



## Climate Refugia for Salmon

- Failure to attain temperature standards
- Temperature-related mortality of ESA-listed salmon and steelhead populations
- Implications for Tribal Treaty rights, Orcas, among many others



The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

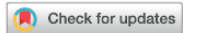


# Finding: Refuges critical for migrating salmon

Cold water refuges are becoming increasingly critical for migrating salmon and steelhead

The screenshot shows the EPA website page for "Columbia River Cold Water Refuges". The page header includes the EPA logo and navigation links for "Environmental Topics", "Laws & Regulations", and "About EPA". The main content area features a sidebar with "Columbia River Home", "Chemicals of Emerging Concern", "Cold Water Refuges", "Toxics Reduction Action Plan", and "About EPA's Work in the Basin". The main heading is "Columbia River Cold Water Refuges". Below the heading, there is a paragraph stating: "EPA is in the process of finalizing our draft Columbia River Cold Water Refuges Plan. As part of the public review of the temperature TMDL for the lower Columbia and Snake Rivers, the public has the opportunity to comment on Section 5.0 and Section 6.5.6 of the TMDL that addresses cold water refuges. Therefore, we will review public comments on the TMDL prior to finalizing the Cold Water Refuges Plan. For more information, see [Draft Columbia River Cold Water Refuges Plan](#)." Below this text is a list of links under "On this page": "About Cold Water Refuges", "Project Goals", "Partners", "Contacts", "Related Information", and "Documents". To the right of the text is a photograph of a wide river valley with mountains in the background. At the bottom of the page, there is a section titled "About Cold Water Refuges" with the subtitle "Supporting Healthy Salmon and Steelhead Migration".

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<https://doi.org/10.1080/24705357.2020.1855086>



## Assessing contributions of cold-water refuges to reproductive migration corridor conditions for adult salmon and steelhead trout in the Columbia River, USA

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EPA website for more info:

<https://www.epa.gov/columbiariver/columbia-river-cold-water-refuges>



# Finding: It's not just cold water! (part I)

nature  
climate change

ARTICLES

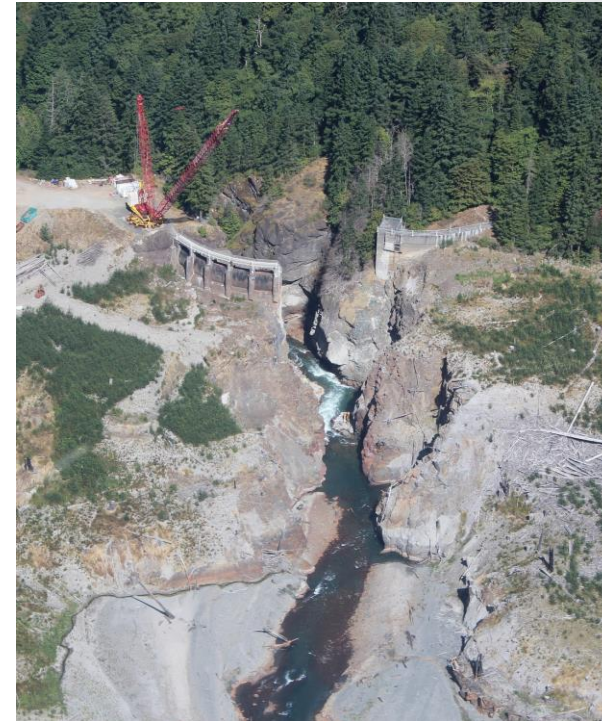
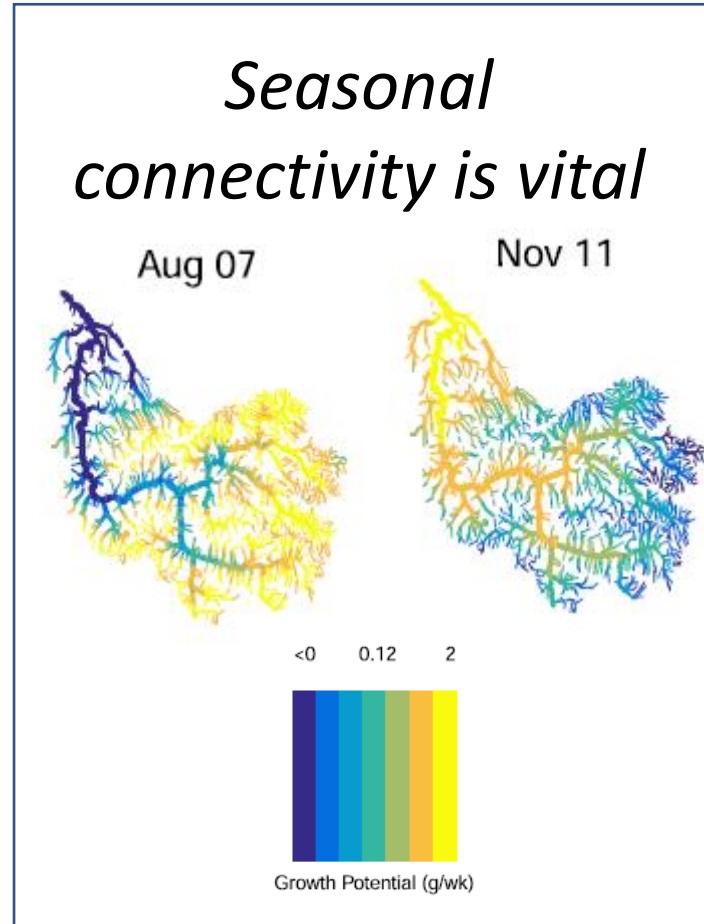
<https://doi.org/10.1038/s41558-021-00994-y>



