Effect of environmental heterogeneity on the increase in Maximum Sustainable Yield (MSY) in a multi-site fishery

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Abstract

We consider a fishery consisting of two fishing sites connected by fish migrations. At each site we assume the classic fishery model with a logistically growing fish population and a Schaefer catch. We assume that migrations between the two sites are fast relative to local growth and fishing. Taking advantage of the time scales, we use methods of aggregation of variables to obtain a reduced model governing the total biomass of the fish population at a slow time scale. Then, we are looking for the maximum sustainable yield (MSY) for the system of the two connected patches. We show that although the total equilibrium population may be greater than the sum of the carrying capacities on each isolated site, the total catch is always less than or equal to the sum of the catches on the isolated fishing sites. We then consider a Lotka-Volterra prey-predator fish community in the same environment. We assume that only the predator is caught and not its prey, still growing logistically on each site. We show that in this case due to connectivity the total catch at MSY can be greater than the sum of the captures on each isolated site. This last result is held when the two sites are heterogeneous. Two heterogeneity parameters are important, the growth rate of the prey and a parameter characterizing the viability of the predator. It appears that the prey growth rate has to be large at one site while the predator viability has to be high at the other site in order to promote excess MSY. Furthermore, an emergence phenomenon can also be observed: even if none of the sites is viable for fishing, the entire system can be viable. Our study is extended to the prey-predator model with a type II Holling functional response