Biomanipulation and Strategic Fisherman Behaviour: A Game Theoretical Approach

Extended Abstract

Improving the quality of eutrified surface waters is often not achievable by merely lowering the external nutrient loads. After some threshold level, accelerated internal loading maintains the higher level of eutrophication despite changes in external loads. Therefore, it is often necessary to affect this internal nutrient load directly. The water quality can be improved by biomanipulation: intensive fishing of planktivorous and benthivorous fish species, such as roach species. Unfortunately these species do not have commercial value and therefore managers have to introduce a subsidy scheme for this fishing.

In Finland, biomanipulation have been practised in several lakes where the manager of the lake has introduced a subsidy scheme to attract fishermen to undertake the required intensive fishing of these targeted species. If the subsidy scheme is properly initialised the manager achieve its' objective: intensive fishing lower the level of the targeted stocks and eventually improved water quality. However due to the complexity of fishery dynamics the subsidy schemes have often failed to achieve the long term objective.

In this paper we studied the optimal subsidy scheme and how these incentives affect fishermen behaviour in a game theoretic model. Within a bioeconomic model we illustrate the complexity of the setting even in a case of perfect information of stock dynamics and costs of fishing. We showed that the optimal subsidy scheme depends on whether or not there are any switching costs changing fishing method from commercial to subsidised fishing.

In a case when it is costless for fisherman to change fishing method we derived equilibrium conditions for optimal subsidy scheme that produce a pure strategy Nash equilibrium (PSNE). There all fishermen have same strategy profile where they divide their fishing effort according to manager's objective. In the case of switching costs, in optimum, fishermen have to specialise either one fisheries. Then there is no pure strategy Nash equilibrium and fishermen have to apply mixed strategy. We found that then optimal subsidy scheme produces a mixed strategy Nash equilibrium (MSNE). In equilibrium all fishermen have the same mixed strategy profile where fishermen randomise their fishing according to those probabilities.

In PSNE all fishermen practise same mixed fisheries where they earn same profit. In MSNE the subsidy scheme equals the expected profits, but fishermen specialise in one fishing and realised profits are not the same. Subsidy levels are different in two cases, but they produce the same result. However, the subsidy scheme in PSNE produces the targeted fishing effort and environmental impact with certainty, while in MSNE the target level will be achieved only at expected level. Which subsidy scheme produces higher subsidy level depends on biological factors and prices as well as targeted stock level.