One-player game

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Marko Lindroos

Schäfer-Gordon model

Gordon (Journal of Political Economy 1954),
Schäfer (1957), Scott (JPE 1955)

Biology

- Logistic growth $F(x)$

- Biomass x

Logistic function

$$F(x) = Rx(1 - \frac{x}{K})$$

- R: intrinsic growth rate
- x: fish stock
- K: carrying capacity of the ecosystem

Production

- Harvest function:

$$h = qEx$$

- E: Fishing effort
- q: Catchability

Sustainability

- $F(x) = h$
- Steady state

Steady state fish stock

$$Rx(1 - \frac{x}{K}) = qEx$$

$$R(1 - \frac{x}{K}) = qE$$

$$\Rightarrow \quad x = K(1 - \frac{qE}{R})$$

Steady state harvest

- Insert steady state stock into production function :

$$x = K(1 - \frac{qE}{R})$$

$$h = qEx$$

$$h = qEK(1 - \frac{qE}{R})$$

Economics

Assumptions:

- Fish price per kg constant
- Unit cost of effort c constant (constant marginal cost). Note marginal revenue not constant.

Optimum

- Maximise economic yield by choosing E.

max $$\pi = ph - cE = pqEK(1 - \frac{qE}{R}) - cE$$

FOC: $$\frac{\partial \pi}{\partial E} = pqK(1 - \frac{2qE}{R}) - c = 0$$

$$\Rightarrow \quad E^* = \frac{R}{2q} - \frac{cR}{2pq^2K} = \frac{R}{2q}(1 - \frac{c}{pqK})$$

Comparative statics

- $dE/dR > 0$
- $dE/dK > 0$
- $dE/dc < 0$
- $dE/dp > 0$
- dE/dq ?

Open access

- Unregulated fishing. E.g. no international fisheries agreement.
- Fishers (countries) enter into the fishery until profits (rent) is equal to zero.

Open access effort

$$ph - cE = 0$$

$$pqEK(1 - \frac{qE}{R}) - cE = 0$$

$$pqK(1 - \frac{qE}{R}) - c = 0$$

$$Þ \quad E^{OA} = \frac{R}{q} - \frac{Rc}{pq^2K} = \frac{R}{q}(1 - \frac{c}{pqK})$$