Modeling the Bioaccumulation of a Pharmaceutical Contaminant in a Simple Trophic Web Interaction

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Project Overview
- Objective: To investigate the bioaccumulation of pharmaceutical contaminants through a simple trophic web interaction, involving one prey and one predator.
- Reasoning: Previous study performed by Florida International University displayed the occurrence of pharmaceuticals in the blood plasma of bonefish as well as their prey items (Rehage, Castillo, personal communication 2022).
- Application: To be used as the foundation to model the effects of pharmaceutical contaminants on population dynamics.
- Model:
  - Matches the life history of Bonefish (Atherinidae) and a selected prey item within the South Florida Region.
  - Age-structured population model that separates bonefish into two age classes, juveniles, and adults, that both feed on a prey item that grows logarithmically.
  - Spatially separates the adult bonefish into two areas, with differing chemical loads in the areas.

Background
Pharmaceuticals have been shown to remain bioavailable for aquatic organisms for long periods of time, increasing the potential that they could reenter the food web after some time (Lagerson et al. 2016). The taking up of pharmaceuticals through the surrounding water is referred to as bioconcentration whereas the accumulation of pharmaceuticals in a fish through both feeding on contaminated prey and the surrounding water is defined as bioaccumulation (Boström et al. 2016). Studies performed about the bioaccumulation of pharmaceutical contaminants emphasize that both waterborne exposure and trophic interactions need to be considered when discussing the ecological effect of pharmaceuticals (Ruhl et al. 2016). Wu et al. 2020 showed that sulfadiazine and enoxacin were biomagnified along the food web but enrofloxacin, ciprofloxacin, ofloxacin, norfloxacin, and trimethoprim were biodiluted from the food web. There are many discrepancies when it comes to whether respiration or dietary uptake is the primary source of accumulation of pharmaceuticals in aquatic species, thus both factors need to be included when discussing the risk of pharmaceutical contaminants in the aquatic environment.

Steps to Solve Equations
- The approach used follows a classic method for solving dynamic systems
- Equilibrium points were found by setting the derivative to zero.
- The next step is to find local stability using a Jacobian or community matrix
- A set of parameters were chosen from varying literature (Larkin 2011, Huang 2014)
- The equations were graphed using literature found parameters and the mathematical programming software Maple

The Chemical Loads in Area 1 and Area 2

As the dispersal rate increases, more adult fish will swim away from area one, carrying the pharmaceutical load they gained in area one. As the fish swim away from area one, the total chemical load in adult fish in area one will decrease as the total chemical load in adult fish in area two will increase.

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