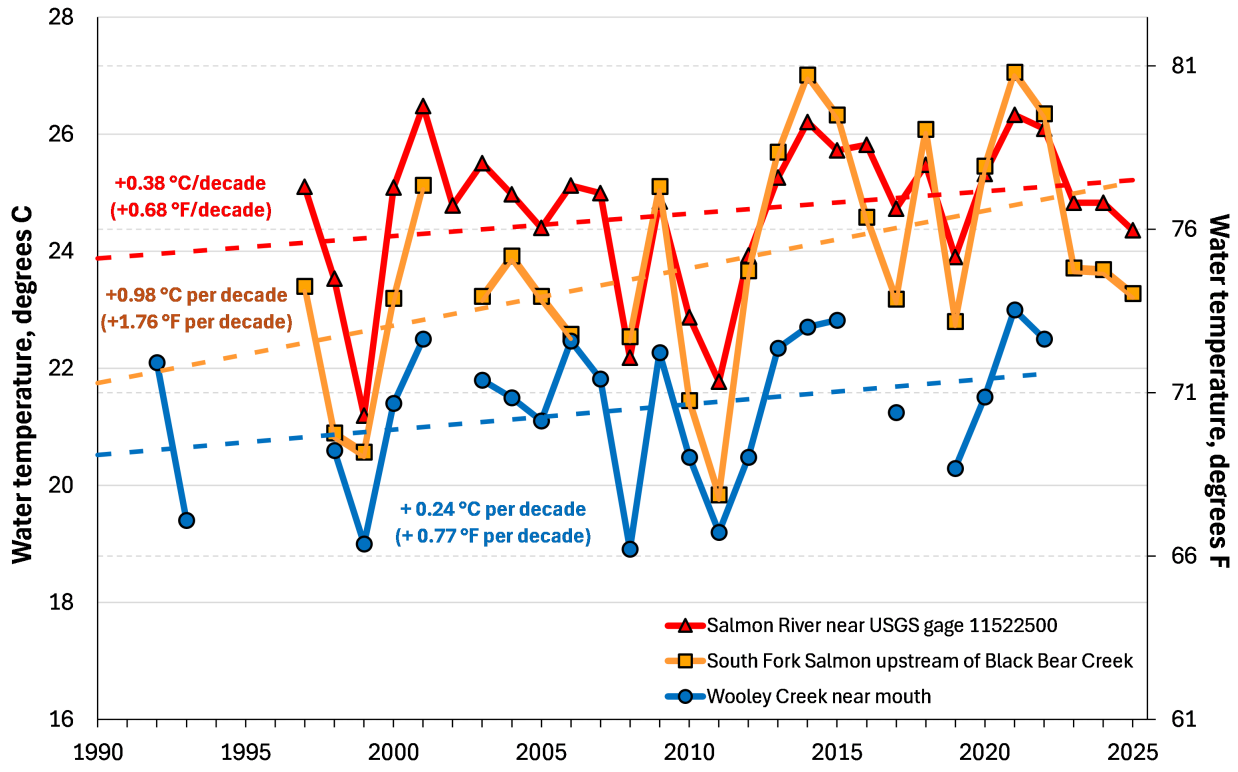
# 3.14 Salmon River Water Temperature

Water temperatures in the Salmon River and its tributaries have been warming, coincident with warming air temperatures and decreasing snowpack. The watershed has been relatively little altered by human activities and has no dams. The river's aquatic life, including salmon, depends on cold-water conditions, making it suitable for tracking the ecological effects of climate change.

## Figure 3.14.1. Salmon River Water Temperatures* (1992-2025).




The figure above shows annual maximum temperatures -- i.e., the highest instantaneous temperature--during the summer, at three monitoring sites in the Salmon River watershed. Dashed lines denote linear trends. Source: SRRC, Karuk Tribe, and USFS (2026)

## What does the indicator show?

From 1992 to 2025, water temperatures, measured as annual maximum temperature (AMT) at three sites in the Salmon River watershed (**Figure 3.14.1**) are trending higher. The Salmon River watershed is a 750 square mile sparsely populated area in Siskiyou County surrounded by subranges of the Klamath Mountains. Temperatures at the South Fork Salmon River site upstream from Black Bear Creek are increasing the fastest, with a rate of 1.8 degrees Fahrenheit (°F) per decade, or 0.98 degrees Celsius (°C) per decade. Water temperatures at the Wooley Creek and Salmon River at US Geological Survey (USGS) gage stations are increasing more slowly, with rates of 0.68°F (0.38°C) and 0.77°F (0.43°C) per decade, respectively.

