



NOAA
FISHERIES

Columbia Basin Partnership Workshop #2

Hydropower and Dam Effects Information

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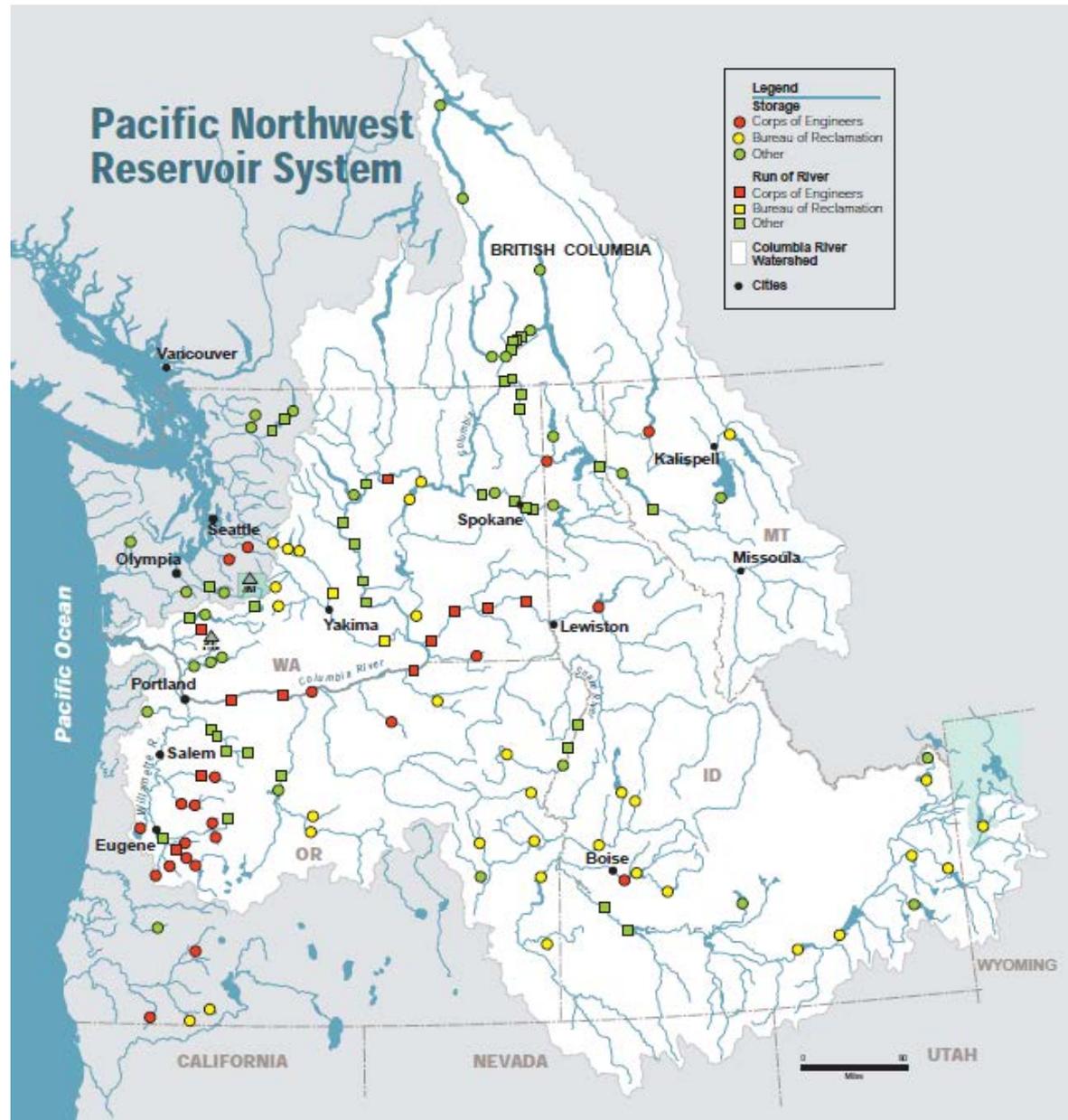
Hydropower and Dam Effects

- Locations / Types of Dams
- Effects of Dams
 - Passage Barriers / Habitat Inundation
 - Water Quantity and Timing
 - Water Quality
 - Sediment Transport & Turbidity
 - Food and Predation (Ecosystem Effects)
 - Fish Passage
- Actions to Reduce or Minimize Effects
- Monitoring
- Challenges



Dams in the Columbia Basin

- 258,500 square miles
- 200 million acre-feet runoff
- 60+ large dams
- Multi-purpose
 - Flood Control
 - Irrigation
 - Hydropower
 - Navigation
 - Recreation
 - Fish & Wildlife
 - Water Supply and Quality



Types of Dams

Water Storage



Detroit



Mica



Brownlee

Run of River



Priest Rapids



Lower Monumental

EFFECTS OF DAMS

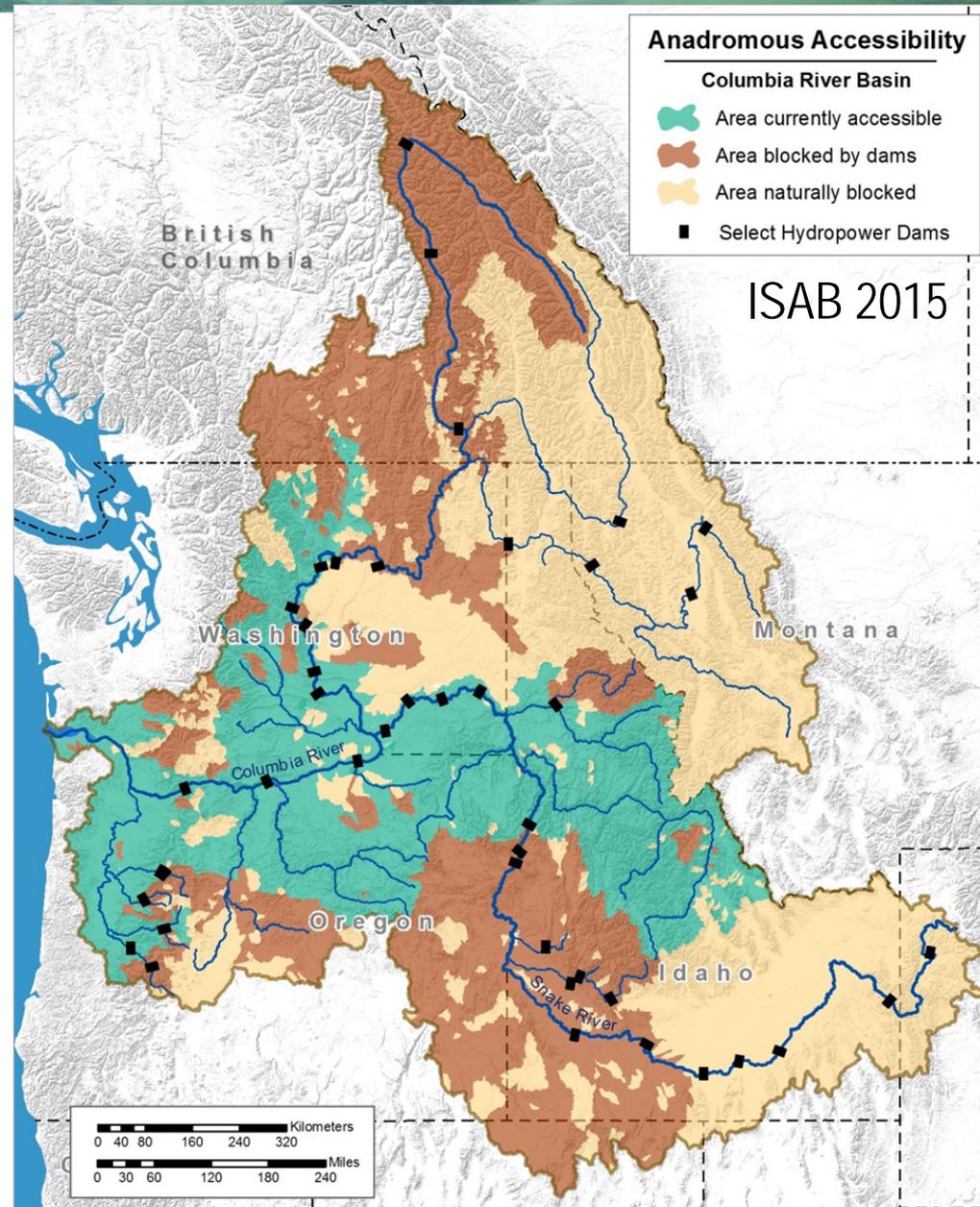


Cougar Dam – SF McKenzie River. Photo courtesy of BPA.

