Appendix 5 – Alternative model formulation with increasing marginal costs of effort
Investing in the commons: transient welfare creates incentives despite open access

Consider an alternative formulation of our model (Appendix 1) in which the marginal cost of effort is increasing. Now the current-period average net benefits are equal to:

$$NB_i = p_i q X - c_i E_i, \quad \text{Eq.A5.1}$$

The modified versions of Eq. S3-4 then become

$$0 = \delta E^*_{rov}[p_{rov} q X^* - c_{rov} E^*_{rov}] \text{ if } \begin{cases} p_{rov} q X^* = c_{rov} E^*_{rov}, \ E^*_{rov} > 0, \\ E^*_{rov} = 0 \end{cases} \quad \text{Eq.A5.2}$$

$$0 = \delta E^*_{res}[p_{res} q X^* - c_{res} E^*_{res}] \text{ if } \begin{cases} p_{res} q X^* = c_{res} E^*_{res}, \ \ E^*_{res} > 0. \\ E^*_{res} = 0 \end{cases} \quad \text{Eq.A5.3}$$

From these new equilibrium equations, an alternative condition will emerge (compare to Eq.A1.5):

$$\frac{c_{rov} E^*_{rov}}{p_{rov} q} = \frac{c_{res} E^*_{res}}{p_{res} q} = X^* \ \rightarrow \ \alpha^* = \frac{E^*_{res}}{E^*_{rov}} = \frac{c_{rov}/p_{rov}}{c_{res}/p_{res}} \quad \text{Eq.A5.4}$$

The alternative condition implies that the ratio of equilibrium effort levels of the two angler groups is inversely related to the ratios of their cost and benefit parameters.

Exploring this model of increasing marginal cost we find that three of our four key model results hold, as detailed below.

Key Result 1: “Local users had clear incentives to invest in the fishery despite open access”. This holds as shown in Figure A5.1, which compares time discounted net benefits from stocking to not stocking in a system where there are increasing marginal cost of angling effort. The new results show gains for both local and centralized managers. The figure is similar to Figure 2 in the main text, where switching to no stocking after the welfare dissipating equilibrium is reached leads to large losses as the system must transition to a new equilibrium with a lower level of the resource stock.

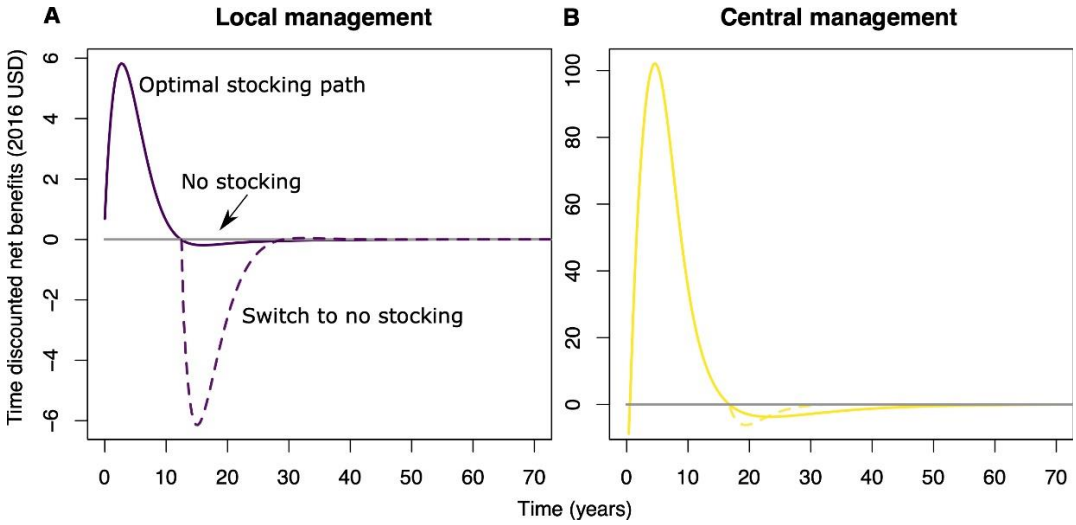

Figure A5.1. Welfare accrues during the transition to equilibrium, even though rents are dissipated at equilibrium, under (A) local management and (B) centralized management. Starting from the no-stocking open access equilibrium, we considered three scenarios. First, if there is no stocking (grey line), the system remains at the open access equilibrium and time discounted net benefits are zero over the entire time horizon. Second, if stocking follows the welfare-maximizing optimal path (solid line), welfare is initially negative because costs but not benefits of stocking have been realized; becomes positive and then negative again as effort responds sluggishly to changes in the fishery; and finally re-equilibrates at the open access equilibrium. Third, switching from the optimal stocking path to no stocking (dashed line) does not yield gains in welfare, regardless of the time point at which the switch is made, because ceasing to stock produces negative net benefits for anglers as effort declines and the system transitions to equilibrium.

