National Park Service
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Denali National Park and Preserve

Ecology of Upwelling Areas in the Toklat River

Photo credit: Jill Crossman

Flow in the Toklat River is a combination of glacial meltwater, run-off from side valleys, and upwellings. Biodiversity is high in the upwelling channels because of nutrients and channel stability.

These large braided rivers may look like sterile, inhospitable environments, but there is, in fact, a complexity of habitats with high biodiversity.

—Alexander Milner
Institute of Arctic Biology

Springs of water bubble to the surface in small channels of the Toklat River, upriver from the park road. These upwelling channels occur where the braided channel of the main river flows through low terraces at the side of the wide outwash plain. The fact that these upwelling channels and their surrounding vegetation are very different from the large braided channel of the main river has intrigued Dr. Alexander Milner for years.

The upwelling channels run clear, not turbid with glacial silt as the main channel often does. The upwelling channel areas support more willows and woody vegetation than the gravel bars adjacent to the main Toklat. If they are like upwelling channels elsewhere, they are "hotspots" of biodiversity.

Dr. Milner, colleague Dr. Chris Bradley, and graduate student Jill Crossman are investigating these upwelling channels, and the mechanics of how the natural mixing of waters in the Toklat produces the conditions to support their high biological diversity.

Sources of water flow in the Toklat

Water in the Toklat River is a result of three flow sources, each with different physical and chemical properties: (1) glacial melt (ice and snow) at the head of the valley, (2) run-off of precipitation from valley sides, and (3) groundwater upwellings.

The Toklat has seasonal periods of high and low flow typical of large glacial rivers. The braided main channel has maximum flow and turbid waters during warm summer days when glacial melt is maximum. When snow- and ice-melt are reduced, the braided flow is likewise reduced. In winter, the river is a single channel with clear water.

Biodiversity in upwelling channels

If the Toklat water flow is similar to upwelling systems studied elsewhere, the turbidity and channel instability of the main braided channel typically translate to poor habitat for biotic communities. In contrast, the more stable upwelling channels provide productive habitat for algae, macroinvertebrates, and fish. They also support woody plant growth (e.g., willow and birch) that is important for many animals, including moose and bears. The upwelling areas may also be important as summer habitat for species that feed on fish or macroinvertebrates (e.g., wading birds), and as overwintering habitat for fish.

Research objectives

By quantifying and comparing the upwelling channels and the main glacial channel in terms of water temperature and chemistry, rates of water flow, and plant and animal composition, these three researchers can determine how the flowpaths influence the biological diversity of the upwelling

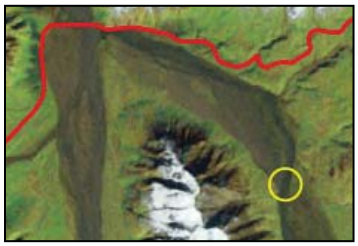
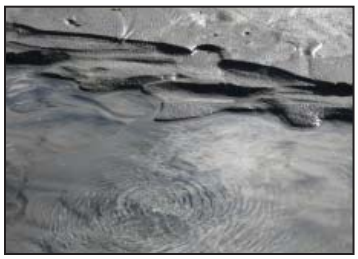


Photo by Jill Crossman



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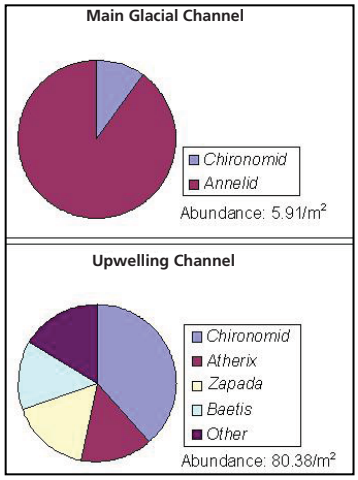


A satellite image of the Toklat, with the study site (yellow) upriver of the park road (red).

Researchers install a small pipe (piezometer) in one of the upwelling channels.

Bubbles are visible where the groundwater flow reaches the surface in an upwelling channel.

The number and diversity of macroinvertebrates was higher in the upwelling channel than in the main glacial channel.

channels. Specifically, they are collecting data to determine (1) whether the combined water flow in the upper Toklat River basin has spatial and temporal patterns that reflect the three contributing water-flow pathways (glacial melt, runoff, upwellings), (2) whether the temperature regime in the upwelling channels is less variable than that in the main glacial channel, (3) whether the chemical properties of the upwelling channels are different from those of the main glacial channel, (4) how the richness and abundance of the biotic communities in the upwelling channels compare to those in the main glacial channel, and (5) whether riparian (stream bank) vegetation associated with upwelling channels differs significantly from other areas of the Toklat.

