Columbia River Cold Water Refugia Plan Scope of Work
September 2016

Project Goal: Develop and issue a Columbia River Cold Water Refugia Plan by November 2018 as described in the 2015 NMFS Biological Opinion Reasonable and Prudent Alternative for the Oregon water quality standards.

Scope of Work: This scope of work describes the teams, organizational coordination efforts, tasks, and timeframes to develop the Columbia River CWR plan. This is an iterative plan that will be updated as work progresses. The RPA requires EPA to submit a final scope of work to NMFS by Aug 2016.

Geographic Scope: The Columbia River CWR Plan will address the main stem Columbia River from the mouth to River Mile 310 (Washington-Oregon border). The geographic scope includes the lower portion of tributaries to this segment of the Columbia River that serve as CWR to the warmer main stem.

EPA Team: The EPA team will develop the plan. Christine Psyk will serve as the executive sponsor for the project. John Palmer and Dru Keenan will serve as co-leads for the project. John will focus on providing overall guidance for the project and coordinating with external agencies and organizations. Dru will focus on facilitating the EPA team and coordinating work tasks. EPA team members will lead specific identified tasks in this scope of work. The EPA team members will coordinate other agency officials and stakeholders as needed on identified tasks. EPA team members: John Palmer, Dru Keenan, Rochelle Labiosa, Mary Lou Soscia, Jenny Wu, Gretchen Hayslip, Peter Leinenbach, Ben Cope, Martin Jacobson, Jonnel Deacon, Joe Ebersole, and Randy Comeleo.

EPA-NOAA Coordination Team: EPA and NOAA will meet periodically to coordinate on the project. John Palmer (EPA) and Ritchie Graves (NOAA) will serve as the respective agency leads for coordination purposes.

Columbia River Federal Caucus: EPA will use the monthly Federal Caucus meetings to update federal agencies on the project (Army Corps, BPA, BUR, USGS, USFS, BIA, USFWS, and NOAA). EPA will work with the Federal Caucus to get assistance and participation from federal agencies on identified tasks and workshops and coordinate this project with other related federal projects.

States and Tribes: EPA will coordinate with ODEQ, ODFW, WDOE, WDFW and the lower Columbia Tribes, including the Nez Perce, Yakima, Umatilla, Warm Springs, Cowlitz tribes and the Columbia River Inter-Tribal Fish Commission.

Other organizations: In additional to the above organization, EPA will coordinate with the Northwest Power and Conservation Council, Fish Passage Center, the Lower Columbia River Estuary Program, Pacific Northwest university fisheries programs, including the University of Idaho and Oregon State University, and other organizations and experts as identified

Overall Timeframe for Development of Plan

- Draft Plan for public comment (Spring 2018)
- Final Plan (November 2018)

Columbia River Cold Water Refuges (CWR) Plan Chapters & Associated Tasks

Introduction

Objectives: To provide an overview of the project including a discussion of warm temperatures and salmon, Oregon Water Quality Standards, EPA Temperature Guidance, NOAA BiOp and RPA.

Chapter 1. Characterization of the Current Spatial and Temporal Distribution of CWR

Objectives: Identify tributaries within the project reach that could act as CWR; to characterize the spatial and temporal extent of each CWR; characterize the Columbia River mainstem temperatures, and assess CWR and Columbia River mainstem temperatures under climate change conditions.

Approach: Identify CWR by compiling all existing temperature and flow data for each tributary to Columbia River within project reach; filling data gaps with field monitoring; screen tributaries based on >2°C colder than Columbia River and summer flows >10cfs; and characterize the thermal spatial and temporal extent of each screened tributary using CORMIX dilution model or by conducting field plume characterization. Characterize the spatial and temporal temperature patterns of the mainstem Columbia River (e.g., longitudinal thermal profile) with modeled and field data. Apply climate change projections to determine the persistence of CWR and changes in Columbia mainstem temperatures under various climate change scenarios.

