ECN 275/375 Environmental and natural resource economics 16: Renewables - fisheries – 2 (Perman *et al.* Ch 17)

Reading guide

Read rest of chapter (from sec. 17.8) for an overview. Focus in this session is on differences in the private and social discount rates, *i* and *r* (sec. 17.11 to 17.1.1) , renewable (fisheries) policy (a simplified approach that captures the essentials using the static models), and SMS for renewables (sec. 17.12 – discussions surrounding fig. 17.8)

Remark on notation:

Private interest (discount) rate: Book uses *i* or *r*. This note: consistently *r*

Public interest (discount) rate: Book uses *i* or *r*. This note: consistently *δ*

Shadow prices on constraints: Book uses ρ (which is hard to separate from *p*). This note uses λ

Differences in the private (*r*) and social (*δ*) discount rates

Recall the steady state solutions for the single owner fishery (time subscripts are dropped in steady state):

(A) $\lambda = P - \frac{\partial C(H,S)}{\partial H}$ (λ = shadow price of resource constraint = marg. revenues less marg costs)

(B) $r\lambda = \lambda \frac{dG(S)}{dS} - \frac{\partial C(H,S)}{\partial S}$ (the interest rate condition for time indifference)

where λ is the shadow price on the resource constraint $\dot{S} = -G(S_t) - H_t$ (from the resource stock change) in the current value Hamiltonian ($\mathcal{L}$): $\mathcal{L} = PH_t - C(H_t, S_t) + \lambda(G(S_t) - H_t)$.

Most often the private interest rate (*r*) is higher than the social discount rate (δ). This implies that the social time indifference condition in (B) becomes

(B') $\delta\lambda = \lambda \frac{dG(S)}{dS} - \frac{\partial C(H,S)}{\partial S} < r\lambda$

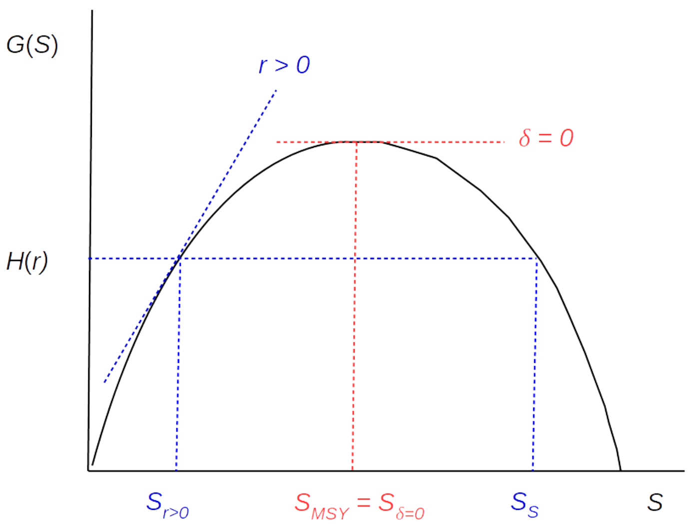
The ordinary concave curvatures of the marginal growth function $\frac{dG(S)}{dS}$, and marginal harvest costs as a function of stock size, *S*, → the socially optimal stock size is a bit larger that the privately optimal stock size. Figure 17.7 or the adapted figure to make this points here.

Special case 1: δ = 0 → the socially optimal stock size is at the max sustainable yield, i.e., $S_{MSY} = S_{\delta=0}$

$r > 0$: → $S_{r>0}$

It then follows that for 0 < δ < *r*, the optimal stock size $S^* = \langle S_{r>0}, S_{\delta=0} \rangle$

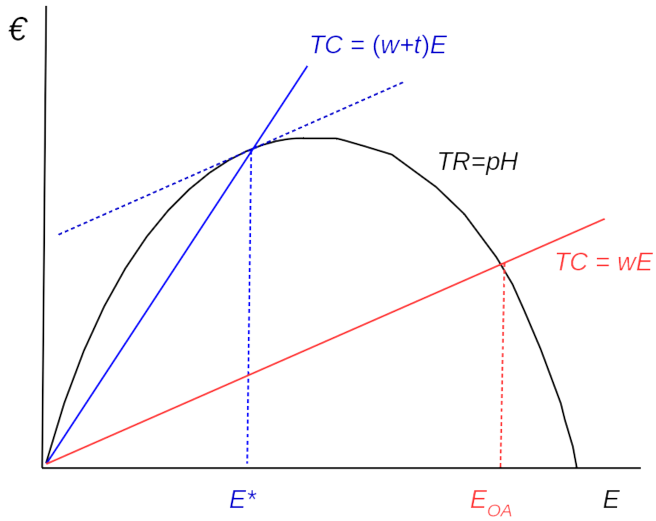
The link between interest rate and stock size is that as the stock size declines, the growth rate of the stock increases (from $G'(S) > 0 \; \forall S < S_{MSY}, G''(S) < 0$).



Indifference between growth of the fish stock and growth of financial capital in the bank for an individual is equivalent to: $G'(S)=r$

Remark: The stock level S_S gives the same harvest $G(S_S)=H(r)$, but the (unstable) equilibrium $\{H(r), S_{r>0}\}$ allows for some initial higher harvests (= temporarily higher rents) until stocks are reduced to $S_{r>0}$. $\{H(r), S_{r>0}\}$ is therefore the most profitable equilibrium given the private interest (impatience for consumption) r.