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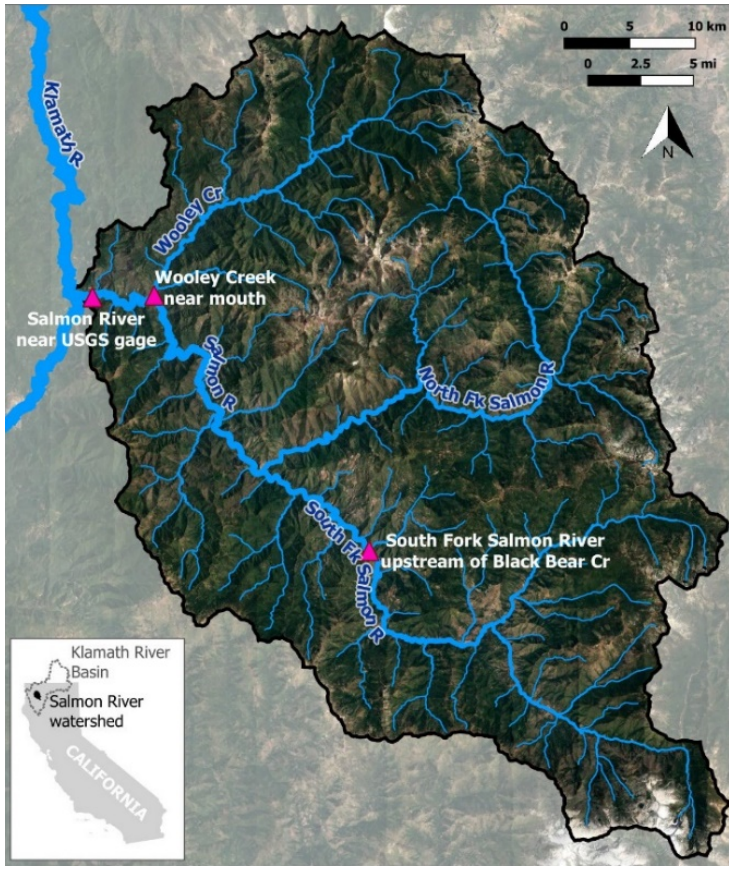
### Figure 3.14.2. Location of Three Temperature Monitoring Sites in the Salmon River Watershed.




Source: Riverbend Sciences

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The three monitoring sites (shown in **Figure 3.14.2**) are a subset of many sites throughout the Salmon River and its tributaries where water temperatures are monitored. A previous analysis combined 27 long-term sites in the watershed to assess collective trends for the month of August during the period 1995 - 2017, finding that daily maximum temperatures warmed by 0.70°F per decade (0.39°C per decade) and daily mean temperatures warmed at a rate of 0.38°F per decade (0.21°C per decade) (Asarian et al., 2019). Years showing higher water temperatures generally coincided with low flows and high air temperatures; years reporting the lowest stream temperatures coincided with high flows and cool air temperatures (Asarian et al., 2019).

## Why is this indicator important?

Water temperature is a fundamental regulator of river ecosystems. It influences species' metabolism, growth rates, reproduction and distributions (David et al., 2018). The Salmon River watershed provides cold water habitat for anadromous fish, notably steelhead and coho and Chinook salmon. Identified as a Key Watershed by the US Forest Service, it serves as a refugia for at-risk salmon and steelhead stocks in the Pacific Northwest (Elder et al., 2002). This river system still retains wild runs of salmonid species that have disappeared from much of their historic range within California (SRRC, 2020).