Definitions: Per Oregon water quality standards, "Cold Water Refugia" means those portions of a water body where or times during the diel temperature cycle when the water temperature is at least 2 degrees Celsius colder than the daily maximum temperature of the adjacent well-mixed flow of the water body. CWR, per Oregon's CWR definition, that are over 18C will be qualified as "marginal" CWR due to the limited thermal benefits of refuge greater than 18C. CWR where salmon and steelhead access and use is limited by geomorphic features or water quality conditions will be qualified as "limited-use CWR."

Assumptions and Limitations:

- CWR tributaries that have August mean flows of less than 10 CFS are assumed to be too small for salmon or steelhead to detect and/or provide sufficient refuge space and therefore not included as CWR.
- Data are available from the NorWest model at a nominal 1km resolution.
- For plumes that cannot be modeled or monitored, we will be making assumptions about size.
- We will be using modeled temperature and flow in some cases.
- CORMIX model will be assuming: uniform discharge (velocity and depth) entering a uniform receiving water (velocity and depth profile); no heat exchange with atmosphere with physical mixing only; and include structural limitations of the CORMIX model framework (Doneker and Jirka (2007), such as internally selected mixing modules

Tasks

1. Identify and assemble existing Columbia River tributary temperature monitoring data (States, Norwest, USGS, LCREP, etc.) to identify, map, and categorize tributaries that may provide CWR relative to the Columbia River. Generate tributary vs. Columbia River temperature and flow comparison graphic summaries for CWR tributaries. Develop a screened list of CWR tributaries with August mean flow greater than 10 cfs for detailed analysis.
2. Develop a QAAP and conduct instream tributary monitoring for targeted tributaries with insufficient temperature data to characterize CWR.
3. Develop a QAAP and conduct plume modeling (CORMIX) to characterize the spatial (3 dimensional) and temporal extent of targeted tributary plumes.
4. Develop a QAAP and conduct thermal plume monitoring study to characterize the spatial (3 dimensional) extent of targeted tributary plumes that are unsuitable for CORMIX modeling.
5. Identify geomorphological features (springs, hyporheic flows, sand bars, etc.) that may serve as potential CWR through inquiries of local experts and review studies/reports; characterize their associated areal extent and volume.
6. Characterize the Columbia River mainstem longitudinal, seasonal, diurnal, and vertical thermal patterns, including inter-annual variability. Describe the time duration the mainstem is above critical temperature thresholds. Generate summary graphics.
7. Characterize Columbia River mainstem and selected tributary historical temperature trends and future predictions with climate change. Develop predicted temperature profiles for Columbia River and selected tributaries for a range of climatic conditions and climate change scenarios.
8. Develop outline of Chapter 1, assemble above information and write draft Chapter 1 and associated appendices of Columbia River CWR plan.

Chapter 2. Characterization of Salmon and Steelhead use of CWR

Objectives: Characterize the current pattern of CWR use by salmon and steelhead species migrating through the Columbia River between June and September (with specific emphasis on SR Fall Chinook, SR Sockeye, Snake River Steelhead, Upper Columbia Steelhead, and Middle Columbia Steelhead) and the associated Columbia River temperatures that trigger use of CWR; describe the adverse effects, survival rates, and temperature-survival relationship for salmon and steelhead migrating through the Columbia River mainstem; and the describe the fitness advantages and risks associated with use of CWR..

Approach: Use existing research, reports, and data analyses, identify, per species, run size, migration route, travel time, and location and extent of CWR use. Correlate duration of CWR use and migration rate through the Columbia River with mainstem temperatures. For each species, quantify overall thermal exposure to temperatures above biological thresholds under different temperature conditions (e.g., hot, cold, median summers).

Definitions: N/A at this time.

Assumptions and Limitations:

- Successful migration is measured by returns to spawning ground.
- The data available is representative of those species.
- Data on spawning success is limited.
- Absence of data on fish that don't use CWR during critical temperatures.
- Data is limited on use of CWR below Bonneville.

