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Fractional Bioeconomic Fishery Model with Caputo–Fabrizio Derivative: Memory Effects and Dynamic Analysis

Communication Info

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Abstract

This work investigates a bioeconomic fractional-order model governed by the Caputo–Fabrizio derivative to describe the coupled dynamics of resource biomass, harvesting effort, and post-capture deterioration. The proposed system extends classical renewable resource models [3] by incorporating non-singular memory effects through the Caputo–Fabrizio operator [2], capturing resilience and hereditary ecological behaviors. Existence and qualitative properties of solutions are established within the fractional framework, while stability and dynamic responses are analyzed in relation to the fractional order parameter. The modeling approach is motivated by recent advances in fractional ecological systems and optimal control theory [4,7,8]. Furthermore, the formulation connects with fractional optimal control principles in the sense of Pontryagin [1,6] and recent developments for fractional delay systems [5]. Numerical simulations based on fractional Adams–Bashforth schemes [9] illustrate the impact of memory on sustainability and long-term equilibrium. The results highlight the crucial role of fractional dynamics in enhancing management strategies for renewable resources under uncertainty.

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