Cold Water Refuges and TMDLs

- rethinking "fishable" for large rivers and climate change

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Association of Clean Water Administrators

Annual Meeting

August 16, 2016

Cold Water Refuges and TMDLs

What is a CWR?

- Cold water tributaries, including headwaters
- Channel features: pools, hyporheic outflow
- Floodplain features: side-channels, gravel bars
- Groundwater springs, springbrooks, upwelling
- Microclimates from shading, woody debris, overhangs
- (Closely related: temporal thermal regimes – cool pulses)

Why is this important?

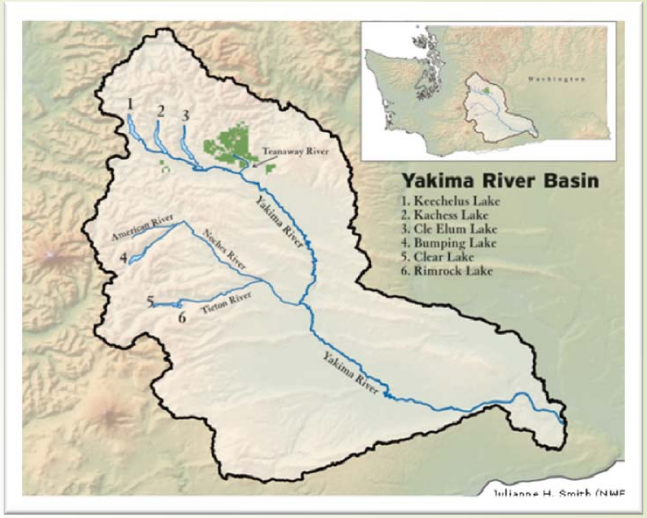
- Over 40 studies published since 1990s
- Identified as critical survival strategy in large, warm rivers
  - Columbia, Snake, Willamette, Grande Ronde, John Day
  - Create resilience by providing refuges and "stepping stones"
- Important adaptation strategy for climate change
  - Modeling shows increasing water temperatures throughout the state

Cold Water Refuges and TMDLs

Large rivers raise troubling questions

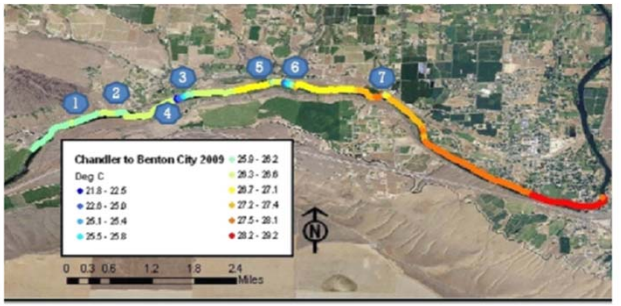
- Pend Oreille River Temperature TMDL
  - Major tributary of the Columbia River
  - Few dischargers, run-of-river hydroelectric dams
  - Natural temperatures high – wide river w/ lake surface outflow
  - Bull Trout study showed fish survived in cool tribs and springs
  - Little that dams can do directly to reduce temperatures
  - Reducing daily maximum temperatures in the middle of the river does not support fish

Cold Water Refuges and TMDLs



Large rivers raise troubling questions

- Yakima River Water Quality Study
  - Highly regulated river
    - 5 USBR dams for irrigation
  - Semi-arid climate, wide valley
  - August water temperatures above 27°C at the mouth
  - "Reaches Study" identified CWRs created by floodplain reconnection
    - Snowmelt high water charges shallow groundwater
    - Cool springbrooks and pockets support fish
  - Fisheries restoration focus on CWRs & cold water pulses
  - Lower Yakima survey identified cool water pockets



