**Topic Summary**

**Salmonid habitat preference in response to temperature**

Salmonids are ectotherms meaning they rely on the environment to regulate their temperature (Breau et al., 2011). Therefore, environmental temperature is tightly linked to physiological and behavioural functioning in salmonids (McCullough et al., 2009). When salmonids experience extreme environmental temperatures, they will behaviourally thermoregulate by moving from suboptimal temperatures to other areas of refuge with physiologically suitable temperatures (McCullough et al., 2009). This behaviour allows them to maintain normal functions such as digestion, territory defense, foraging, and cellular processes (Breau et al., 2011; Tomalty et al., 2015).

Using PIT tagging, snorkel surveys, and environmental data, multiple studies have found that fish aggregate in cooler regions of the river when temperatures rose to suboptimal levels (20-28°C, depending on species and population) (Ritter et al., 2020; Armstrong & Schindler, 2013; Dugdale et al., 2016). The aggregation response has been observed in many populations across the latitudinal range of salmonids indicating the ability of salmonids to adapt to extreme temperatures regardless of thermal history (Armstrong et al., 2016). However, different populations may have varying tolerances to warm temperatures depending on thermal history and exposure time (Corey et al., 2020). Additionally, Armstrong & Schindler’s (2013) multi-year study observed coho seeking out daytime locations based on temperature which changed geographic locations year to year suggesting this migration is indeed behavioural thermoregulation rather than swimming between geographic locations. Interestingly, time of day and duration of temperature exposure can influence behavioural thermoregulation. Coho salmon (Oncorhynchus kisutch) have been known to have a diel horizontal migration in which they forage in cold waters at night and move to warmer temperatures during the day to facilitate digestion (Armstrong & Schindler, 2013).

  Clearly, the search for thermal refuges does not come without a cost and other studies have examined the trade-off between the search for thermal refuges and exploitation of other resources. While Dugdale et al. (2016) also found evidence of behavioural thermoregulation aggregations, they also noticed main stem movement, which likely signaled a search for thermal refuge, did not start until stream temperatures were beyond lethal limits. Armstrong & Schindler (2016) found coho salmon will leave physiologically optimal temperatures in search of food. Another study measured dissolved oxygen in addition to tracking fish movement and temperature and found rainbow trout (Oncorhynchus mykiss) will choose regions with low dissolved oxygen if the temperatures are physiologically preferable than areas with high dissolved oxygen and suboptimal temperatures (Matthews & Berg, 1997). Breau et al. (2011) found adult Atlantic salmon (Salmo salar) will stop defending their territory and foraging in search of thermal refuges when exposed to stressful warming events. These studies exhibit choices salmonids face when trying to maintain optimal body temperatures.

The choices made when faced with these trade-offs underline internal responses in salmonids to changing temperatures. Researchers exposed salmonids to suboptimal temperatures in a lab setting and measured a molecular response, either physiological or genetic, to understand the internal mechanisms. For example, Sauter et al. (2001) found two races of fish, with different life-history strategies, living in the same stream responded differently to high temperatures while migrating out to sea. Fish that migrate during the summer follow stronger temperature cues and often had longer migrations increasing physiological demand thereby requiring a stronger response to higher temperatures when they migrated (Sauter et al., 2001). Breau et al. (2011) measured juvenile and adult Atlantic salmon oxygen consumption and lactate levels. They found adult salmon had increased lactate levels indicating anaerobic metabolic activity which coincided with behavioural thermoregulation at high temperatures (Breau et al., 2011). Tomalty et al. (2015) examined the effect of high heat events on gene expression in chinook salmon and found upregulation of several genes corresponding to a stress response. These studies show the negative impact of high temperatures and suggest several reasons why salmonids exhibit a behavioural thermoregulatory response to temperatures in this way. While it is clear salmonids need to stay within a certain thermal range, it is not yet known how fast and to what thermal maximum populations with different thermal histories and life-history strategies will be able to respond to a rapidly changing climate.

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