Analyzing Risk of Stock Collapse in a Fishery under Stochastic Growth Model

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Abstract

Acknowledging that there is stochasticity in the dynamics of a fish stock, one has a situation where the fish stock can collapse even without any fishing pressure. To derive the probability of collapse, we suggest a Monte Carlo approach because it is relatively simple model and can capture complex stock dynamics. We use an economic model with downward sloping demand for fish and stock dependent costs. Then, we calculate the optimal harvest profile as a feedback control rule. We analyze effects of different level stochasticity. We observe that the stochastic solution is more conservative compared to deterministic solution apart from a very small stock level, however, the effect from increased stochasticity is small at high stock levels. We simulate the system forward in time with the optimal solution. In simulated paths some stock collapsed, while other recovered. The paths are easily identified and we group the paths and estimate the probability of collapse for a given stock level. The precision of the estimate only depends on the number of paths. We have also looked at the time required for stock to reach stable level. The system needs more time to stabilize if the initial stock level is small and with stochasticity. Finally, the stochastic stock stabilizes on a level which is lower than the deterministic level. In this study, we demonstrate an approach to quantify stochasticity in fish stock dynamics, derive the optimal stochastic harvest profile, and demonstrate a method to assess the risk of collapse.