Thermoregulation

Definitions:

Thermoregulation- The process by which fish maintain a stable internal temperature or manage physiological functions in response to changes in external water temperature.

Thermal Tolerance- The range of temperatures a fish can survive and function within without experiencing stress or mortality.

Optimal Temperature- The temperature range where a fish performs best in terms of growth, movement, metabolism, and survival.

Ectotherm- An organism that relies on external environmental temperatures to regulate its body temperature. Fish are ectotherms, meaning their internal temperature changes with the surrounding water.

Stress- a physiological response to a challenge or disturbance that disrupts the fish's internal balance, or homeostasis.

Description of Process:

Thermoregulation refers to how fish respond to changes in environmental temperature. Because fish are ectotherms (cold-blooded), their internal temperature matches that of the water. However, they can regulate their behavior to avoid thermal stress by moving out of areas that are too hot or too cold.

Anadromous fish may experience sharp temperature changes during migration, especially in shallow estuarine and riverine habitats. Each species has a thermal tolerance range and an optimal temperature window for activities like spawning, feeding, and migration. When temperatures fall outside this range, fish may become stressed, delay movement, or experience reduced survival.

Thermal stress raises metabolic rates, meaning fish use more energy for basic survival. Prolonged exposure outside optimal temperature can also weaken immune systems, reduce reproductive success, or increase mortality. Younger fish or those with low energy reserves are especially vulnerable.

In modeling, thermoregulation should reflect species-specific thresholds, size- and age-based sensitivity, and the energetic costs of moving to or remaining in thermally suitable areas. It can also interact with other functions, such as foraging or spawning, when temperature becomes a limiting factor.

Little Facts:

- Water temperature affects metabolic rate: warmer water speeds it up, colder water slows it down.
- Fish often shift depth or location to maintain suitable temperatures.
- Thermal stress increases oxygen demand, but warmer water holds less oxygen.
- Prolonged thermal stress can reduce spawning success or lead to mortality.
- Some fish can acclimate gradually, while others are more sensitive to short-term temperature spikes.

Discussion Objectives:

- Is this function accurate and realistic to your knowledge?
- Do all species in the model respond the same way to temperature changes?
- What accounts for species-specific differences (i.e., life stage, physiology, habitat use)?
- Where in the system would you expect the greatest thermal stress, and for which species?
- What kind of outputs should the model include from this function?
    - What physical environmental conditions are more likely to induce thermal stress?
    - Does temperature stress delay migration or alter behavior?
    - Whether higher temperatures increase contaminant uptake or decrease migration success?