November 2022

WaterSMART

Internal Applied Science Project

BUREAU OF RECLAMATION

Flow Habitat Relationships in the Klamath River for Juvenile Salmon

Analyzing the Effects of Mesh Resolution on Hydraulic Model Results and Habitat Estimates

Modeling Need for Salmon Habitat

The Klamath River in northern California and southern Oregon is important habitat for salmon (Figure 1). Reclamation will use hydraulic models to simulate the flow of water in the Klamath River to estimate the quantity and quality of aquatic habitat. The habitat estimates will be used to select areas most in need of habitat restoration actions and to evaluate the effectiveness of restoration actions.

Hydraulic models analyze specific water movement in the river system but inherently lack representation of the complexities found in real rivers – but by how much? This project investigated the spatial resolution of the hydraulic model and how it affects the simulated hydraulics and habitat estimates, such as water depth, water velocity, and the amount of habitat. The advances in hydraulic modeling will improve Reclamation's decisions about future habitat restoration locations.

Hydraulic Model Overview

Reclamation's two-dimensional hydraulic model covers nearly 200 miles of the Klamath River, from Iron Gate Dam to the Pacific Ocean (Figure 2). At this size, the model has a coarse resolution for estimating the salmonid habitat. This study examined how the coarseness of the model affects the components of existing habitat metrics and the results will help interpret new habitat estimates for threated and endangered fish species in the Klamath River.

Figure 1. Klamath Basin salmon

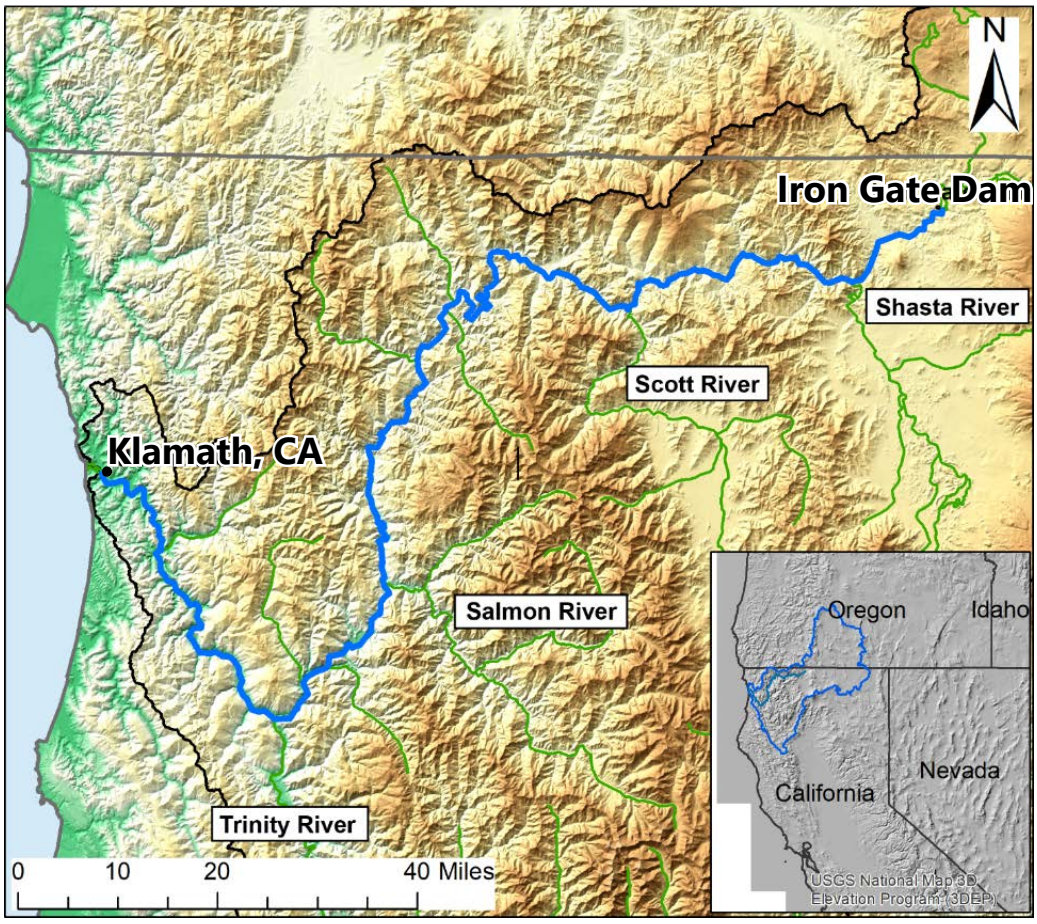

Figure 2. The Klamath River in northern California from Iron Gate Dam at upper right to the Pacific Ocean near Klamath, California at left. The mainstem river is shown as a heavy blue line. The tributaries are shown as green lines.