Although the Salmon River (**Figure 3.14.3**) is still affected by the legacy of historic mining that began in the mid-19$^{th}$ century during the California Gold Rush, and some of the watershed's forests have been logged, today's relatively modest human influences make it an excellent location for tracking the effect of climate change on water temperatures (Asarian et al., 2019). The river has no dams and much less water is diverted for human uses in the Salmon River watershed than in other areas of California due to the area's low population density.

Warming summer water temperatures threaten the production and health of culturally and economically important fish in the Salmon River watershed (Asarian et al., 2019). Higher temperatures can increase metabolic demands, susceptibility to disease and pose a threat to fish populations, especially to spring-run Chinook salmon. Fish live in these habitats through the entire summer. Under current conditions, temperatures in

portions of the river and its tributaries are likely to exceed thermal suitability for this species during the hottest periods in summer. The survival of the dwindling population of spring Chinook salmon, as well as coho salmon, hangs in the balance. These fish are critical to food security, cultural survival and well-being of the Karuk Tribe and other indigenous peoples in the Klamath Basin (Karuk Tribe, 2016) (see *Chinook Salmon Abundance* chapter for further discussion).

## Figure 3.14.3. Salmon River.

The Salmon River flows from the high elevations of the Salmon Mountains, a sub-range of the Klamath Mountains, in Northern California. It is the second largest tributary to the Klamath River and joins the Klamath at Somes Bar, California, about 106 km (66 miles) upstream from the Pacific Ocean. Photo credit: USDA Forest Service

The Karuk Tribe's Ancestral Territory occupies 60% of the Salmon River watershed, a sub-basin of the larger Klamath River Basin (Elder et al., 2002). The Karuk consider the Salmon River sub-basin as one of the most culturally significant watersheds within the Klamath National Forest. There is a strong commitment for cooperative stewardship of the watershed among residents, the Salmon River Restoration Council (SRRC), the Karuk Tribe, the US Forest Service (USFS), and the California Department of Fish and Wildlife (CDFW) (Elder et al., 2002).

In 1994, the North Coast California Regional Water Quality Control Board and the US Environmental Protection Agency determined that beneficial uses in the Salmon River, including cold water salmonid fisheries, are impaired due to elevated water temperatures (NCRWQCB, 2005). Regulations intended to address those impairments were adopted in 2005. Coho salmon in the basin are state and federally listed as threatened (NCRWQCB, 2005). Spring Chinook salmon were listed as endangered by the state of California in June 2021 (Karuk Tribe, 2021). The removal of four dams on the mainstem Klamath River in 2024 provided spring Chinook salmon opportunities for re-establishing populations in their former habitats upstream of the Salmon River (ODFW and The Klamath Tribes, 2021).

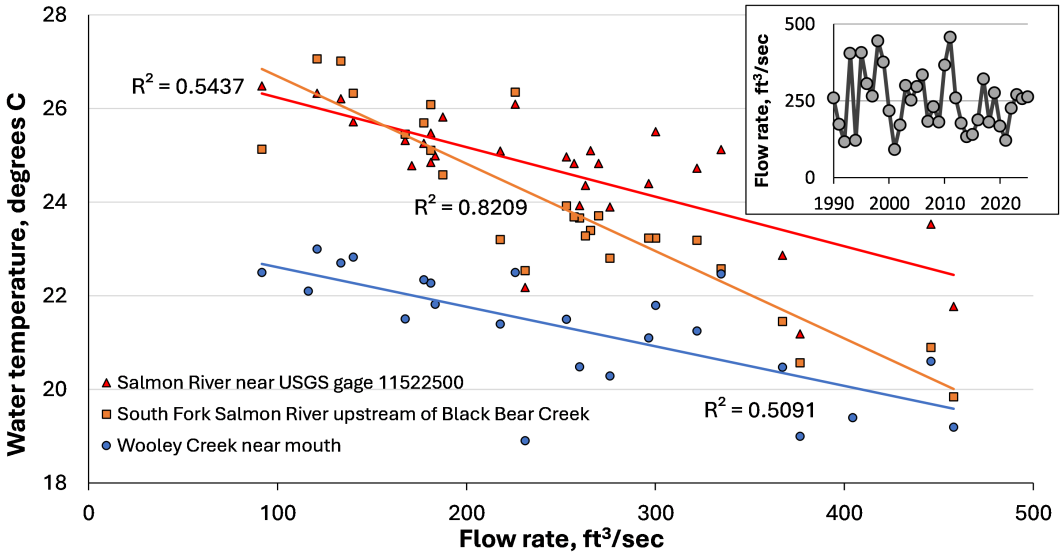
## What factors influence this indicator?

