Osmoregulation

Definitions:

Osmoregulation- The process by which fish maintain the balance of salts and water in their bodies as they move between freshwater and saltwater environments.

Chloride Cells- Specialized cells in fish gills that help regulate salt levels by actively transporting ions in or out of the body during osmoregulation.

Salt Wedge- Is a bottom layer of dense saltwater that intrudes landward beneath freshwater in an estuary, with mixing concentrated at the interface and the upstream limit defined by the extent of salt intrusion.

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

Description of Process:

Osmoregulation is the physiological process fish use to maintain internal salt and water balance as they move between freshwater and saltwater. Anadromous fish must cope with rapid and frequent changes in salinity, especially in estuarine transition zones. This process relies on chloride cells that are grown or reabsorbed depending on external salinity levels.

Species differ in their osmoregulatory capabilities. Some are better at tolerating rapid changes or wider salinity ranges, while others may become stressed more quickly. Younger fish or those with less energy may take longer to acclimate, increasing risk. Energy is required to grow new chloride cells, maintain existing ones, or remove unneeded cells. When salinity changes rapidly, fish must expend more energy to stay in balance. This process is further influenced by acclimation rate, internal energy reserves, and environmental variability.

Salinity stress can lead to delayed migration, reduced foraging efficiency, or increased vulnerability to predation as a result of increased energy demand. In modeling, osmoregulation should account for individual acclimation, energy cost, and spatiotemporal variability in estuarine salinity. Outputs like stress hotspots or osmoregulation-related energy loss can help guide restoration priorities or evaluate the model.

Little Facts:

- Stress increases respiration and the frequency of water coming in contact with the gills of a fish.
- Water volume across gills is directly correlated to salt balance (more salt across gills leads to increased uptake of salt, or vice versa).
- Chloride cells come in two forms freshwater and saltwater chloride cells depending on a fish's need to excrete extra salt or extra water.
    - You could expect fish use freshwater chloride cells when they move into an estuary, and use saltwater chloride cells when exiting the estuary.

Discussion Objectives:

- Is function accurate and realistic to your knowledge?
- Do all species in the model perform this function?
- What accounts for species specific differences (i.e., acclimation, size, age)?
- Should different types of stress impact risk differently?
    - Salinity stress vs Thermal stress
- Where in the system would you expect the most energy expended for Osmoregulation and why?
- What type of information would we like to know from this function or process?
    - Where fish experience salinity stress?
    - Does this stress impede migration success or other functions & behaviors?
    - Does salinity stress increase mercury exposure or bioaccumulation risk?