Tasks:

1. For salmonids species migrating through Columbia River between June and September, characterize their migration (run timing, run size, spawning location and migration route) and compare migration timing to Columbia River mainstem temperatures.
2. Summarize what temperatures trigger impacts to migration fitness (e.g., swimming, gametes survival, energy loss, disease, delayed spawning).
3. Assemble and synthesize existing studies and reports related to salmon and steelhead use of CWR in Columbia River to determine: what tributaries are used for CWR, by which species, under what temperature conditions, and for how long; the number of fish for each species holding in Columbia River at different CWR locations.
4. Assemble and synthesize existing studies and reports to quantify adult migration survival rates and the mortality vs temperature relationship for salmon and steelhead migrating through the Columbia River mainstem.
5. Prepare and hold a technical workshop to gather input and establish contacts.
6. For representative fish for each species, define individual fish travel pathways and temperature exposure patterns for fish that use and don't use CWR. Based on scientific literature estimate a survival and egg viability relationship for different temperature exposure patterns.
7. Identify by species what data is missing. Work with researchers to propose studies to fill gaps.
8. Develop outline of Chapter 2, assemble above information and write draft Chapter 2 and associated appendices of Columbia River CWR plan.

Chapter 3: Assessment of whether the Spatial and Temporal Extent of CWR meets Oregon's CWR Narrative Criterion, and if not, the additional Extent Needed.

Objectives: To evaluate the energetic and fitness consequences of CWR use by migrating adult salmon and steelhead and compare among different scenarios of CWR use in order to quantitatively estimate whether CWR are 'sufficient' for migrating salmon and steelhead under current and future scenarios.

Approach: Use an individual-based modeling (IBM) approach to: summarize exposure of migrating salmon and steelhead to spatially and temporally variable thermal regimes, fishery harvest, and pathogens; translate those exposures to consequences for individual survival, fitness, or egg viability/energetics; and evaluate alternative scenarios of CWR availability (e.g., warm year, cool year, high quality/frequency of CWR, low quality/frequency of CWR, etc.,) and compare outcomes for fish populations in terms of survival and fitness.

The model will provide a framework for compiling the state of the science regarding what we know about how salmon and steelhead use thermal refuges; the effects of temperature on behavior, fitness and survival; and our assumptions about processes for which we may have limited data.

Definitions: "CWR Sufficiency**"** refers to the ability of refuges to support salmon and steelhead populations as assessed by a measureable physiological or demographic outcome at a defined endpoint. Sufficiency of a suite of refuges available to migrating adult salmon and steelhead within the Columbia River corridor, for example, could be defined by the ability of a network of suitable refuges to provide increased probability of survival or reproductive fitness to the spawning grounds. Refuge sufficiency is influenced by the suitabilities, capacities and characteristics of individual refuges, as well as the spatial and temporal context (temperature and conditions in the mainstem) and arrangement of refuges. It is important to recognize that sufficiency is a relative and context-dependent term, and will need to be defined according to measureable outcomes and criteria. For example, what level of increased probability of survival or reproductive fitness is required to meet the threshold of sufficiency? 1%? 5%? 10% or some other measure? And under what conditions?

Assumptions and Limitations:

- Data availability will be limited for many of the key factors listed above. Assumptions will be need to made in the absence of complete data.
- How fish make decisions regarding whether to use CWR and for how long.
- Density-dependent effect on CWR use.
- How CWR use is affected by minimum temperature, temperature differential, water depth, and distance from migration route.
- Physiological response curves for thermal exposure.
- Species or stock-specific variation in any of the above.
- Temperature data are not available for all times and locations within the study area; temperature data will have to be interpolated where missing, necessitating assumptions about spatial correlation and gradients.
- Effects of dams/passage on thermal exposure and migration timing held constant (not a priority for initial models).