Key Result 2: The equilibrium effort levels of both user groups depend on the initial conditions. This result does not hold given the new equilibrium condition on effort is only a function of the ratio of economic parameters, i.e.

$$\alpha^* = \frac{E^*_{res}}{E^*_{rov}} = \frac{c_{rov}/p_{rov}}{c_{res}/p_{res}} \qquad \text{Eq.A5.5}$$

The new condition specifies that with a greater steepness in the slope of the marginal cost function for a particular angler group, there will be a smaller fraction of that angler group present at equilibrium, which seems intuitive. However, it also seems intuitive that lakes starting out with high roving angler effort will attract less lakeside homeowners with interest in recreational angling. Therefore, it is not clear which model assumption is superior and whether equilibrium conditions in recreational fisheries depend on initial conditions, or not, is an empirical question.

Key Result 3: For local managers stocking is positively related to the fraction of resident anglers at equilibrium. This result holds as shown in Figure A5.2. To explore this result, we run the model over a range of values of the c_{rov} parameter thus creating variation in α^*. The results can be compared to Figure 1 in the main text.

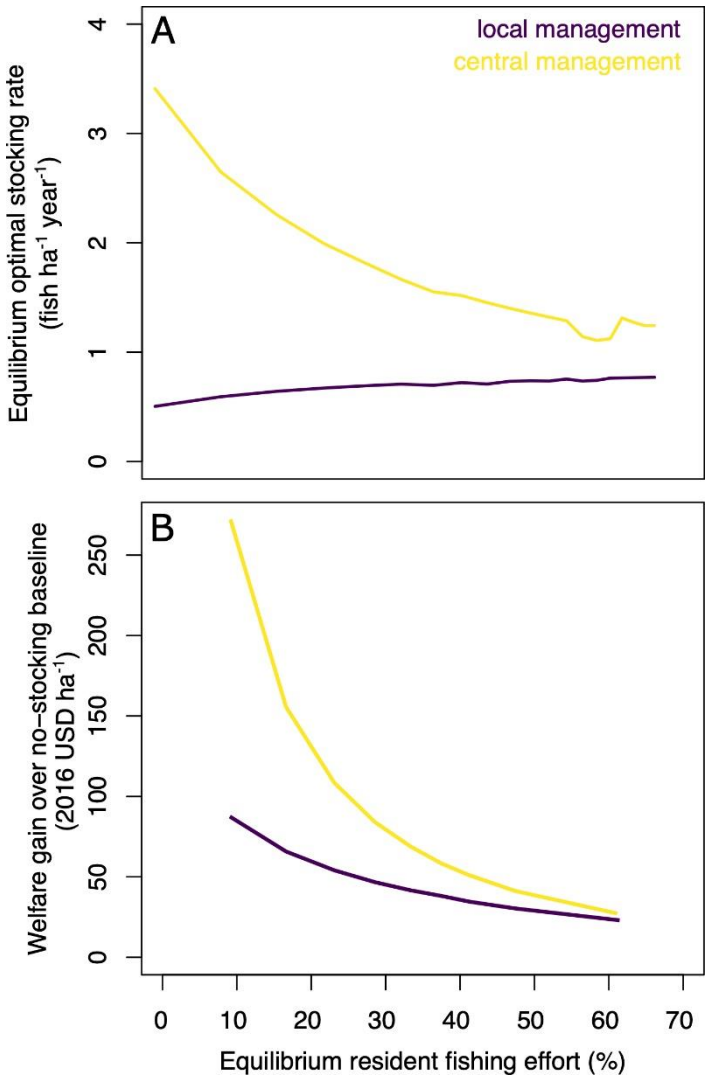

Figure A5.2. (A) Optimal stocking rate and (B) welfare gain (time discounted net benefits) from stocking relative to a no-stocking baseline, under local management by a collective action organization of lakeshore residents or centralized management by a government agency. The optimal investment and the resulting welfare gain depend on the proportion of total equilibrium angling effort that is comprised of resident anglers (x-axis).

Key Result 4: Welfare gains are greatest for residents when they comprise the most equilibrium angling effort. This result is also shown in Figure A5.2, which can be compared to Figure 1 in the main text.