## The importance of warm habitat to the growth regime of cold-water fishes

Jonathan B. Armstrong<sup>1</sup>✉, Aimee H. Fullerton<sup>2</sup>, Chris E. Jordan<sup>2</sup>, Joseph L. Ebersole<sup>3</sup>, J. Ryan Bellmore<sup>4</sup>, Ivan Arismendi<sup>1</sup>, Brooke E. Penaluna<sup>5</sup> and Gordon H. Reeves<sup>5</sup>

A common goal of biological adaptation planning is to identify and prioritize locations that remain suitably cool during the summer. This implicitly devalues areas that are ephemerally warm, even if they are suitable most of the year for mobile animals. Here we develop an alternative conceptual framework, the growth regime, which considers seasonal and landscape variation in physiological performance, focusing on riverine fish. Using temperature models for 14 river basins, we show that growth opportunities propagate up and down river networks on a seasonal basis, and that downstream habitats that are suboptimally warm in summer may actually provide the majority of growth potential expressed annually. We demonstrate with an agent-based simulation that the shoulder-season use of warmer downstream habitats can fuel annual fish production. Our work reveals a synergy between cold and warm habitats that could be fundamental to support cold-water fisheries, and highlights the risk in conservation strategies that underappreciate warm habitats.



Elwha River Dam Removal. USGS Photo.

Climate adaptation options?




# Finding: It's not just cold water! (part II)

THE ECOLOGICAL SOCIETY OF AMERICA

## Frontiers in Ecology and the Environment

Volume 18, Issue 5  
Special Issue: Climate-Change Refugia  
Pages: 225-308  
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CLIMATE-CHANGE REFUGIA 271

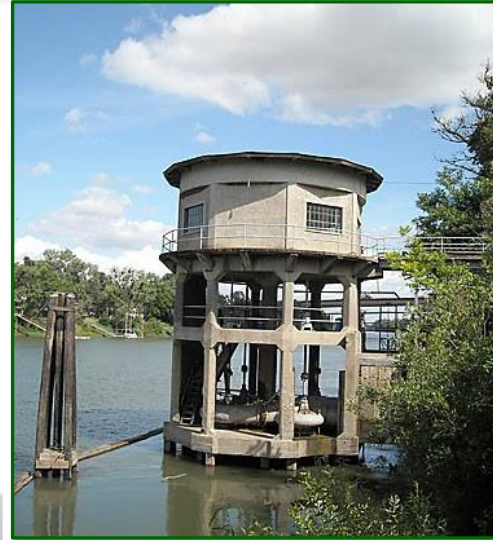


### Managing climate refugia for freshwater fishes under an expanding human footprint

Joseph L Ebersole<sup>1\*</sup>, Rebecca M Quiñones<sup>2</sup>, Shaun Clements<sup>3</sup>, and Benjamin H Letcher<sup>4</sup>

Within the context of climate adaptation, the concept of climate refugia has emerged as a framework for addressing future threats to freshwater fish populations. We evaluated recent climate-refugia management associated with water use and landscape modification by comparing efforts in the US states of Oregon and Massachusetts, for which there are contrasting resource use patterns. Using these examples, we discuss tools and principles that can be applied more broadly. Although many early efforts to identify climate refugia have focused on water temperature, substantial gains in evaluating other factors and processes regulating climate refugia (eg stream flow, groundwater availability) are facilitating refined mapping of refugia and assessment of their ecological value. Major challenges remain for incorporating climate refugia into water-quality standards, evaluating trade-offs among policy options, addressing multiple species' needs, and planning for uncertainty. However, with a procedurally transparent and conceptually sound framework to build upon, recent efforts have revealed a promising path forward.

Front Ecol Environ 2020; 18(5): 271-280, doi:10.1002/fee.2206



*Human actions matter*



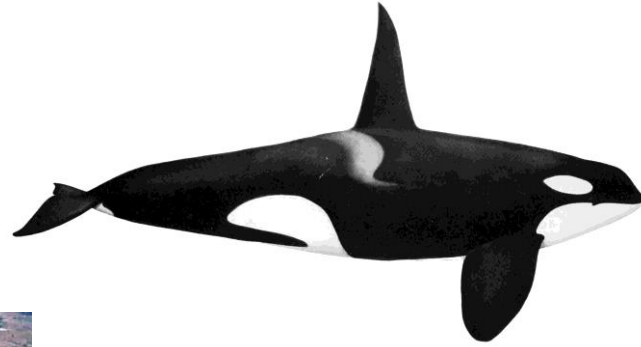
Photo: The Nature Conservancy

**(Warming) x (Human Land and Water Use) = Double Whammy**

**Or adaptation opportunity?**



## Who cares?



*ESA-listed species*

- *salmon*
- *Orca*

*Energy production*

*Coastal fisheries*

*Tribal treaty rights*



- Water quality and fish population modeling
- Linkage to economic models





## Publications from this work

- Armstrong, J. B., Fullerton, A. H., Jordan, C. E., Ebersole, J. L., Bellmore, J. R., Arismendi, I., . . . Reeves, G. H. (2021). **The importance of warm habitat to the growth regime of cold-water fishes.** *Nature Climate Change*, 1-8.
- Ebersole, J. L., P.J. Wigington, Jr., Leibowitz, S. G., Comeleo, R., & Sickle, J. V. (2015). **Predicting the Occurrence of Cold Water Patches at Intermittent and Ephemeral Tributary Confluences of Warm Rivers.** *Freshwater Science*, 34(1), 111-124.
- Ebersole, J. L., Quinones, R., Clements, S., & Letcher, B. (2020). **Climate refugia for cold-water fishes under an expanding human footprint.** *Frontiers in Ecology and the Environment*, 18(5), 271-280.
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