Temperature Thresholds for Trout Species

Real time, continuous-measurement stream monitors show that increasing temperatures in many streams, both locally and worldwide are affecting average summer water temperatures and are increasing the proportion of time during spring and fall that stream temperatures exceed stress and toxicity thresholds for native fish (1). Fish survival under the conditions of a warming climate and high stream temperatures is dependent on their access to the spatial structure of the stream, thus structures that impede fish movements throughout the stream network create challenges for fish populations. Another problem of increasing temperatures is the corresponding decrease in oxygen levels in water or sediment, which causes respiratory stress, changes in behavior, and greater mortality in aquatic life. Biological effects also include large fish dying before small fish, species that need higher dissolved oxygen dying first, fish gulping air, and macroinvertebrates that are sensitive to dissolved oxygen being replaced by fly larvae and worms (2).

Brook Trout spawn in waters that are between 4°C and 10°C and grow optimally between 13°C and 16°C. Cellular stress responses initiate at around 20°C (3, 4). The upper lethal limit for Brook Trout is around 24 °C (incipient, chronic exposures), similarly for Brown Trout and Rainbow Trout. Fish must be able to move throughout the steam, and high stream temperatures make thermal refuge habitats critical areas to lower heat stress. Predictions of trout vulnerability to increasing global heating (5, 6), may depend on the locations and number of thermal refugia in the stream system (7). Loss of thermal refuge habitats is one of the most significant threats to stream fish communities and could lead to extirpation of cold water fish populations (8, 9).

High stream temperatures can affect fish behavior differently among individual fish depending on individual fish attributes such as size, resource needs, personality, and dominance (7). These individual attributes may interact with time spent, and competition for, foraging and seeking thermal refugia. As temperatures approached a critical maximum, fish spent more time in thermal refugia and less time in forage patches where food was available. How close thermal refugia are to foraging locations within their larger habitat may be critical to survival.

TEMPERATURES OF NOTE

Coldwater fish (trout)

Optimal growth: **13–16 °C**
Stress responses initiated: **20 °C**
Upper Incipient Lethal Temperature: **24 °C**

Warmwater fish

Optimal growth: **26–30°C**
Upper Incipient Lethal Temperature: **30–32 °C**

Fishing catch allowances do not address stream temperature limits, nor take into account the changing climate impact on stream temperatures. Survival, reproduction, and growth rates of trout are strongly dependent on their ability to adapt through movement within the spatial and temporal variability in their local ecosystems, and on their tactics for regulating heat exposures (10). Trout move among both main-stem and tributaries at different times through the year for spawning, location of refugia, and greater forage opportunity. Petty and colleagues (10) found that trout mobility is greater in a main-stem or creek with higher temperatures, than in tributaries where temperatures may never come close to 24°C. In the main-stem trout sought thermal refugia from coldwater seeps, tributary confluences, and groundwater upwellings. Management actions are needed to protect and facilitate the movements of mobile fish within the watershed to allow them to respond to catastrophic events, dispersal barriers that prevent movements between the main-stem and tributaries, and over-harvesting, which could cause extirpation of populations.

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