The Role of Marine Protected Area in the Optimal Management of Fisheries

D. Ami[1] , P. Cartigny[2] and A. Rapaport[3].

We analyze impacts of Marine Protected Area (MPA) creation from both economic and biological point of views. We adopt a simple model of two areas, whose density stocks are X_1 for the protected area and X_2 for the harvested one :

$$\begin{aligned} \dot{X}_1 &= F_1(X_1) + \lambda(t)D(X_1, X_2) \\ \dot{X}_2 &= F_2(X_2) - \lambda(t)D(X_1, X_2) - QE_2(t)X_2(t) \end{aligned} \tag{1}$$

The $F_i()$ are the growth functions while $D()$ is the diffusion term between the two areas. We assume that the harvesting effort $E_2()$ and the dispersal coefficient $\lambda()$ are manipulated variables. We have taken the point of view of a coastal manager who wants to maximize social welfare :

$$\max_{E_2(),\lambda()} \int_0^{+\infty} e^{-\delta t}(pQX_2(t) - c)E_2(t)dt \tag{2}$$

where p is the unitary price and c the cost per unit of effort. This kind of problems has been already tackled in the literature (see for instance [2]) but in our work, λ is considered as a decision variable, and not as a constant parameter.

For this model, we analyze the existence and the stability of non trivial steady states, with a simple convexity assumption on the growth functions. We then characterized the optimal steady states for the problem (2). Depending on the functions F_i, we compare the profit with the optimal solution without any protected area. As the solution of problem (2) is not know analytically (see also [2]), we provide several sub-optimal scenarii for the opening or closure of a protected area, which provide effective decision rules. Finally, we present numerical experiments which show the possible benefit, both from the biological and economical view points, of the creation of a reserve area.

[1]GREQAM, 2 rue de la Charité, 13002 Marseille, France (e-mail: ami@ehess.cnrs-mrs.fr).

[2]INRA LAMETA, 2, Place Viala, 34060 Montpellier, France (e-mail: cartigny@ensam.inra.fr).

[3]INRA LASB, Montpellier, 2, Place Viala, 34060 Montpellier, France (e-mail: rapaport@ensam.inra.fr).

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