RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Measuring Biological Effects of Altered Flows

Understanding how flow and water temperature relate to stream health

Bottom Line

Aquatic invertebrates are important ecological indicators of flow and temperature alterations because of their rapid response to environmental changes. This research project examined the degree of alteration in macroinvertebrate communities to help evaluate the relationship between the severity of hydrological alteration (including flow and temperature) and the biological integrity of the ecosystem.

Better, Faster, Cheaper

Using aquatic invertebrates as indicators provides an accurate, low-cost method for environmental assessment and evaluation that is directly related to important resources. These insights could help develop models that would aid researchers and managers in predicting the ecological consequences of streamflow alteration expected under various scenarios of climate change.

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Problem

Regulated flows need to meet the needs of both ecosystems and society. Understanding ecosystem requirements, however, has been hindered by an inability to quantify the relationships between stream health indicators and hydrologic alteration.

Alteration of natural streamflows is a multidimensional phenomenon affecting frequency, duration, and timing of various streamflow magnitudes. In addition, altered flows affect stream ecosystems through habitat modification, temperature modification, desiccation, and sheer stress. Changes in aquatic macroinvertebrate communities may occur because of altered habitat, changes in sediment input, water quality, thermal regimes, and flow patterns. Aquatic invertebrates also play a role in transferring energy to higher trophic levels since they are a major part of the food resource for fishes. Changes in invertebrate communities may result in changes in condition of fish communities. Further, many aquatic invertebrates have nonaquatic phases leading to their importance to other predators, including birds.

This quantification of flow/thermal alteration in simple terms and biology in terms of condition will provide valuable ecological information for decisionmakers.

Sampling aquatic invertebrates in a Sierra Nevada (California and Nevada) stream.

Study and Results

This Reclamation Science and Technology Program research project expands a preliminary exploration of the range of biological integrity as represented by macroinvertebrate communities encountered over a wide range of hydrological alteration (see research project "Assessing the Ecological Costs of Streamflow Regulation," which can be found at: www.usbr.gov/research/projects/detail.cfm?id=6188).

This effort is among the first to quantify the relationships between biological integrity and hydrological alteration. This research project conducted macroinvertebrate community assessments in a set of regional rivers in the Sierra Nevada mountain range (California and Nevada) with varying degrees of hydrological alteration and provide quantitative relationships between measures of invertebrate community integrity and hydrological/thermal alteration.

Aquatic invertebrate samples were collected and hydrological information obtained from U.S. Geological Survey Sierra Nevada gaging stations that varied in flow alteration. Hourly water temperatures were measured for about a year with site-deployed temperature loggers. Hydrological and thermal alterations at each site were computed relative to reference site values, both observed and expected.

March streamflows and summer water temperatures were important predictors of invertebrate communities. Temperature alterations did not necessarily covary with streamflows, possibly because of variability in dam flow management. Hydrology and temperature may be differentially important to macroinvertebrates at some damsites. Macroinvertebrate taxa were identified that increased or decreased in response to dam operations and some of these responses were found to be consistent with other studies.

Future Plans

While the previous study in this area focused on flow, this research project's results point to the additional importance of temperature in modification of biotic communities. Although the exact mechanisms remain unclear, these relationships are still a useful guide to decisions about the tradeoff between flow depletion and stream health. The ability to generalize this relationship to other mountain streams, such as Rocky Mountain streams, also remains unclear and needs corroboration by similar studies in other subregions. It is also unclear how far downstream modifications in macroinvertebrate communities are continued. These data would be useful in assessing the full impacts of flow/temperature alterations on aquatic communities.

Future studies should focus on these other dimensions of natural streamflows, as well as the mechanisms that affect biological communities and their habitats as hydrological characteristics are altered by water management activities.

"The nation's waterways are called upon to serve many purposes and populations. Each use adds physical and biological stress to the river that the ecosystem must bear. Managing our part of each river's course is key to Reclamation's mission. Techniques like those in this study are useful for indicating the status and trend of waterways, based on the lowest level biologic building blocks. If the bugs, water temperature, habitats, and other basic components are prospering, theory says that the conditions for sustaining or recovering higher level ecosystem components are positive."

Rod Wittler
Mid-Pacific Region Science Liaison, Research and Development Office

More Information

Carlisle, D.M., S.M. Nelson, K. Eng. 2012. *Macroinvertebrate Community Condition Associated With the Severity of Streamflow Alteration*. River Research and Applications.

www.usbr.gov/research/projects/detail.cfm?id=8721

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www.usbr.gov/research/docs/updates/2013-08-streamflow-ecology.pdf