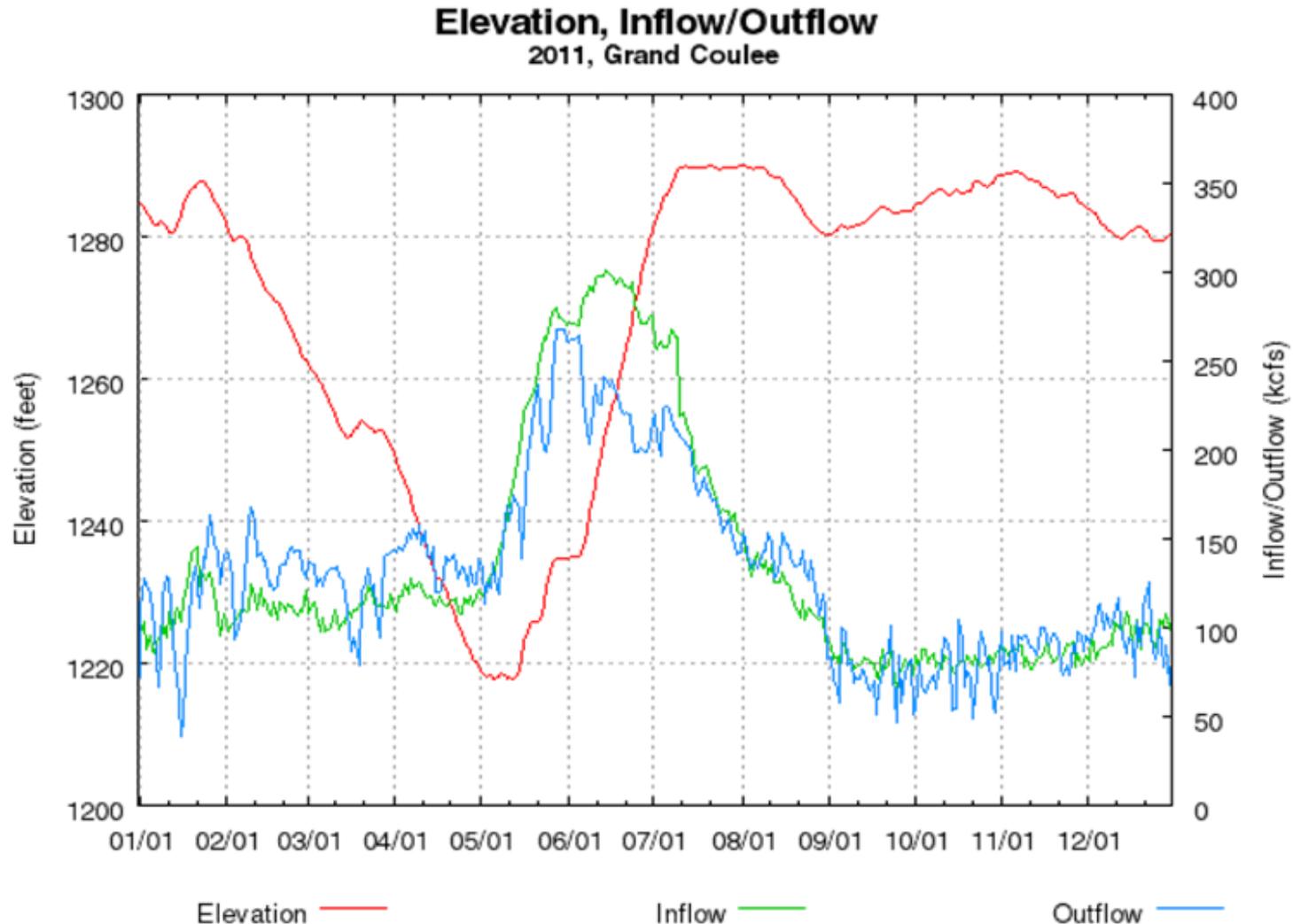


Passage Barriers / Habitat Inundation

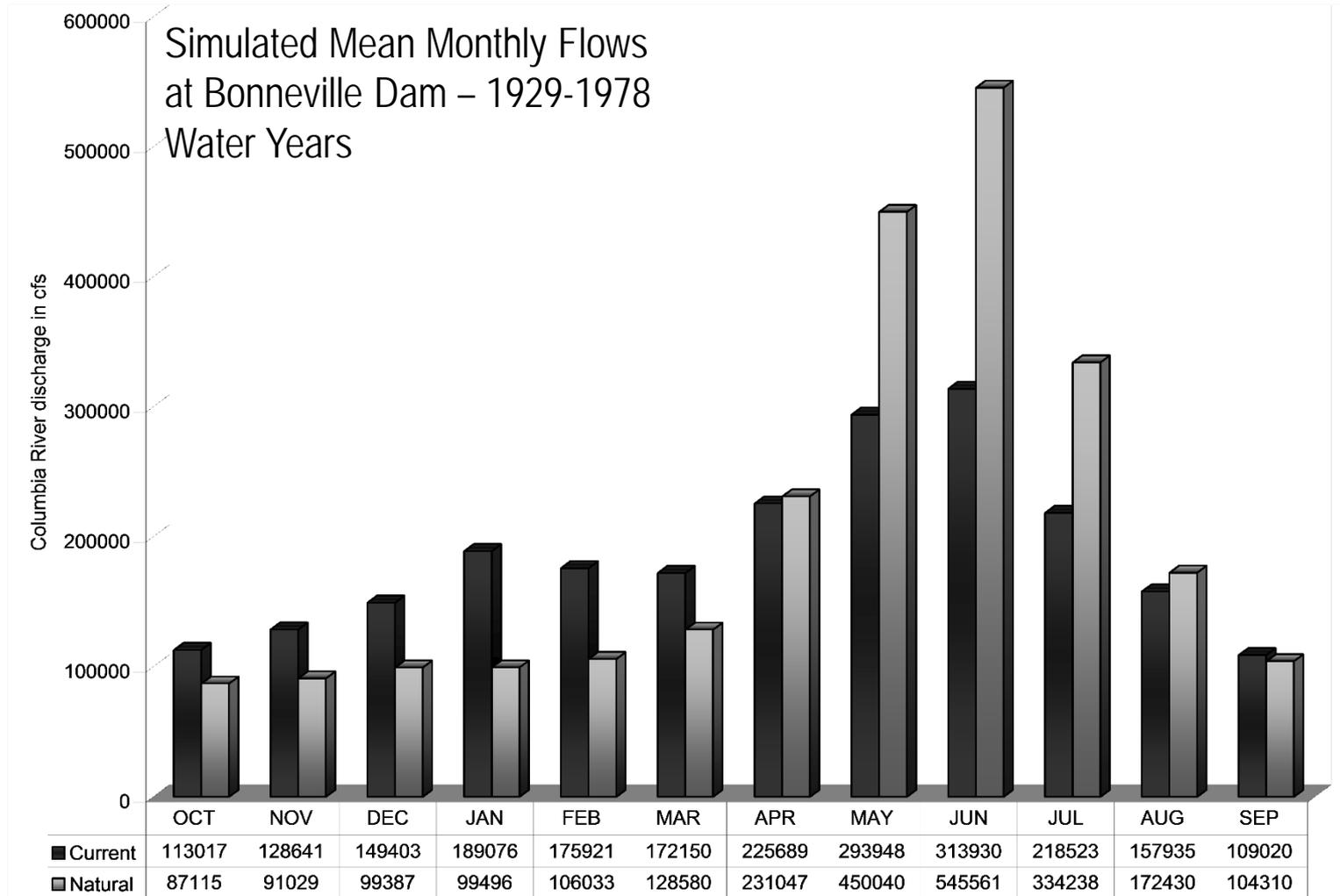
- Columbia Basin
 - $\approx 669,500 \text{ km}^2$
 - ($\approx 258,500 \text{ miles}^2$)
- 23,598 river km of habitat in 1850 (ISAB 2015)
 - $\approx 31\%$ or 7,391 river km of habitat blocked by 1976
 - Additional mainstem habitat inundated



Water Quantity and Timing - Seasonal



Water Quantity and Timing - Seasonal



Fish Passage – Travel Time

- Juvenile
 - Increased substantially due to reduced spring flows and increased cross-sectional area of reservoirs
- Adult
 - Little change: increased at dams (finding and passing ladders); decreased through reservoirs



Water Quantity and Timing – Daily / Hourly

Snake River below
C.J. Strike near
Grand View, Idaho

Graphic courtesy of Idaho Power
Company.