Summer stream temperatures in the Salmon River and its tributaries are trending warmer due to warming air temperatures, decreased snowpack, earlier snowmelt and spring runoff, and decreases in water flow (Asarian et al., 2019; see the *Snow-Water Content* and *Snowmelt Runoff* chapters). Years of low snowpack and snow water runoff tend to yield decreases in stream and river flow in watersheds (Asarian, 2020). Since the 1940s, April 1 snowpack has been decreasing in the Salmon River watershed (CDEC, 2021; Van Kirk and Naman, 2008). Since summer river flow is strongly influenced by snowpack, temperatures at the South Fork Salmon River site are particularly sensitive to climate change and have warmed relatively rapidly since monitoring began in 1997. Water temperature has been increasing at the highest rate at this location (**Figure 3.14.1**). A symptom of warmer temperatures and less snow is the extinction of the Salmon Glacier in the Trinity Alps at the headwaters of the Salmon

River's South Fork in 2015 following a multi-year drought and many decades of ice loss (Garwood et al., 2020; also see *Glacier change* indicator). The nearby Grizzly Glacier has since gone extinct as well. In previous decades, these glaciers fed cold water to streams during the summer.

Streamflow is an important determinant of water temperature (Asarian et al., 2023a and b). River and stream temperatures are cooler when flows are high and warmer during years with diminished flows. **Figure 3.14.4** shows the relationship between stream flow rates during the month of August at the Salmon River monitoring station and maximum temperatures at the three stations shown in **Figure 3.14.1**. Low August flow rates coincided with warmer stream temperatures in 2001, 2014, and 2015. Conversely, higher flow rates in 1999, 2010, and 2011 corresponded with much cooler stream temperatures during those years.

## Figure 3.14.4. River Water Temperatures and August Stream Flow.




Annual maximum water temperatures from 1992 to 2020 at the three monitoring sites are plotted against average August streamflow measured at the Salmon River monitoring station (at Somes Bar, USGS Gage 11522500). ($R^2$ values indicate the strength of the correlation; a value of 1 indicates a perfect correlation between the variables.) The inset graph presents annual average August streamflow over the past 30 years. Source: Water temperature data from SRRC, Karuk Tribe, and USFS (2026); Streamflow data from USGS (2026)

Other physical factors also influence water temperatures in streams and rivers, including solar radiation, heat radiated from objects (e.g., clouds and vegetation), evaporation, convection of heat from air to water, conduction of heat between the water and stream bed, and mixing of water from different sources (Dugdale et al., 2017). During the summer, water temperatures in streams and rivers with wider channels that are more exposed to solar radiation tend to be warmer than water upstream in small well-shaded streams. Water temperatures fluctuate over time in response to atmospheric conditions (air temperatures, clouds, and smoke), hydrologic conditions (snowmelt, rain, stream flow, and groundwater), and growth or loss of vegetation. Factors affecting spatial patterns in water temperature include elevation (cooler air temperatures at higher elevations), topography (mountainous terrain reduces solar exposure), and near-stream vegetation (cooler temperatures where trees provide shade). Wooley Creek flows through steep, mountainous terrain, which partially protects it from solar radiation and keeps its waters relatively cool for its size. Temperatures are increasing at a slower rate at Wooley Creek due to these characteristic features. Because near-stream vegetation helps regulate water temperature through shading, changes in vegetation resulting from wildfires can also affect stream temperatures. Fire plays an integral role in regulating vegetation in the Salmon River watershed. Prior to fire suppression that became effective in the early/mid-20th century, fires burned more frequently and typically in smaller patches compared to what is occurring today (Skinner et al., 2018). Approximately a century of fire suppression has dramatically altered forest structure and fuel continuity. As a result, when fires now occur and escape containment, the probability of high fire severity is increased, which can reduce stream shade and increase water temperature (Karuk Tribe, 2016).

