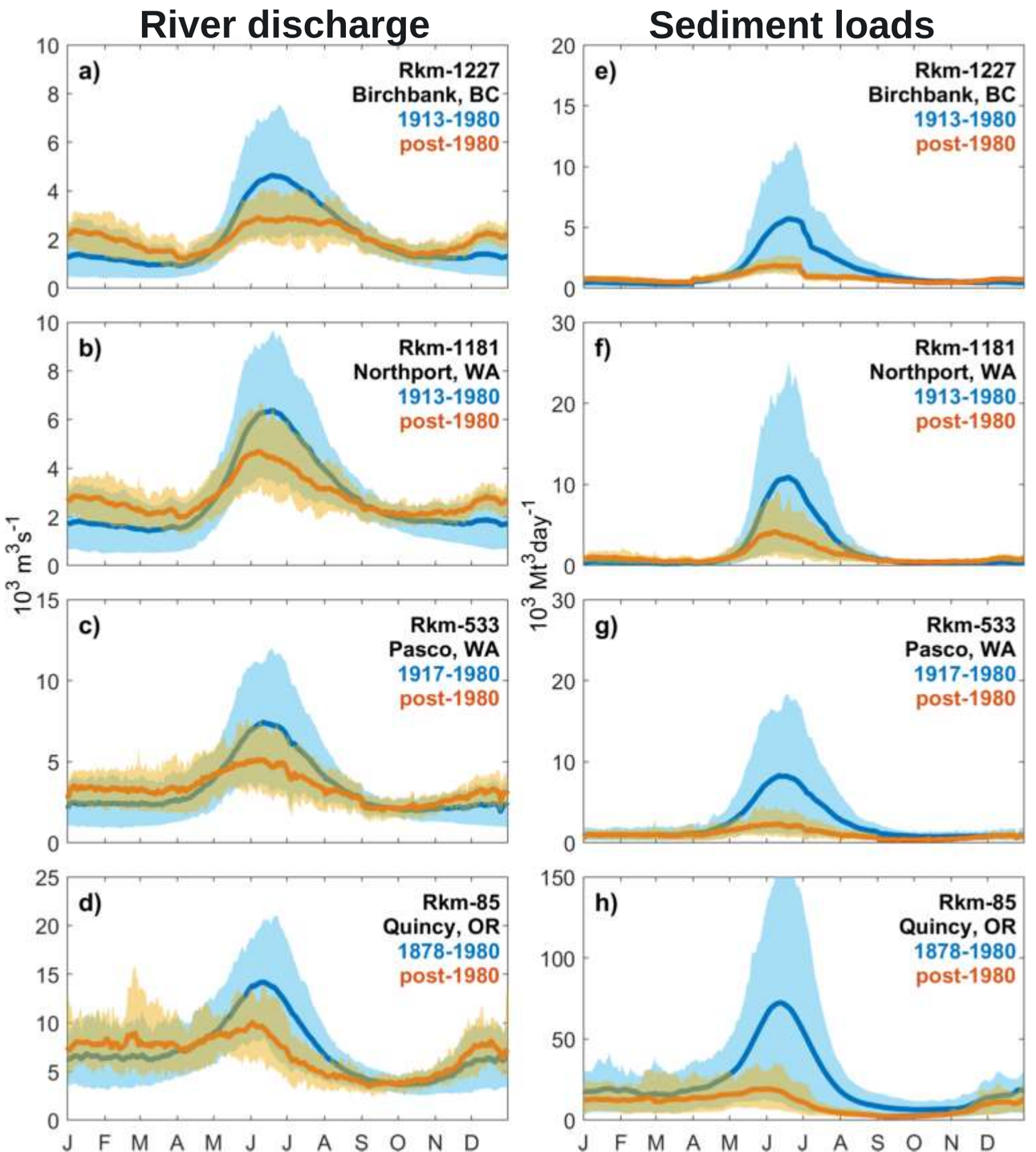

The entire system has seen a significant reduction in sediment loads compared to historical estimates.