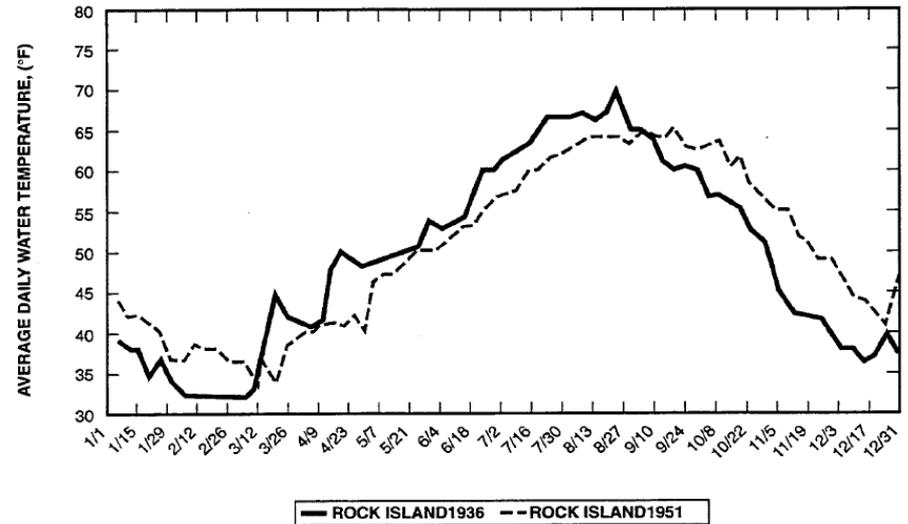


Water Quality – Temperature Effects of Storage Projects

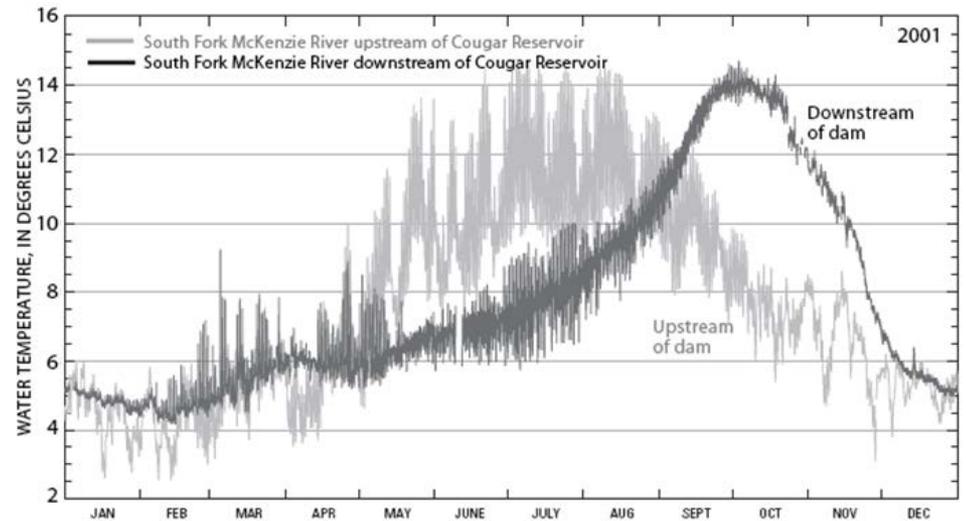
- Increased winter minimum
- Delayed spring warming
- Reduced summer maximum
- Delayed fall cooling

Sources: Coutant 1999. USGS.

ORNL 98-128284A/mhr



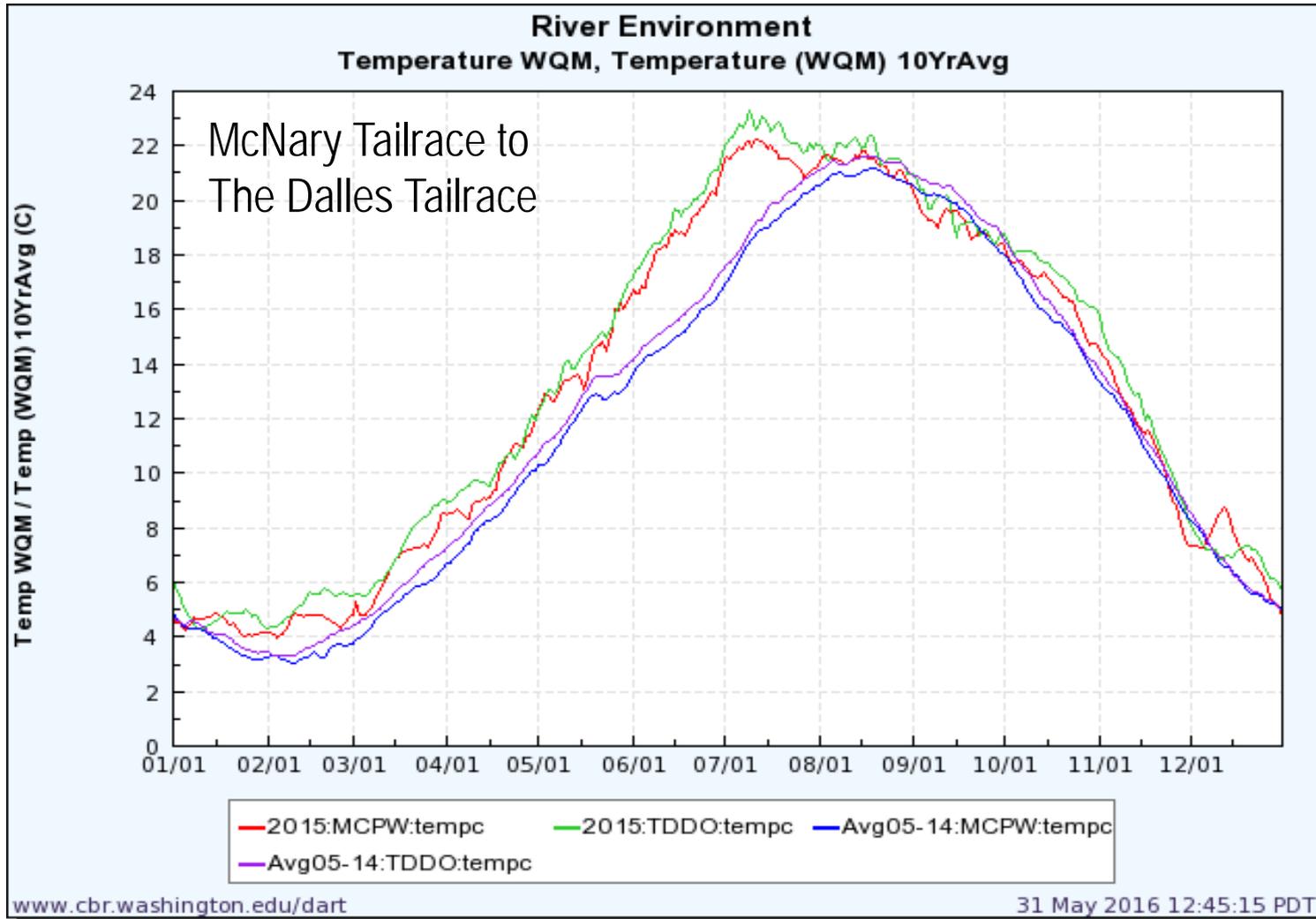
SOURCE: DATA FROM DAVIDSON, 1964



Seasonal water temperature patterns in the South Fork McKenzie River upstream and downstream of Cougar Reservoir, prior to the construction of a selective withdrawal tower at Cougar Dam, Oregon, 2001.



Water Quality - Temperature Effects of Run-of-River Projects



Water Quality - Sediment Transport

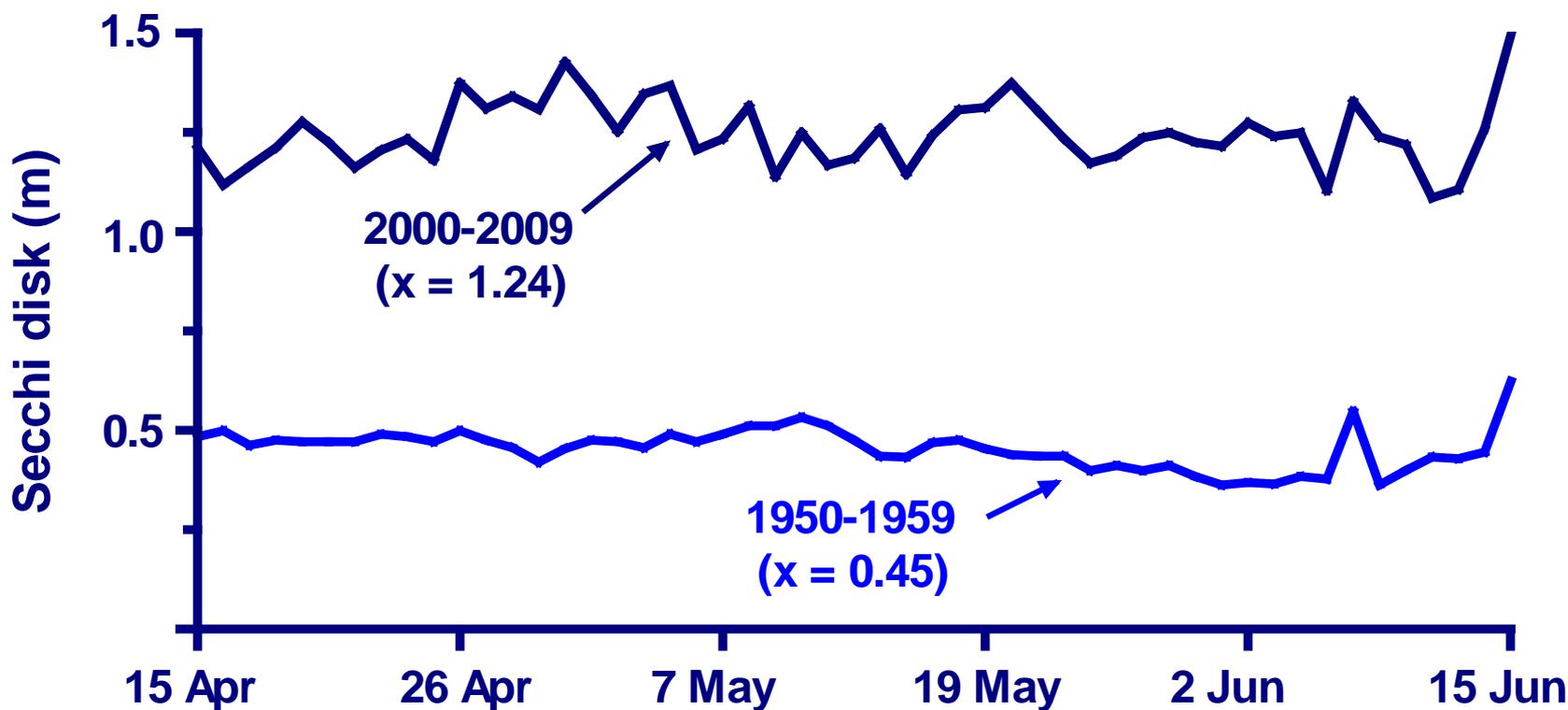
- Larger sediments (sand, gravel, cobbles) are trapped
- Some fines are passed