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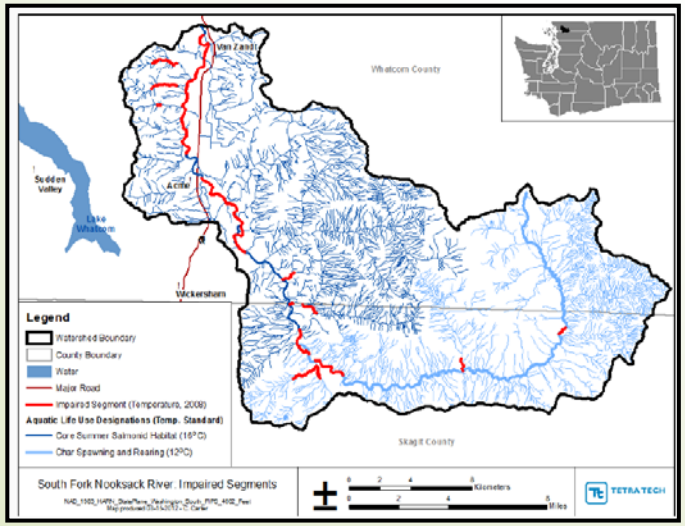
Other CWR studies on large rivers

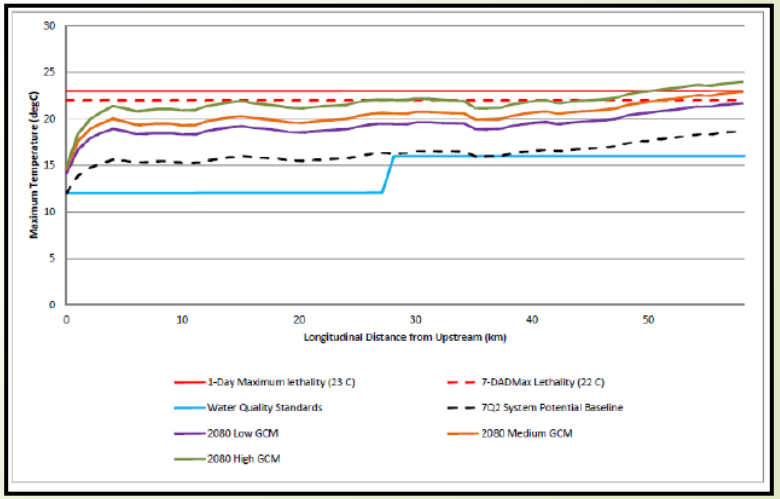
- This issue has been identified in many other PNW studies
  - Columbia and Snake Rivers
    - Salmon use cooler tributaries to hold in during hot spells
    - Fishing pressure on CWRs can be a challenge
  - Willamette River – CWRs as "stepping stones"
    - Off-channel areas and deep pools
  - John Day and Grand Ronde Rivers
    - "Cold water patches": tributaries, side channels, alcoves, lateral seeps, floodplain springbrooks

Cold Water Refuges and TMDLs

Climate change raises troubling questions

- SF Nooksack River Temperature TMDL and CC Pilot
  - Small river, wide and shallow in valley
  - Rain/snow hydrologic regime – no flow regulation
  - Pilot study evaluated temperature compliance under future climate change scenarios
    - Mainstem temperature above salmon lethal threshold by later in this century
    - Cold Water Refuges (CWRs) needed for resiliency





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Challenges with CWRs and CWA

- WA State Standards
  - Daily maximum midstream is first line of defense
  - CWR monitoring cannot be used for assessment
    - Perceived as a loophole?
  - Thermal regime not addressed
    - e.g windows of cool weather, daily minimums
  - CWR addressed in Tier 3 Anti-degradation
    - But process unclear, appears to be cumbersome

Cold Water Refuges and TMDLs

Challenges with CWA, CWRs, and ESA

- WA WQ standards: NOAA and USFWS BiOp (2008)
  - Raised concerns with large rivers with high temperature criteria (e.g. 21 ^{o}C)
  - Identified TMDL as process to address natural conditions for temperature in large rivers
- OR WQS CWR: NOAA Fisheries ESA Jeopardy call on narrative criteria due to lack of implementation
  - Triggered EPA studies of CWRs in Columbia and Willamette

Cold Water Refuges and TMDLs

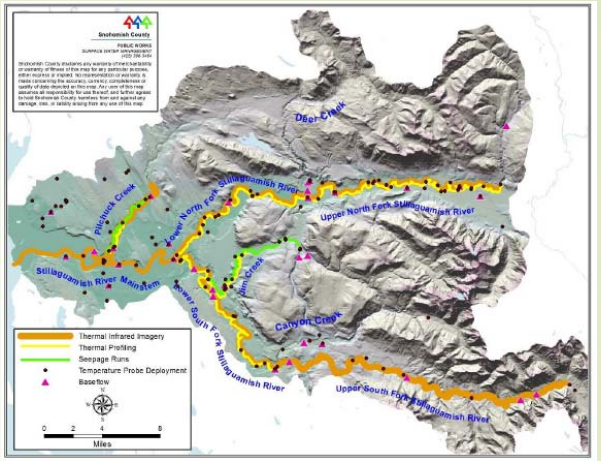
Should we address CWRs in TMDLs… and how to do it?

