

1. A population  $P_t$  of mussels reproduces annually with an intrinsic rate of increase  $r$  of 3%. Harvesting removes  $h = 60$  tons a year.

a. Write the updating equation for this discrete process; that is write  $P_{t+1}$  in terms of  $P_t$  and numbers.

$$P_{t+1} = P_t + 0.03P_t - 60 = (1.03)P_t - 60$$

b. Is there an equilibrium value for this population? If so, compute it.

Yes No value: 2000 tons

$P_{t+1} = P_t$  condition for equilibrium

$$(1.03)P_t - 60 = P_t$$

$$0.03P_t = 60$$

$$P_t = 2000 \text{ tons}$$

Notes: we have no explicit formula solution for this model!

c. Write the updating equation as you would enter it in your calculator.

Hint: It will have the form  $u(n) = (1.03)u(n-1) \pm h$  or  $u(n) = u(n-1) + (0.03)u(n-1) \pm h$ .

$$u(n) = 1.03u(n-1) - 60$$

d. If the population is currently 1000 tons what will it be in 23 years? in 24 years? How do you interpret what is happening?

Let the calculator do the work!  $u(n \text{ Min})$  entry  
Somewhere between  $n=23$  and  $n=24$ , the pop. became 0, i.e. the pop. went extinct.

$$u(23) = 26.4 \quad u(24) = -32.8$$

e. If the population is currently 3000 tons, what will it be in 6 years?

$$u(n \text{ Min}) = 3000 \quad u(6) = 3194$$

f. (Bonus) Is the equilibrium value (assuming that there was one) stable or unstable? Explain, perhaps using a graph to help.

unstable - if we start  $P_0$  above 2000,  $P_t$  gets larger & larger. If we start  $P_0$  below 2000, then  $P_t$  falls to 0. In either case the pop. does not return to 2000.