

One-player game

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Schäfer-Gordon model

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

Biology

- Logistic growth $F(x)$
- Biomass x

Logistic function

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

- 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

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

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

$$\text{p } x = K\left(1 - \frac{qE}{R}\right)$$

Steady state harvest

- Insert steady state stock into production function :

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

$$h = qEx$$

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

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.

$$\max \quad p = ph - cE = pqEK \left(1 - \frac{qE}{R}\right) - cE$$

$$\text{FOC:} \quad \frac{\partial p}{\partial E} = pqK \left(1 - \frac{2qE}{R}\right) - c = 0$$

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

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

$$ph - cE = 0$$

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

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

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