How are Aquatic Habitat Estimates Affected by Mesh Resolution?

Reclamation developed hydraulic models of varying mesh cell sizes at three sites on the Klamath River using Reclamation's Sedimentation and River Hydraulics two-dimensional model, SRH-2D. The reference resolution (denoted as 1x) is the same as Reclamation's Klamath River model from Iron Gate Dam to the Pacific Ocean. The other meshes were created by doubling the number of mesh nodes in both the streamwise and stream normal direction (2x), doubling again (4x), and doubling one final time (8x). The resulting meshes have channel elements that are approximately 1/4, 1/16, and 1/64 the area of the 1x mesh.

The primary difference between a coarse model mesh with large cells and a higher resolution mesh with smaller cells is how well the mesh represents the river bathymetry. This study examined the effects of varying mesh resolution on channel cross-sectional area, water surface elevation, bed elevation, model wetted area, model water depth and velocity, and juvenile salmonid habitat estimated using a habitat suitability index developed for the Trinity River.

Key Results

The analysis of the varying mesh resolution showed that cross-sectional area tended to increase and bed elevation tended to decrease with increasing mesh resolution, which lowered water surface elevation. The increase in cross-sectional area resulted in a slight increase in total wetted area because shallow areas were better represented by the higher resolution meshes. The amount of slow, shallow water favored by juvenile salmonids increased with increasing mesh resolution. This increase in the amount of slow, shallow water, in combination with the increase in wetted area, resulted in an increase in estimated juvenile salmonid habitat with increasing mesh

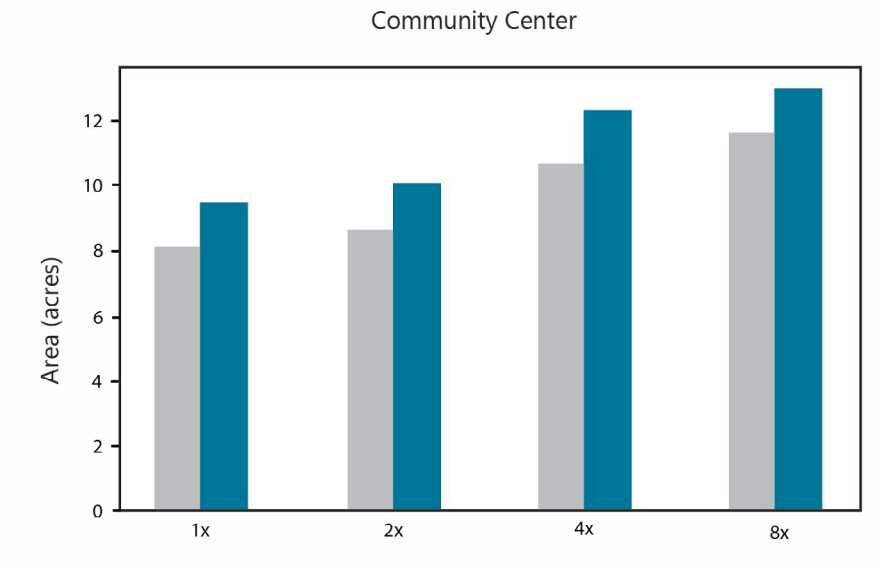

Figure 3. Habitat estimates at the Community Center site increase with increasing mesh resolution. Solid bars (left) indicate fry habitat. Bars with a grid (right) denote presmolt habitat, a later life stage.

resolution. For the highest resolution meshes, there was a 10-44 percent increase in estimated habitat relative to the lowest resolution mesh, depending on site and fish life stage. Habitat results from one site are summarized in Figure 3.

This study confirmed that coarser mesh hydraulic models of rivers tend to underestimate the amount of aquatic habitat relative to models with more detailed spatial resolution. It quantified the differences and detailed why models that use a higher resolution mesh predict larger areas of the slow, shallow water that juvenile salmonid favor.

Continued Coordination

The U.S. Fish and Wildlife and the U.S. Geological Survey are developing a data collection and analysis plan that forms the basis of new salmonid habitat metrics for the Klamath River. Estimates of the quality and quantity of salmonid habitat in the Klamath River will be computed using results from Reclamation's hydraulic model when the new metrics become available. These habitat estimates will inform habitat restoration efforts on the Klamath River by identifying areas most in need of habitat restoration actions, guiding the type of action performed, and providing a baseline to evaluate the effectiveness of restoration actions.

Additional Information

Useful Links for Applied Science:

https://www.usbr.gov/watersmart/appliedscience/index.html

WaterSMART Website:

https://www.usbr.gov/watersmart

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