The optimal effort/harvest/stock



From the static model in lecture 15:

- Open access effort E_{OA} → $\pi(E_{OA})=0$
- Rents maximized at E^* (follows from differentiation the profit function $\pi(E)=pH(E)-wE$ with effort E → familiar profit max condition $pH'(E^*)=w$

Ways to achieve E^*:

- Introduce a tax, t, on effort to get total costs such as private rents become 0: $\pi(E^*)=pH(E^*)-(w+t)E^*=0$
  - remark: The tax revenues on effort is the social rent that is now captured by society
- Introduce a quota system on effort equal to E^* (= limit the number of fishing boats to get close to E^* with normal working hours). Problem: boat technology changes over time → higher catch per boat / unit of effort.
- Introduce a total harvest quota $H^*=H(E^*)$ Remark: make the quotas transferable → intertransferable total quota ITQ

Some fisheries regulatory problems

1. Bycatch: Non-selective fishing methods (like trawling) makes the catch of non-targeted fish species large or take place outside the season
2. How to allocate the quotas: auction or assign for free (the latter is the same as a huge wealth transfer from society to quota owners)
3. Who should own the quotas: boat owners/fishermen OR processing plants?
   1. Ownership to boat owners/fishermen → problem: coastal jobs in the processing industry disappear
   2. Ownership to land based processing plants → problem: prevents processing of the fish when it is fresh, i.e., on the fishing boat

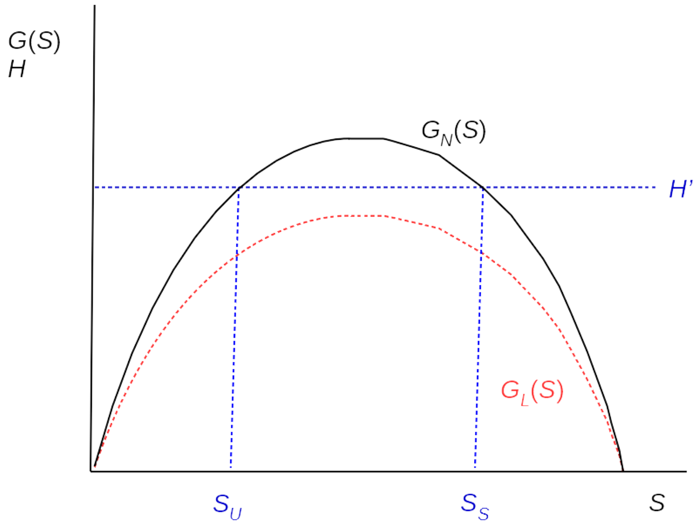
Safe minimum standard

"normal" growth as a function of stock: $G_N(S)$

Harvest level *H'* and stock S_S → stable equilibrium $\{\{G_N(S_S), H'\}\}$ = OK SMS

If growth for a prolonged time is less than "normal", i.e., $G_L(S)$, harvest H' no longer creates a stable equilibrium (steady state), and is hence no longer an SMS.

Remark: S_U is the unstable equilibrium.



Farmer/Randall build on the fact that the SMS varies depending upon the growth of the renewable resource (see sec. 17.12).

The regeneration function of bellshaped logistic growth functions we have used → fig. 17.8 (right).

In the graph the slope of the figure is given by $1+g_S(S)/g(S)$ where $g_S(S)/g(S)$ is the stock dependent growth rate of the fish population, and δ is society's chosen discount rate.

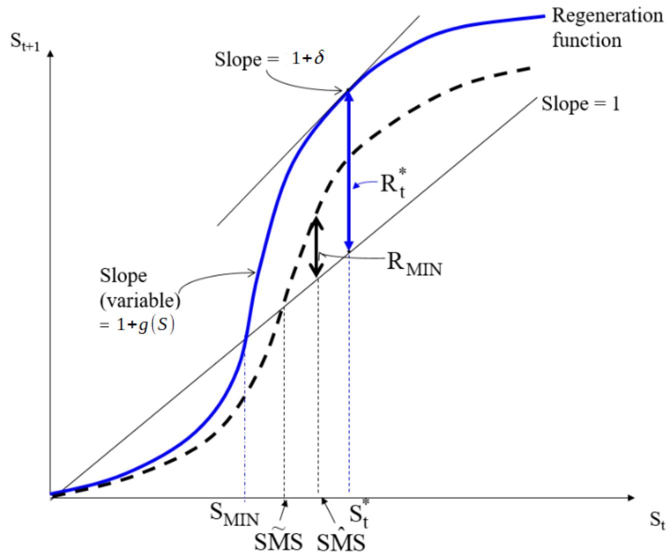


Figure 17.8 A safe minimum standard of conservation

With a condition of sustainability at the outset (growth of the stock is above the line with slope 1) they show that once sustainability is achieved, there will be some positive rents (*R* in their notation), and it is not optimal to reduce the stock down to the state dependent SMS (illustrated $\widetilde{SMS}$ and $\widehat{SMS}$ in the graph) as long as segments of the regeneration function is above the 45 degree line (line with slope=1).

Remark: if the adjusted regeneration function (dahsed curve) is everywhere below the slope=1 reference line, it is optimal to liquidate (kill all of) the fish species.

Exercises

See exercises

Discussion topics

1. Why, using the standard bell shaped growth function $G(S)$, will an interest rate that exceeds $G'(S)$ increase the risk of extinction of the fish stock?
2. Why are SMSs more warranted in the Farmer/Randall framework above than in the standard framework in (1). Hint: draw the marginal curves for the standard bell shaped growth function and the convex-concave relationship in the

3. The bycatch is often thrown over board (storage space on the fishing boat is needed to store the target fish catch).
    1. Give examples of technical regulations that would reduce the bycatch. Briefly discuss advantages and disadvantages of each.
    2. What kind of economic (incentive based) regulations could also contribute to reducing the bycatch?