Condit Reservoir after breach.
Source: PacifiCorp

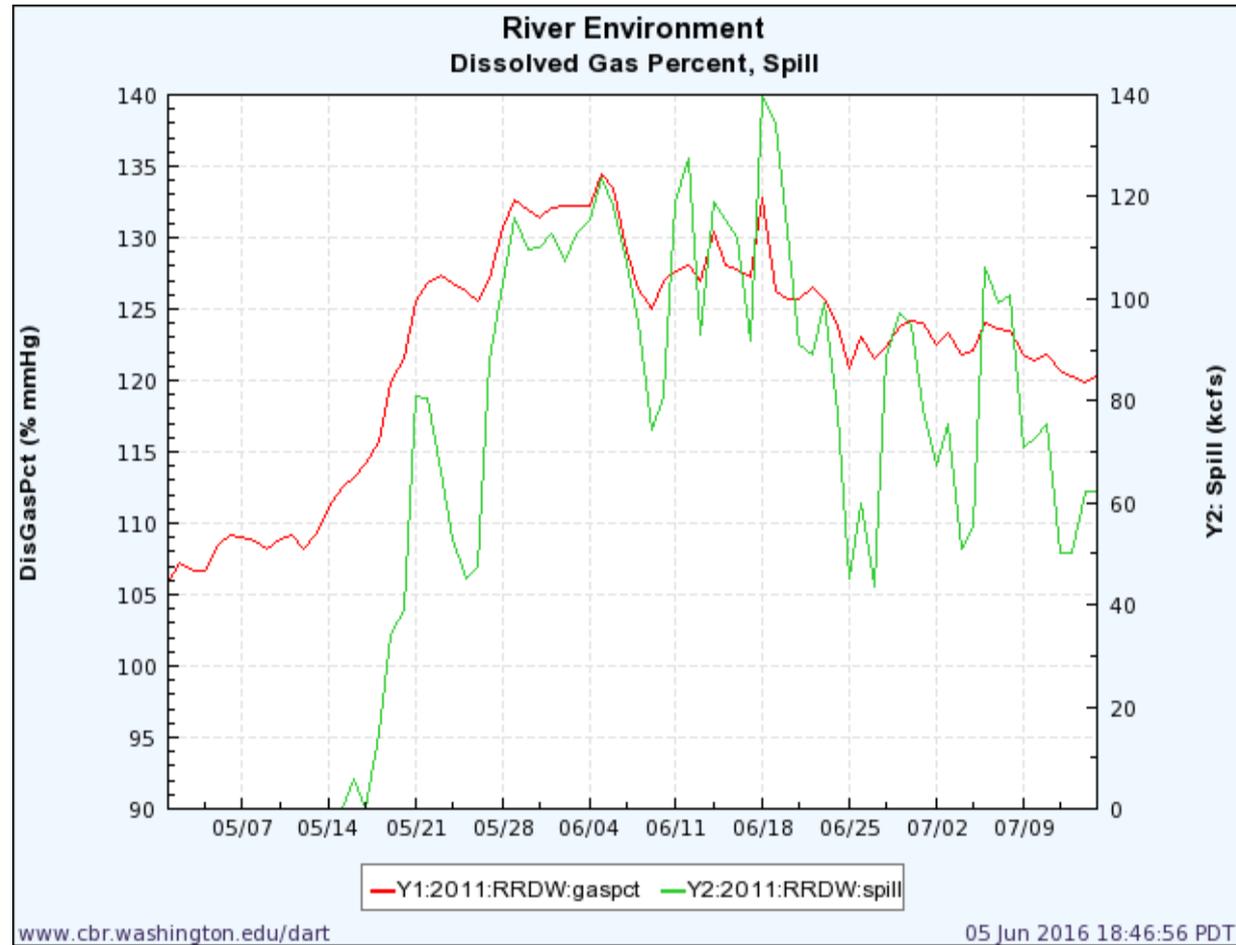
Water Quality - Turbidity

10 year average turbidity at Bonneville Dam



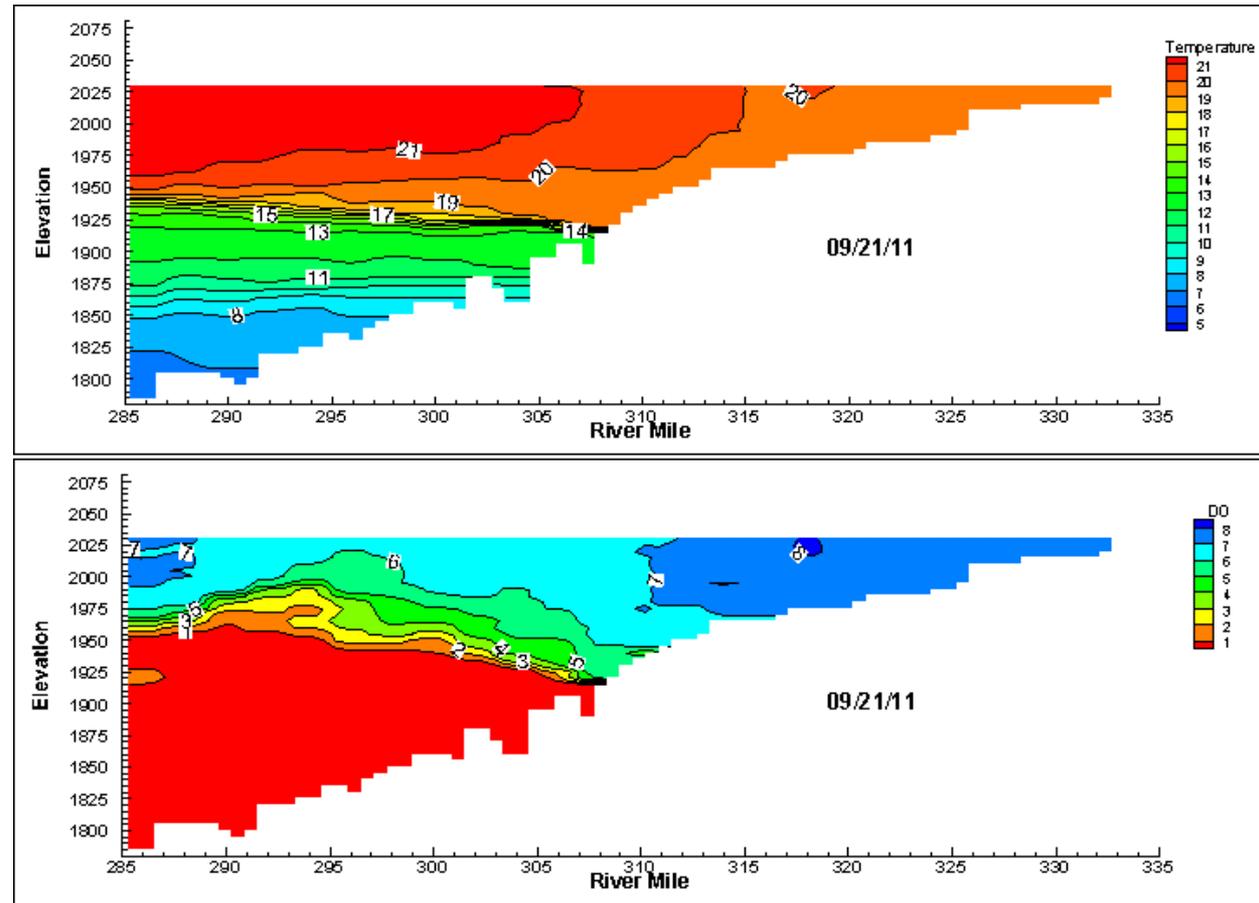
Water Quality – Total Dissolved Gas

- CWA Standard is 110%
- “Gas Waivers”
 - 120% tailrace
 - 115% in forebay
- Depth Compensation
 - 10% decrease for every meter of depth