Tasks:

1. Develop HexSim model prototype for Bonneville Dam to The Dalles Dam, including bathymetry and estimated CWR nodes.
2. Run a prototype of model on test reach.
3. Prepare and hold a model workshop with fish modelers and fish physiologists to ground truth model and establish reasonable range of relationship equations and simulations.
4. Expand HexSim model to extend from Bonneville Dam to McNary Dam, and to complete lower Columbia River (RM 0-310) if possible. Run various simulations for fish populations migrating during June-September (e.g., summer steelhead, summer Chinook, Fall Chinook). Run simulations with Columbia River at range of current Columbia River temperature conditions: (e.g., hot, cold, median, years)

5. Develop a framework to determine sufficiency of CWR. Framework may include: thresholds for survival and reproductive success of for each species (e.g., steelhead, summer chinook, fall Chinook) and/or individual ESUs; assessment at current fish returns and/or at recovered and harvestable population levels; and assessment at various Columbia River mainstem temperature conditions.
6. Using information from HexSim model simulations and any other relevant information apply sufficiency framework to determine if CWR in the Columbia River are currently sufficient to meet thresholds.
7. If CWR is currently insufficient, use HexSim model and apply sufficiency framework to determine how much additional CWR is needed under current temperature conditions to meet fish fitness or population thresholds. Also, estimate CWR sufficiency under climate change scenarios.
8. Develop outline of Chapter 3, assemble above information and write draft Chapter 3 and associated appendices of Columbia River CWR plan.

Chapter 4. Programs and Actions to Protect and Enhance Existing CWR

Objectives: Identify priority CWR for protection and enhancement; identify existing mechanisms and additional protection actions to ensure CWR are protected; identify actions to enhance CWR.

Approach: Evaluate information from Chapters 1 – 3 to determine areas with good CWR that should be protected and, if possible, enhanced. This will include factors such as flow, size of CWR, fish use and location. Map these locations. Identify existing programs and future actions to protect CWR by evaluating state and local regulations and programs, TMDL implementation plans, salmon recovery plans, and by collaborating with watershed groups. Develop additional actions to prevent warming of tributaries and to enhance existing CWR.

Definitions: "Priority CWR for Protection" are tributaries which currently provide or have water quality and physical characteristics to be a cold water refuge for salmonids migrating in the mainstem Columbia River. Initial screening factors include: documented or probable CWR fish use; August mean temperature less than or equal to 18C; at least 2C cooler than Columbia River mainstem; and August mean tributary flow greater than 30 cfs.

"Priority CWR for Enhancement" are tributaries that are "Priority CWR for Protection" and can be further restored for even cooler temperatures or improved physical habitat.

Assumptions and Limitations:

- This chapter relies on analyses from Chapters 1-3 and available fish use information.

Tasks:

1. Identify Columbia River tributaries that currently provide cold water refuges and should be protected by evaluating temperatures, documented fish use, flows, CWR volume, and other information summarized in Chapters 1-3.
2. Evaluate whether tributaries in Task 1 have TMDLs and/or watershed restoration plans that indicate the CWR could be enhanced.
3. Develop a map of candidate tributaries to protect and enhance.

4. Verify CWR tributaries to protect and enhance by visiting candidate tributaries. Observe physical characteristics for any barriers that could limit fish use. Coordinate with local watershed groups and organizations for feedback on candidate CWR tributaries for protection and enhancement.
5. For selected "Priority CWR tributaries for Protection," develop watershed maps depicting land use and vulnerability to activities that could warm tributary temperatures. Highlight and summarize the local, state and federal programs and any additional actions to protect and prevent thermal warming in the tributary watersheds and at the confluence/plume areas.
6. For selected "Priority CWR tributaries for Enhancement" highlight specific actions that could be taken by local, state, or federal agencies to enhance CWR.
7. Identify "Priority CWR tributaries for Protection" confluences where habitat structures and/or landscape alterations could improve CWR and/or create better fish access to CWR (e.g., re-establish original stream channel, re-establish natural vegetation, construction of coves, etc.).
8. Develop outline of Chapter 4, assemble above information and write draft Chapter 4 and associated appendices of Columbia River CWR Plan.