Research methods

To measure water levels in the upwelling channels, in 2007, the field crew installed nested piezometers (small pipes inserted side by side into the river at depths of about 6 in and 12 in (15 and 30 cm) (see photo at left). Water level was also monitored in a braid of the main glacial channel of the Toklat River. From July to September 2007, field staff checked water levels in each piezometer two or three times daily to detect fluctuations in flow and to create flow nets (diagrams of water flow).

Water samples taken from the stream surface and below the surface were analyzed for water chemistry (nutrients and ions), pH (acidity), and conductivity. Researchers collected macroinvertebrates every two weeks from surface channels using a Surber sampler (a net that funnels water into a collecting vial) and every week from water pumped out of the piezometers.

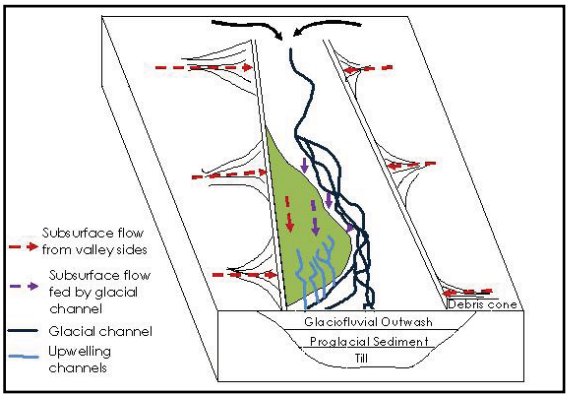
Patterns of water flow

During a 24-hour period, the pattern of rises and falls in stage (water level) of the main glacial channel, due to variation in glacial melt with time of day, was also mirrored in the upwelling channels (see graph at right). However, there was a time lag of about 20 hours. This pattern suggests that the upwellings are being fed predominantly by the main glacial channel, with the time lag due to the time it takes the water to seep through as groundwater.

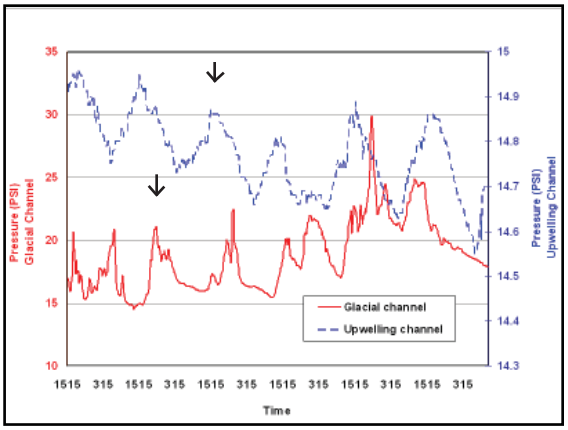
After a heavy rainfall, there is an increase in stage of the main glacial channel and of the upwelling channels suggesting that additions by rainwater from valley sides may also play a role. Chemical analysis of the water samples will provide more clues about the water flow. The glacial water may flow within the terrace and then emerge where the terrace slopes to the level of the subsurface water table.

Biodiversity hotspots

Because the upwelling channels have a stable flow and are likely to be enriched by nutrients, they provide more suitable habitat for biota than the main glacial channel. Compared to the glacial channel, the upwelling channels had higher chlorophyll levels and both higher abundance (25 times higher) and higher diversity of macroinvertebrates (see pie charts at left).



Both glacial meltwater and valley runoff may influence the upwelling channels on the terrace (shaded green) at the edge of the Toklat River.



Daily fluctuations in the water level (stage) of the upwelling channels (dashed blue line) mirror but lag about 20 hours behind those of the main glacial channel (solid red line). For example, researchers hypothesize the arrows in the two graphs represent corresponding pressure peaks.

Ongoing study

In 2008, researchers will collect macroinvertebrates again to further characterize seasonal fluctuations in diversity and abundance. They will repeat the hydrological and chemical studies to detect any year-to-year variation in the upwelling channels. A detailed map of the channels, terraces, upwellings, and vegetation will be used, in conjunction with additional piezometers on terraces further upstream, to identify all water flow sources and to refine the flow nets. This intensive study of the Toklat will enable a better understanding of how species diversity in other Denali rivers may change over time with changes in water flow and other river characteristics.

For more information

Alexander Milner
Institute of Arctic Biology
University of Alaska Fairbanks
ffamm@uaf.edu