Water Quality - Dissolved Oxygen

- Deep reservoirs can become anoxic over the summer
- Anoxic water can be passed downstream through turbine units



Example: Brownlee Reservoir 2011

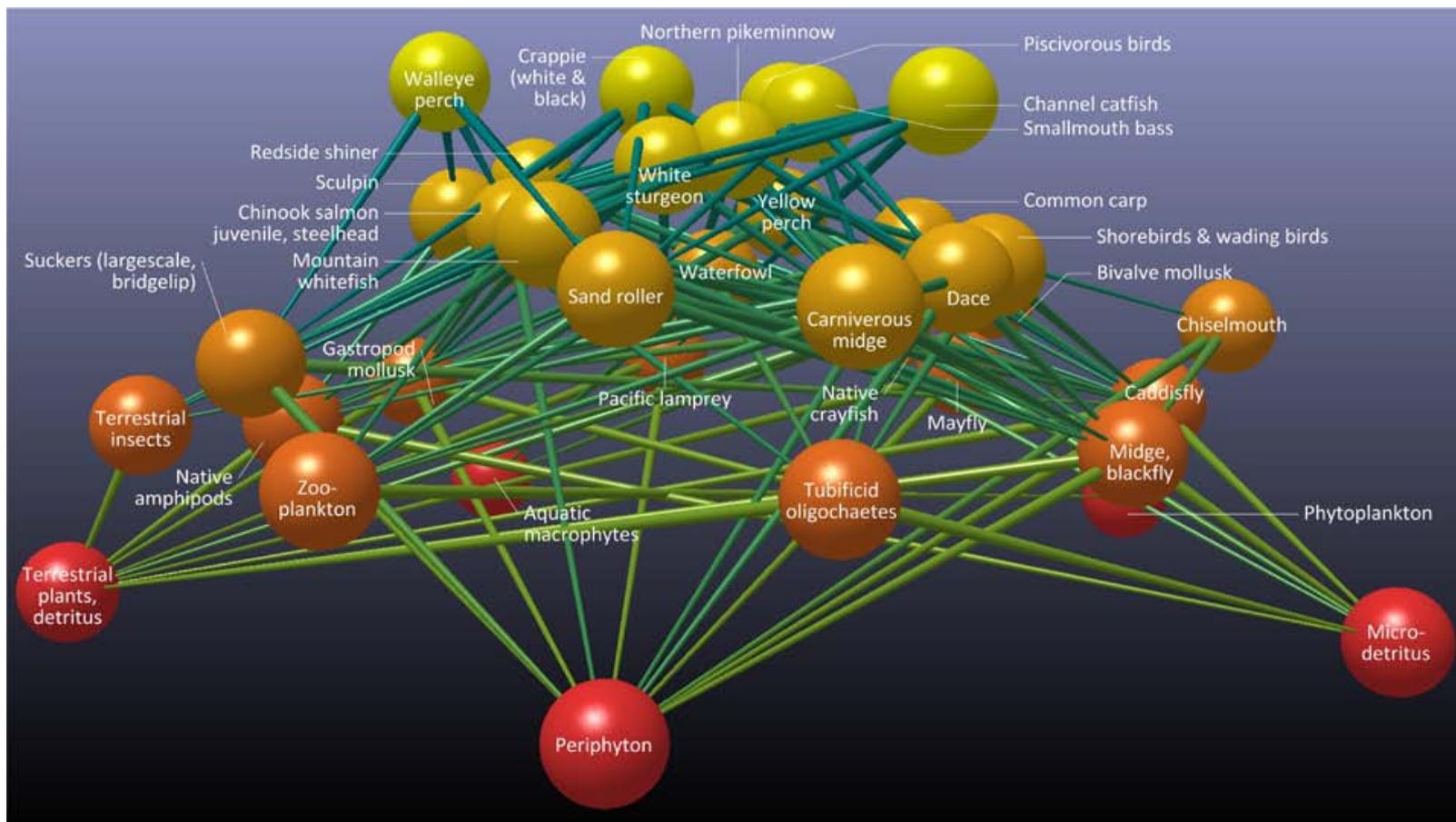
Source: Idaho Power Company

Water Quality - Toxics

- Reservoirs and Sediments
 - Mercury
 - DDT
 - Pesticides
 - Herbicides
 - Pharmaceuticals
 - Fire Retardants



Food (Ecosystem Alteration)



ISAB 2011. Figure D.3.2. Food-web structure in the Hanford Reach of the Columbia River. Red = primary producers, orange = primary consumers, yellow = secondary consumers, green = tertiary consumers (created in J. Dunne's Network3D software)

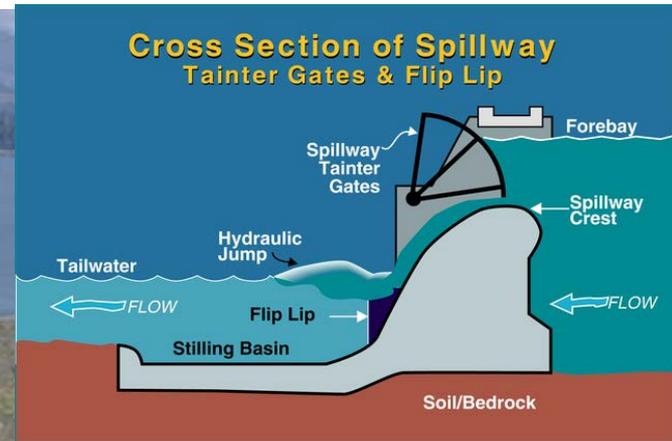
Predation (Ecosystem Alteration)

- Pikeminnow
- Smallmouth bass
- Walleye
- Channel catfish
- Northern pike?
- Gulls
- Caspian Terns
- Double-crested cormorants

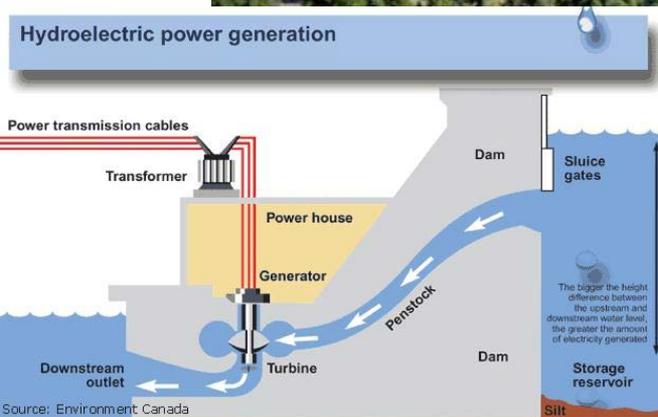


Photo Courtesy of Bird Research Northwest

Fish Passage



Lookout Point Dam. Photo courtesy of USGS.



METHODS TO REDUCE OR MINIMIZE EFFECTS



Removable Spillway Weir for Ice Harbor Dam.

Photo courtesy of NY Times.

