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On the Adequacy of Simple Continuous-Time Models for Snow Crab Population Dynamics

Abstract

Snow crab (*Chionoecetes opilio*) is a major component of the maritime economy in the Gulf of St. Lawrence, with landings generating over $300 million in 2021 according to Fisheries and Oceans Canada (DFO). Beyond its commercial importance, this species plays a key ecological role, but its management is complicated by high sensitivity to climate change and a life cycle characterized by discontinuous growth and cannibalistic behavior.

In this work, we investigate the relevance of continuous-time modeling for describing the dynamics of this resource using a stage-structured framework distinguishing immature and mature crabs. We compare two approaches: a model incorporating cannibalism as a trophic regulation mechanism, and a delay differential equation model accounting for maturation time.

We conduct a mathematical analysis of both models, focusing on equilibrium points and the occurrence of Hopf bifurcations that may explain observed population oscillations. Analytical results are complemented by numerical simulations to assess the ability of each model to reproduce stock dynamics. These findings provide insight into the suitability of stage-structured continuous-time models for understanding snow crab population cycles and supporting sustainable fisheries management under changing environmental conditions.