Researchers have been studying the effects of wildfire smoke and its potential to cool water temperatures. David et al. (2018) analyzed ground-based measurements of air and water temperatures from 12 stations throughout the lower Klamath River Basin in correlation with atmospheric smoke data derived from satellite imagery during six years with widespread wildfires. The analysis indicated that wildfire smoke had a cooling effect on both air and water temperatures at all study locations. This smoke-induced cooling has the potential to benefit cold-water adapted species, particularly because

wildfires are more likely to occur during the warmest and driest years and seasons. A follow-up analysis of a larger number of stations showed the cooling effects of smoke were greater in August than in other months and were stronger in larger waterbodies than smaller waterbodies (Asarian et al., 2020). Wildfire smoke has limited the increases in August water temperatures but has not affected annual maximum water temperatures because in most years fires do not start until after the year's hottest water temperatures have already occurred. The Karuk Tribe has used fire to manage the mid-Klamath landscape since time immemorial and has proposed using prescribed fire smoke as an emergency measure to cool potentially lethal stream temperatures in fish habitat areas (Karuk Tribe, 2019).

Researchers conducted an analysis of both climate and non-climate factors and their comparative influence on August stream temperatures using statistical models (Asarian et al., 2019). Climate parameters evaluated were streamflow, air temperature, snowpack, and smoke; the non-climate parameters included landscape features such as riparian vegetation and river channel morphology. Results indicated that warming stream temperatures observed across the Salmon River watershed are largely attributed to climate conditions. The greatest amount of warming occurred at sites where temperatures are highly sensitive to river flow, including the South Fork of the Salmon River.

## Technical considerations

Data characteristics

SRRC; the Karuk Tribe; and USFS [Klamath National Forest (KNF) and Six Rivers National Forest (SRNF)] have been monitoring water temperatures in the Salmon River watershed since 1990 using automated probes that record measurements every 15–60 minutes. Probes are placed in well-mixed flowing water and are intended to represent overall conditions (i.e., "stream temperature"), not isolated pockets of cold or warm water. At most sites, probes are deployed in late spring or early summer, remain through the summer, and are retrieved in the fall for data download (KNF, 2011). A few sites are monitored year-round.

Although many sites are monitored, a subset of three sites that have long, relatively complete records were selected for this indicator:

1) Salmon River at USGS gage 11522500, approximately 1 mile upstream from its confluence with the Klamath River. In addition to the seasonal temperature probes placed by the USFS at this site, the Karuk Tribe also operates a permanent monitoring station here that provides year-round multi-parameter water quality data available online in real-time at: https://waterquality.karuk.us/
2) Wooley Creek, approximately 0.3 miles upstream from its confluence with the Salmon River. Wooley Creek is one of the Salmon River's largest tributaries and its watershed is entirely protected within the Marble Mountain Wilderness, so human impacts are slight.
3) South Fork Salmon River upstream of Black Bear Creek. Long-term data analyses (Asarian et al., 2020) show that water temperatures at this site are highly sensitive to river flow, with temperatures being cool in high-flow years and warm in low-flow drought years.

Strengths and limitations of the data

There are many ways to summarize stream temperature data, and previous Salmon River analyses (Asarian et al., 2019, 2020) evaluated trends for multiple metrics of summer stream temperature. For this indicator, annual maximum temperature is the highest instantaneous maximum temperature recorded during the summer. This metric was chosen because it is simple to calculate, easy to understand, and biologically meaningful. This metric was calculated only for sites and years when there were enough data to be representative (i.e., complete measurements available during the hottest period of the summer) (Asarian et al., 2020). Equipment and techniques for monitoring these sites have improved over time.

**Figure 3.14.1** shows data gaps for certain years at the Wooley Creek and South Fork monitoring sites. Reasons for data gaps include logistical constraints preventing site access (e.g., fires or staffing shortages), malfunctioning, loss of probes due to vandalism, or low water levels exposing probes to air.

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*OEHHA respects the right of tribal nations to govern the collection, ownership, and application of their data. The Karuk Tribe has given OEHHA permission to use the water temperature data and related information presented in this indicator.*

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