Trends in Stream Temperature in the Snake River

Identification

1. Description

This feature examines water temperatures in the Snake River, which winds through Washington, Oregon, and Idaho. Water temperature is particularly important in the Snake River and other rivers of the Columbia Basin because they are home to many species of salmonids (salmon and related fish), which require relatively cold water to migrate, spawn, and thrive. Migrating salmon are an important part of the ecology of the Pacific Northwest, and they also play vital cultural, spiritual, and economic roles for tribal nations in the region. Rising air temperatures associated with climate change can also raise water temperatures, which could make some watersheds less hospitable to salmon. This feature focuses on temperatures in August, which is when rivers and streams in the region typically register their annual maximum temperatures.

2. Revision History

August 2016: Feature published.

Data Sources

3. Data Sources

This feature is derived from stream temperature measurements collected by the U.S. Geological Survey's (USGS's) long-term stream gauge on the Snake River near Anatone, Washington (site # 13334300). The site is located in eastern Washington, near Nez Perce tribal lands. Data from this site have been collected since October 1959.

4. Data Availability

Daily temperature data, including maximum, minimum, and mean temperatures, are publicly available through the USGS National Water Information System (NWIS) database at: http://waterdata.usgs.gov/nwis. Records for this particular location can be found at: http://waterdata.usgs.gov/nwis/inventory/?site_no=13334300&agency_cd=USGS. Site information available at this link includes location, streamflow, temperature, partial pressure of dissolved gases, and gauge height.

Methodology

5. Data Collection

Temperature data at the sampling location near Anatone are collected hourly by automated USGS monitoring equipment. Daily temperature data are available beginning in 1959, although there is a gap in data availability between May 1984 and May 1986. This feature starts with data from 1960.

6. Derivation

Many aspects of water temperature (e.g., maximum, average, variability) are relevant to salmonid physiology and therefore relevant to an assessment of habitat quality. This feature focuses on average August water temperatures, based on an arithmetic mean of all daily mean temperatures during the month. During early years of the temperature record, only daily maximum and minimum temperatures are available. For these years, mean daily stream temperatures were calculated as the average of the daily maxima and minima (Isaak et al., 2012).

7. Quality Assurance and Quality Control

Temperature data are included in the NWIS database only after extensive quality assurance procedures have been met. Sensors are regularly inspected, and data are labeled as provisional until they are reviewed and receive approval. Only approved, final data were used in this feature.

Analysis

8. Comparability Over Time and Space

This feature includes data from one study site, precluding any issues of comparability over space. NWIS quality assurance requirements help to ensure comparability over time.

9. Data Limitations

Factors that may impact the confidence, application, or conclusions drawn from this feature are as follows:

1. Many factors other than climate change can lead to warming of rivers. Specific anthropogenic effects that may result in variable heat loading include:

    - Removal of streamside vegetation through urban development, agriculture, grazing, and forestry.

    - Changes in stream shape due to bank erosion. Wider and shallower streams increase the surface area that is subject to solar radiation and atmospheric heat exchange.

- Water withdrawals for industrial, municipal, and agricultural uses.

- Heated water discharges from industrial facilities, wastewater treatment plants, and irrigation return canals.

- Reduced groundwater flow due to river channeling, straightening, or diking. Increased prevalence of impervious surfaces due to urban development also reduces groundwater flow.

- Dams and associated reservoirs. Reservoirs may increase maximum temperatures by limiting water movement in shallow areas, and because of their increased heat capacity, they may also reduce diurnal temperature variability and seasonal change.

10. Sources of Uncertainty

Uncertainty has not been quantified for this feature. The uncertainty associated with temperature measurements taken at individual sites is thought to be minimal, as the data are collected at regular intervals by electronic instruments that do not depend on human interpretation.

11. Sources of Variability

Water temperatures can vary substantially from year to year, due in part to the variable nature of annual weather patterns. Air temperature, rainfall, and snowpack can all vary naturally from one year to the next, and all of these variables can influence stream temperature. Additionally, climate in the Pacific Northwest can reflect periodicity in ocean conditions (known as the Pacific Decadal Oscillation, or PDO) that may have strong effects on temporal variability in stream temperatures (Mantua and Hare, 2002). Because the length of the dataset includes opposing PDO cycles (Luce and Holden, 2009), however, the potential magnitude of this source of variability is minimized.

The Snake River at Anatone is downstream of a reservoir that could alter thermal trends, but the likelihood of meaningful changes to the river's thermal regime due to the reservoir's presence is minimal. The nearest reservoir is located more than 160 kilometers (km) upstream of the measurement site. Over this distance, river temperatures should equilibrate to local climatic conditions, as spatial lags in the correlation of stream temperatures are typically much shorter than 160 km (Isaak et al., 2010). Additionally, two large, unregulated tributaries enter the Snake River downstream of the reservoir and upstream of the measurement site. These tributaries, the Salmon and Grande Ronde rivers, double the Snake River's volume and further dilute any remaining reservoir effects.

12. Statistical/Trend Analysis

The long-term rate of change in average August water temperatures was computed using the Sen slope method, which finds the median of all possible pair-wise slopes in a temporal data set (Theil, 1950; Sen, 1968; Helsel and Hirsch, 2002). Autocorrelation within the data was addressed using block bootstrap simulations, with block length set to n/3, where n is the length of the time series (Kunsch, 1989). These calculations resulted in a slope of +0.0139°C (+0.0250°F) per year, with a p-value of 0.038, which makes the trend significant to a 95-percent level ($p < 0.05$). The annual rate was multiplied by 55 years to derive an estimate of total change over the period from 1960 to 2015.

References

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