Chapter 5: Locations and Actions to Restore CWR

Objective: Identify priority tributaries for restoration; identify restoration strategies; and identify mechanisms (TMDL/Restoration Plans) to incorporate restoration work. Explore how tributary restoration will be moderated by climate change.

Definition(s): "Priority CWR for Restoration" are tributaries that may be marginal CWR or that when restored, would have water quality characteristics and a physical habitat where salmon might use these as cold water refuges. Factors include restored flows (e.g., greater than 30 cfs), restored tributary temperatures (18C or less), and potential difference in temperature between tributary and mainstem (2C or more).

Approach: Evaluate the tributary temperature data in Chapters 1-3 and existing studies such as TMDLs, restoration plans, and salmon recovery plans of Columbia River tributaries. Seek feedback from watershed groups, state and federal agencies, and Tribes to determine tributaries with potential to increase the amount of CWR for salmon and steelhead migrating up the Columbia River. Pending the progress of another project evaluating the feasibility of applying the NorWeST model on temperatures in restored watersheds, we will also model the restored potential temperatures in selected tributaries to determine CWR potential. To determine potential locations for CWR restoration, we will consider: potential to cool tributaries from restoration actions; potential to increase cool water tributary flows; size and significance of potential CWR; potential to enhance CWR via altered physical features; and co-restoration benefits from improved rearing and spawning in the watershed.

Assumptions:

1. Tributaries with TMDLs or other restoration plans will have more site-specific information on restoration potential than tributaries with no restoration plans we may model with NorWeST.

2. We assume that the restored temperatures in TMDLs and other plans are correct and will not do additional modeling in those watersheds.
3. Prioritized restoration projects will depend on information in restoration plans, local knowledge, and tributary-specific information.
4. Due to available information, restoration actions in this chapter may be at a broad scale, but smaller scale projects may be more feasible and less resource-intensive.

Tasks:

1. Identify candidate Columbia River tributaries to restore that could provide cold water refuges. Evaluate temperatures, documented fish use, flows, CWR volume, and other information summarized in Chapters 1-3. Evaluate TMDLs, restoration plans, and other information to evaluate restored temperatures and physical habitat.
2. Verify CWR tributaries to restore by visiting candidate tributaries. Observe physical characteristics for any barriers that could limit fish use. Coordinate with local watershed groups and organizations for feedback on candidate CWR tributaries for restoration.
3. Coordinate with watershed experts to assess the extent priority restoration areas to restore CWR align with overall watershed restoration priorities. Compare locations of restoration actions with areas identified in salmon recovery plans, NWPCC sub-basin plans, and other plans to evaluate whether restoration projects would have multiple benefits for improved fish use.
4. For selected "Priority CWR for Restoration," identify reach-specific restoration actions. Focus on stream features (lack of vegetation, stream alteration, low flow, lack of large woody debris) that could be restored to improve stream temperatures. Use information from restoration plans, published literature, and local knowledge to inform priority areas and restoration actions.
5. Develop a map with "Priority CWR for Restoration," tributary locations and corresponding potential restoration actions.
6. Evaluate the cumulative potential for increased CWR and compare to sufficiency analysis developed in Chapter 3. Identify the degree to which potential increased CWR reduces risks and for various ESUs.
7. Develop outline of Chapter 5, assemble above information and write draft Chapter 5 and associated appendices of Columbia River CWR Plan.

Chapter 6: Scientific Uncertainties and Data Gaps and Recommended Studies and Potential Funding Sources

Objective: Identify important areas of uncertainty and limited data in the Plan and identify potential projects and funding sources to address the uncertainties.

Tasks:

1. Develop list uncertainties and gaps and discuss with NOAA, Army Corps, NWPC, UI, and others to frame potential studies and funding sources.
2. Assemble above information and write draft Chapter 6.
3.