Heat Wave Impacts on Glacier Mass Balance, Glacier Runoff, and Salmon in Nooksack River, Washington

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ABSTRACT

In the North Cascade Range, Washington, USA, glacier runoff is a major source of streamflow during the summer low-flow season and mitigates both low-flow and high-water temperatures, particularly during summer heat waves. A thirty-eight-year record (1984-2021) of glacier mass balance and areal extent measurement indicate a significant glacier response to climate change in the North Cascades, Washington, that has led to declining glacier runoff. The ameliorating role of glacier runoff on discharge and water temperature is examined during 23 late-summer heat wave events from 2010-2021 including the early summer 2021 Pacific Northwest heat wave. The heat waves are characterized by local temperature data. Glacier runoff is determined using synchronous observations of glacier ablation on Sholes Glacier and stream discharge immediately below Sholes Glacier. The observed ablation rate is applied to glaciers across the North Fork Nooksack watershed, providing daily glacier runoff discharge to the North Fork Nooksack River. This is compared to observed daily discharge and temperature data of the North Fork Nooksack River and the unglaciated South Fork Nooksack River from the USGS. During the 23 warm weather events the discharge increased an average of +23% in the North Fork and decreased an average of 20% in the South Fork. For water temperature the mean increase was 0.7 °C in the North Fork and 2 °C in the South Fork. For the North Fork glacier runoff production was equivalent to 34% of the total discharge during the 23 events. Heat waves that occurred after significant bare firn and ice was exposed on the glacier surface led to peak glacier discharges. Ongoing climate change will cause further decreases in summer baseflow and an increase in water temperature potentially exceeding tolerance levels of several Pacific salmonid species.

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