Bioaccumulation

Definitions:

Bioaccumulation- The gradual buildup of contaminants, such as mercury, in a fish's body over time through water, sediment, or food.

Biomagnification- The increase in contaminant concentration as it moves up the food chain, causing predators to accumulate higher levels than their prey.

Contaminant Uptake- The process by which fish absorb pollutants through gills, skin, or diet.

Duration of Exposure- The length of time a fish spends in contact with contaminated water, sediment, or prey, which strongly influences the amount of contaminant accumulated.

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

Description of Process:

Bioaccumulation occurs when a fish takes in more contaminants than it eliminates. In estuarine environments, this often involves mercury or methylmercury that binds to suspended particles or enters the food web. As fish move through contaminated areas or consume contaminated prey, these toxic substances build up in their tissues.

Anadromous fish are at high risk during migration and staging, especially in areas where sediment traps contaminants or where foraging and predation occurs in mercury-impacted habitats. Younger fish or smaller-bodied individuals can accumulate contaminants more rapidly due to faster growth rates or higher food intake per body mass.

The rate of bioaccumulation is influenced by environmental factors (e.g., temperature, salinity, sediment loads), physiological traits (e.g., metabolism, lipid content), and behavior (e.g., habitat use, foraging depth, migration timing). Duration of exposure is a key determinant of how much contaminant is absorbed where longer time in contaminated areas increases toxicity risk.

In modeling, bioaccumulation should consider individual-level exposure over time, including the spatial and temporal overlap with contaminated sediments or prey. Metabolic consumption, trophic level, and habitat use patterns can help estimate risk. Model outputs may inform toxicity risk to fish and identify remediation for target species.

Little Facts:

- Methylmercury is the most toxic and bioavailable form of mercury, especially harmful to fish and their predators.
- Both mercury and methylmercury bioaccumulate, but methylmercury is more dangerous because it is biologically active, binding to proteins and accumulating in tissues, especially the brain and muscles.
- Contaminants can accumulate faster in colder water, where metabolic excretion is slower.
- Bottom-feeding and filter-feeding species are often more exposed to sediment-bound contaminants.
- Fish in high-energy-demand life stages (e.g., spawning) may mobilize contaminants stored in fat.
- Exposure risk depends on both contaminant concentration and duration of exposure to affected areas.

Discussion Objectives:

- Is this function accurate and realistic to your knowledge?
- Do all species in the model accumulate contaminants at the same rate or through the same pathways?
- What accounts for species-specific differences (e.g., trophic level, diet, movement, age, behaviors, stress)?
- Where in the estuary would you expect the highest bioaccumulation risk for each model species?
- What kind of model outputs should reflect this process?
    - Are there areas or times when fish are most vulnerable to contaminant exposure?
    - Can bioaccumulation affect spawning, migration success, or behavior response?
    - How might contaminant exposure interact with other stressors like temperature or salinity?