Dam Removal

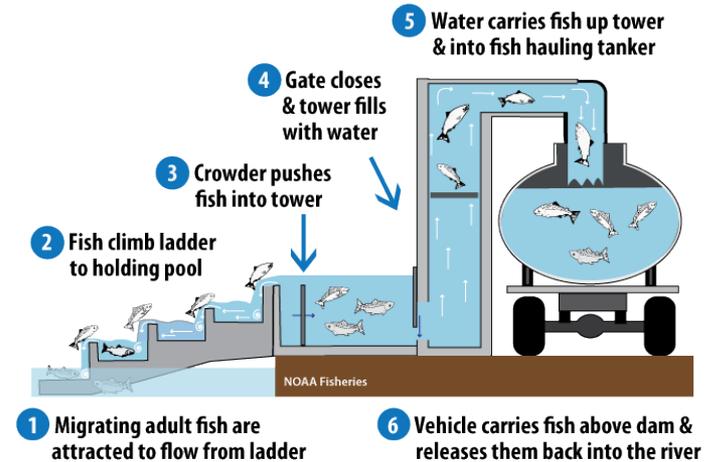
Condit Dam,
White Salmon River
PacifiCorp



Marmot Dam,
Sandy River
Portland General Electric

Passage Barriers

Collect and Transport



Conventional Passage Systems

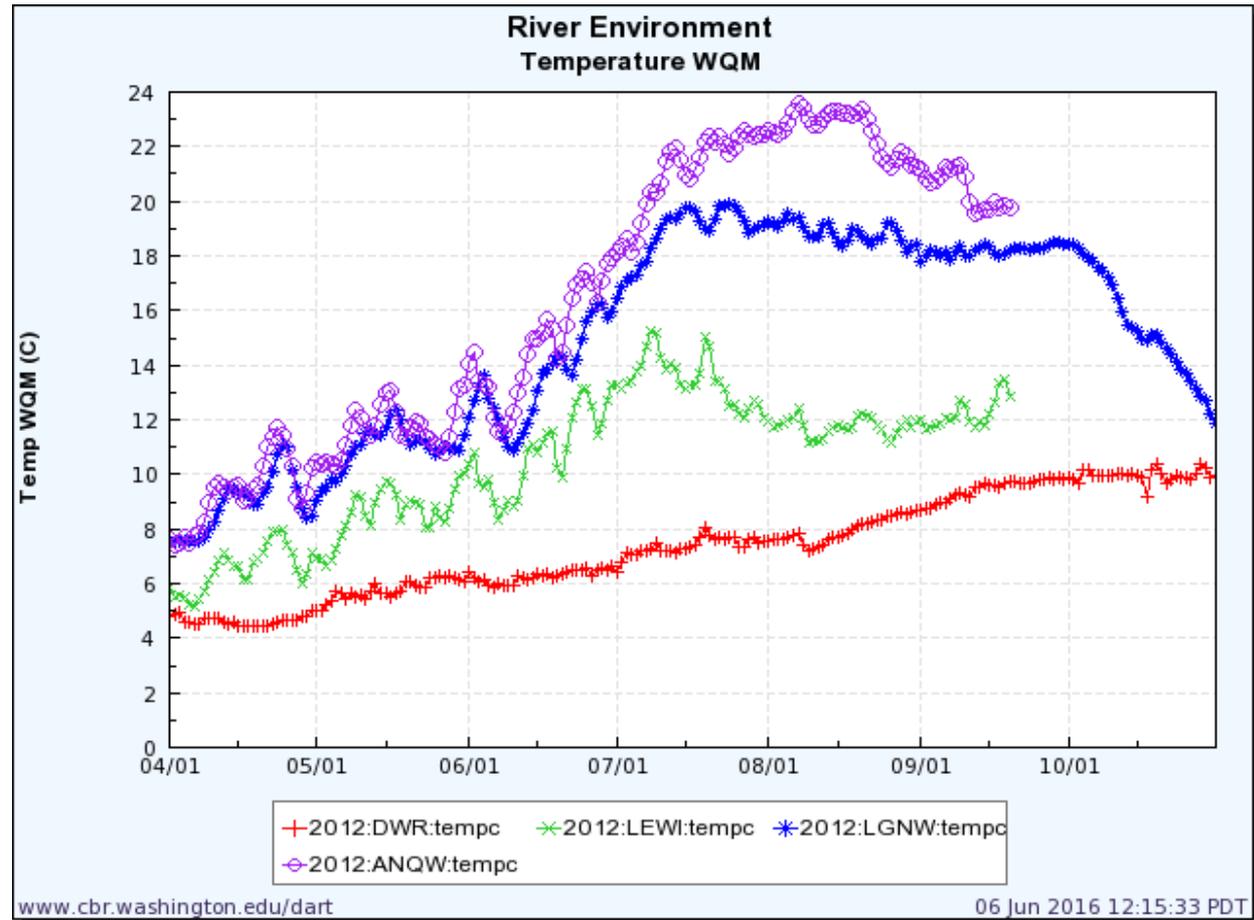


The Dalles Dam, USACE Digital Visual Library



Water Quality - Temperature

- Release cool water from storage projects
- Increase summer flows



Water Quality – Total Dissolved Gas

- Reduce spill (magnitude and duration)
- Install gas abatement structures (“flip lips”)

Water Quality – Dissolved Oxygen

- Voluntary spill
- Inject oxygen into turbine units

Water Quality - Toxics

- Minimize Reservoir Elevation Changes
 - Reduce amount of fine sediments in outflow
- Sediment removal
 - Milltown Dam Example
 - Clark Fork River



Sediment Transport and Turbidity

- Large flow releases to re-distribute downstream sediments (sand and gravel)
- Supplement desired sediments in downstream locations
- Could increase turbidity by:
 - Increasing flows (re-suspending fine sediments)
 - Releasing fine sediments
 - Releasing other materials (bentonite clay)
 - Releasing non-toxic dyes

Food (Ecological Effect)

- Effects are specific to species
- Generally little that can be done
- Study food webs – monitor to assess changes
- Minimize introductions of non-native species



Corophium spp.



Neomysis spp.



Siberian Prawn

Predation (Ecological Effect)

- Avian Predators
 - Hazing, bird wires, other deterrents
 - Lethal removal
 - Reduce nesting habitat
- Fish Predators
 - Bounty programs (pikeminnow)
 - Fishing regulations
 - Operate projects to negative impact key life history stages

Fish Passage – storage facilities

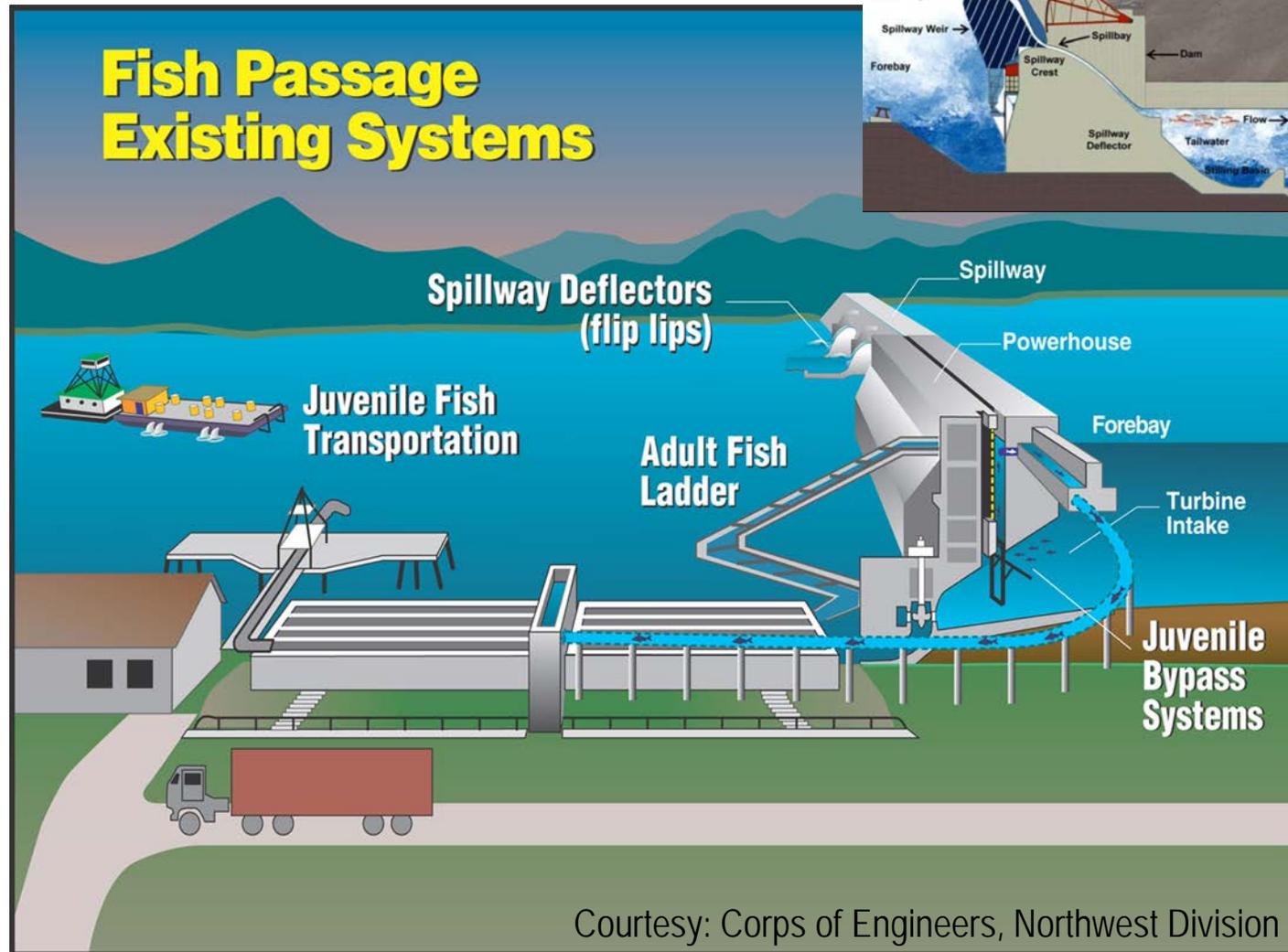
- Juvenile passage is more difficult than adult passage
 - Long reservoirs
 - Dam height
 - Turbine pressures
- No adult passage