In the estuary:

- ~10 Mt (70%) reduction in sediment delivered
- Sediment loads no longer peak in June, but are “high” throughout the winter

Ecosystem implications

- **Reasons to worry about wetlands:**
  - Less sediment making it to estuary
  - Sediment delivered prior to growing season (plants help retention)
- **But the data suggest that there IS accretion happening ~ 10 mm/yr**

Questions

- Are remaining wetlands benefitting from diking?
- Is there more organic material being accreted?
- Have accretion rates slowed?
- What are rates compared to rSLR? (VLM data gap)
- **When and how is sediment reaching wetlands?**

Sediment Sentinel System

Long-term SET monitoring site that will be instrumented with turbidity, water level, and velocity sensors

Thank you

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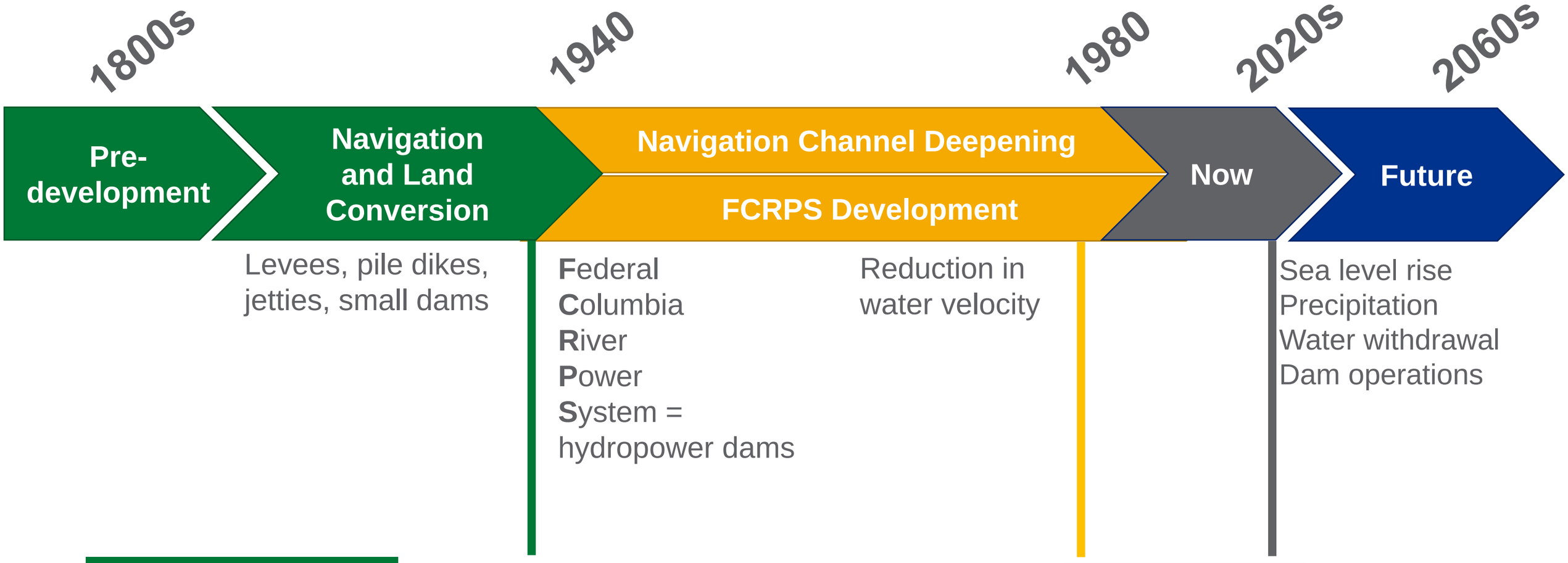
Thank you

Timeline of Columbia river changes



Tributaries: which are important?

Three types:

Upper Columbia + Snake: large late spring freshet (snow melt)

Mid Columbia: medium early spring freshet (rain + snow melt)

Lower Columbia: high winter flows (rain)

1. Tributary flow (magnitude and timing) hasn't changed as much as the mainstem.
2. Since mainstem loads have decreased so much, this makes some tribs even more important: Walla Walla, Umatilla, Cowlitz River