- Revising standards for CWR is complex and controversial
- Easier path: address CWRs in TMDL implementation
- Two elements required:
  - Technical study
  - Implementation methods

Several EPA studies

- Analysis of CWRs on Columbia and Willamette Rivers in response to OR WQS ESA Jeopardy
- RARE study of headwater tributaries as CWRs based on USFW NorWeST temperature data base
  - Includes climate impacts and restored conditions
  - Comparison of results to temperature TMDLs
- Proposed RARE study of FLIR processing
  - Digital Image Analysis to identify CWRs from IR imaging

Cold Water Refuges and TMDLs



How do you measure CWR?

- Thermal Infrared remote sensing
  - TIR, also called FLIR
  - Usually acquired from aerial platforms e.g. aircraft/satellites
  - Emerging technology for FLIR on an UAV ("drone")
- Floating or wading surveys with thermistors
- Fiber optic thermistor cable – linear sensors

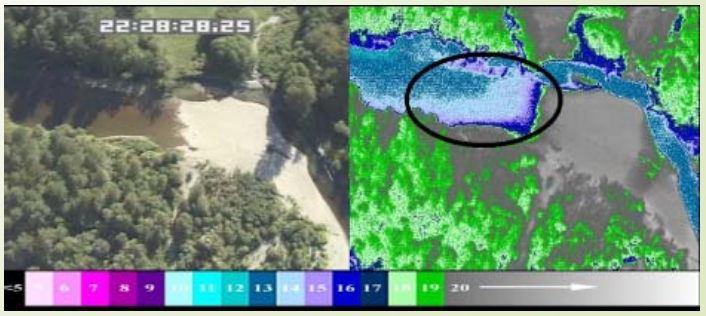
Examples of surveys for existing CWRs

- Lower Yakima River (Benton Conservation District)
  - Continuous temperature collected up/downstream
  - Three boats collecting continuous temperature and GPS positions midstream and on left and right banks
- Stillaguamish River (Snohomish County)
  - TIR flights
  - Thermal profiling from a drifting raft

Cold Water Refuges and TMDLs

CWRs and TMDL implementation

- ***Locating existing CWRs*** heavily studied, but little research has been done on ***identifying sites for restoration***
  - Methodology needs to be developed to identify floodplain and riparian restoration opportunities
  - Could be done with GIS analysis of geomorphology
- Some examples of current restoration approaches:
  - Floodplain and riparian restoration
  - Enhancement at mouths of cooler tributaries
  - Restoration of groundwater inflows and flow regimes
  - Recharge enhancement (off-season infiltration)
- CWRs in TMDL Implementation plans
  - Explore all possibilities to reduce daily maximum temperatures averaged across the channel
  - CWRs as supplemental goal to improve designated use of cold water aquatic life



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Benefits of addressing CWRs in the TMDL process

- Supports CWA to protect cold-water aquatic life
- Aligns with ESA and other fishery restoration needs
- Some technical methodologies well established, others advancing rapidly
- TMDL implementation approaches have been developed and proposed for EPA approval
  - SF Nooksack and Pend Oreille Rivers

Cold Water Refuges and TMDLs

Complications and implications

- Uncertainty regarding how CWRs factor into in federal ESA decisions for EPA CWA actions
- CWRs are linked to the issue of natural conditions, which has been a bone of legal contention
- Addressing the impact of water use on ground water inflows and CWRs can be difficult (water rights issues)
- Although addressing CWRs through TMDLs may be the "right thing to do" in some situations, it adds complexity
  - Legal decisions may shift emphasis more on quantity of TMDLs , and less on quality

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Questions?