North Fork Dam, Clackamas River.
Photo courtesy of Oregon Historical Society
Research Lab

Fish Passage – run of river dams

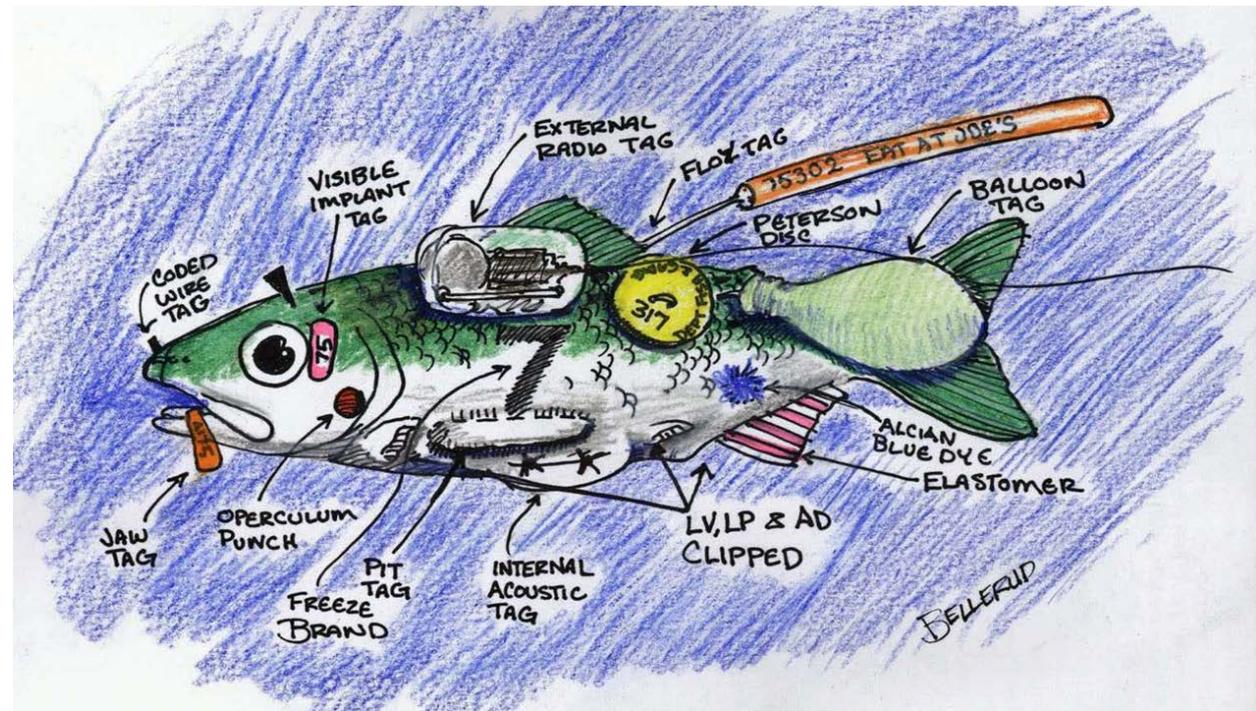
- Advanced turbine units
 - Fish screens and bypass systems
 - Spill through conventional bays
 - Spill through surface passage routes
-
- Issues to watch for:
 - Tailrace egress conditions
 - Adult passage and fallback



Courtesy: Corps of Engineers, Northwest Division

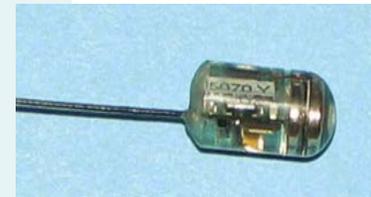
Monitoring

- Coded Wire tags (CWT)
- Passive Integrated Transponder (PIT) tags
- Radio tags
- Acoustic tags



Monitoring

Tag	(+)	(-)	Best Used For:
Coded Wire Tag	Passive tag – can use on very small fish	Presence/absence detection only in live fish	Juv. to Adult
PIT Tag	Passive tag – can use on small fish	Limited det. sites Tagging Effects?	Juv. To Adult Reach Project
Radio Tag	Active Tag – can provide fine-scale behavior info.	Limited tag life Tagging Effects Cannot detect in deep water	Short Reach Project Dam Route-Specific
Acoustic Tag	Active Tag – can provide fine-scale behavior info.	Limited tag life Tagging Effects Range poor in noisy environ.	Short Reach Project Dam Route-Specific



CHALLENGES



Challenges – Latent Mortality

“The ISAB concludes that the hydrosystem causes some fish to experience latent mortality, but strongly advises against continuing to try to measure absolute latent mortality. Latent mortality relative to a dam-less reference is not measurable. Instead, the focus should be on the total mortality of in-river migrants and transported fish, which is the critical issue for recovery of listed salmonids. Efforts would be better expended on estimation of processes, such as in-river versus transport mortality that can be measured directly.”

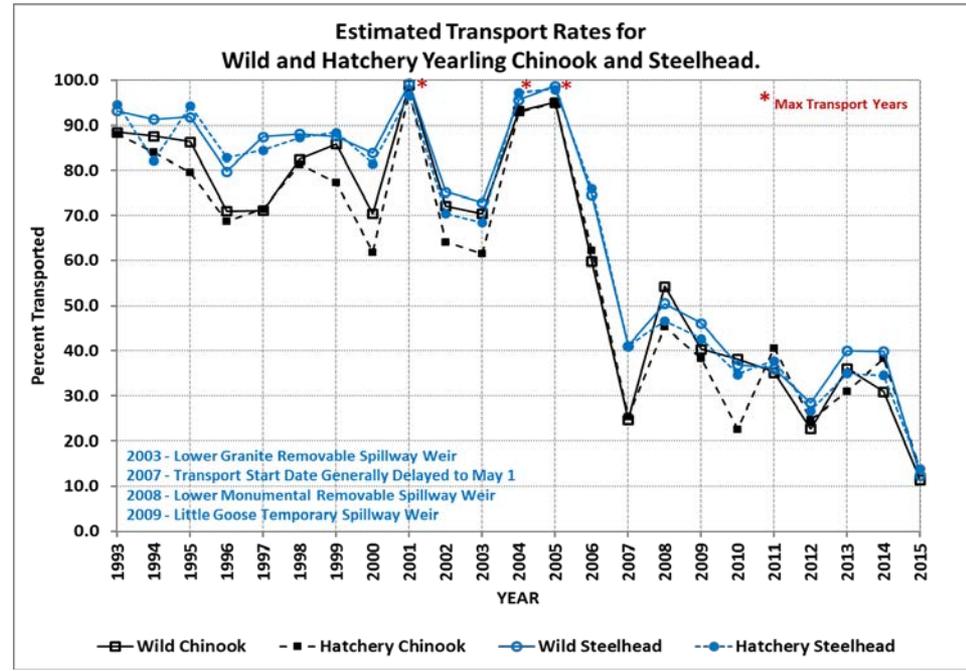
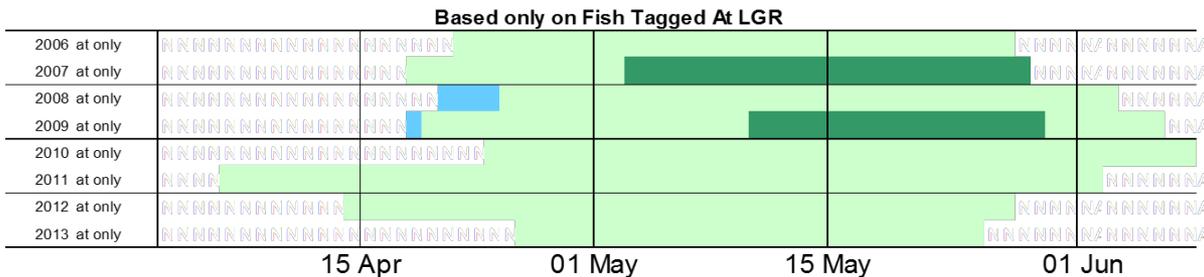
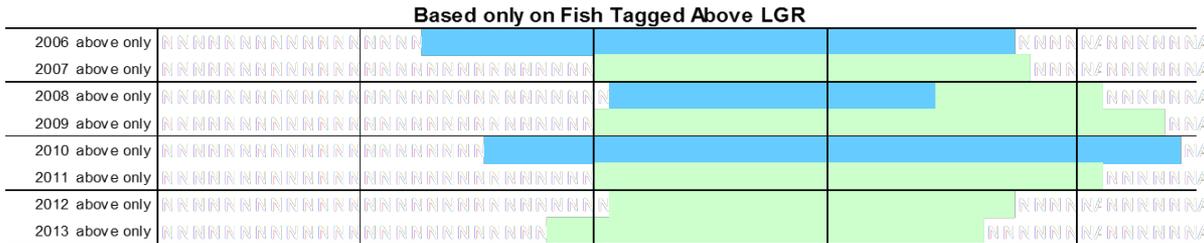


Challenges – Transport

Columbia River - Snake River stocks only as collection and transportation was discontinued at McNary Dam in 2014

Collection and transportation an important strategy at many storage projects in the Northwest

Wild Steelhead - Lower Granite Dam
 Summary of Model-Averaged T:B Values (Descriptive)
 Standard = C0 (Never Bypassed)



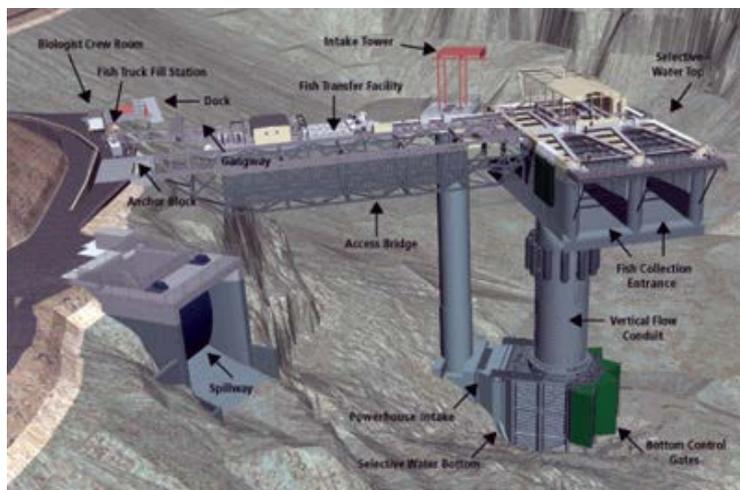
Challenges – Bypass Effects

- “The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis).”
(ISAB 2012)
- Two competing hypothesis
 - Selection Hypothesis
 - Damage Hypothesis



Challenges – Juvenile Survival

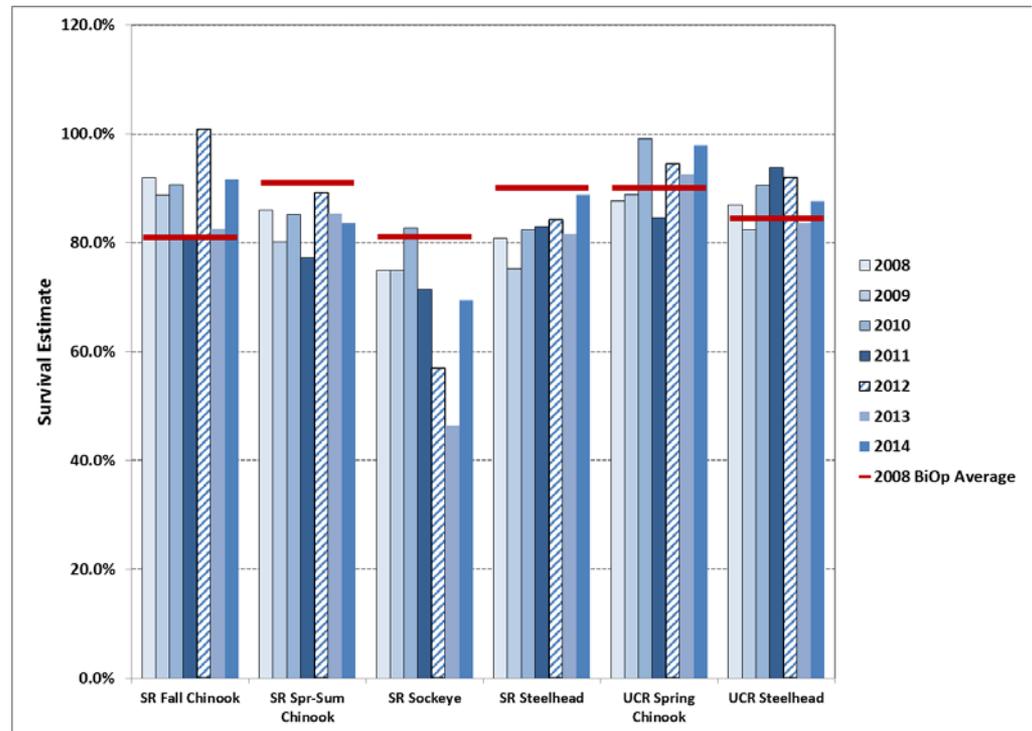
- Reservoir
- Dam
- Multiple Dams
- Predators



Challenges – Adult Losses

Unexpected Losses of Adults Based on adjusted PIT tag survival estimates

- Methodology?
- Dam Effects?
- Harvest Effects?
- Pinniped Effects?
- Interactions?



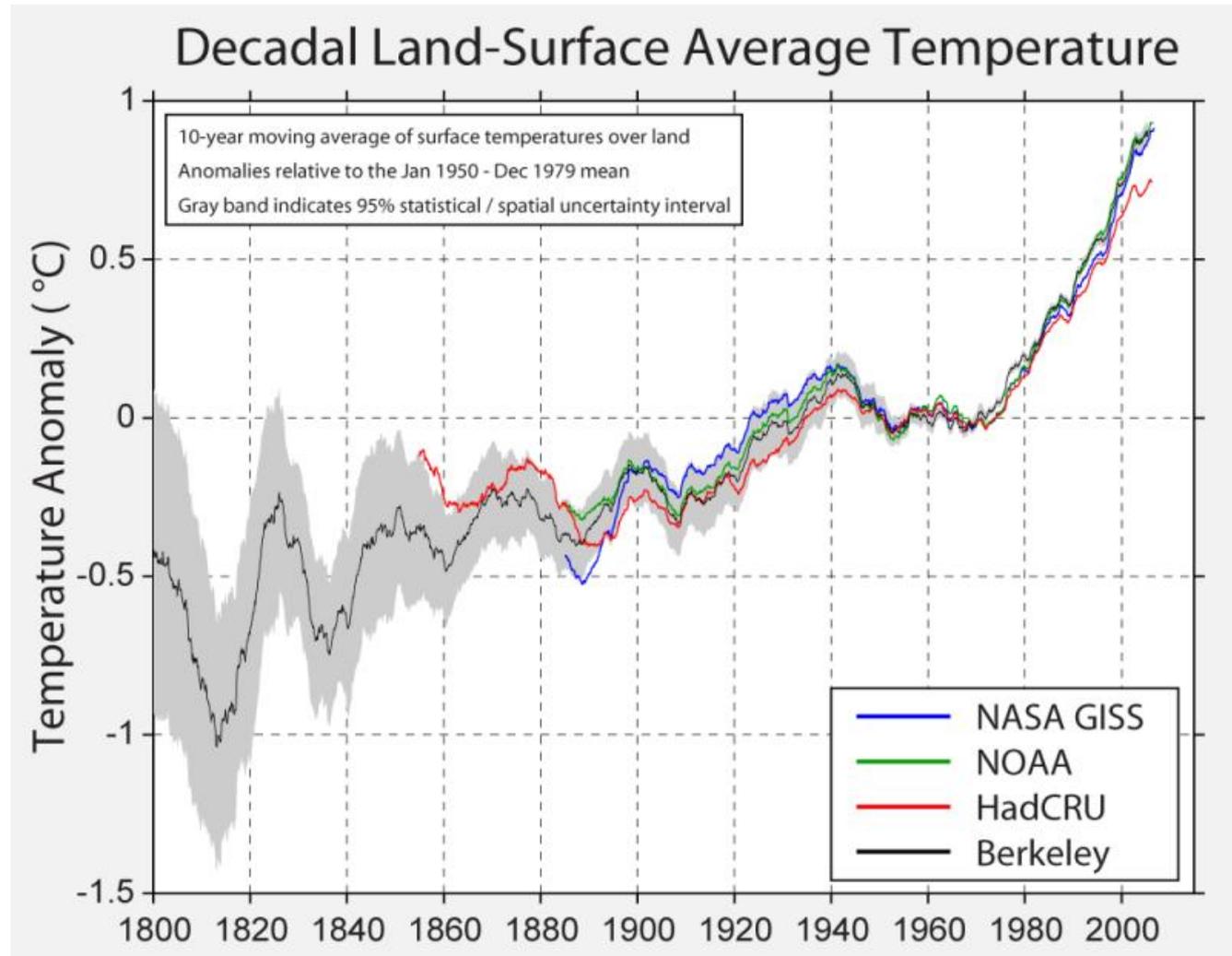
Challenges - Predation

- Estuary
- Lower Willamette River
- Bonneville Dam Tailrace
- Other Rivers?



Challenges - Climate

- Temperature
- Precipitation
- Fish
 - Migration?
 - Passage?
 - Energetics?
 - Spawning / Incubation?
 - Life History?
 - Survival?



QUESTIONS



Bonneville Dam, USACE Digital Visual Library