Appendix 5: Case Study of Fisheries as a common resource

Fisheries in the open ocean are just one example of a common pool resource that can be exploited by anyone or any country. These systems are sensitive to over exploitation. Common pool resources are situations that have high subtractability (where any use subtracts the resource from any other use) and where exclusion from the resource is difficult (anyone can gain entry). There are other classifications of resources that would have different problems and appropriate solutions.

Table 9-5: Resource classification by subtractability and exclusion. Subtractability means that a use of one unit of the resource removes that unit from anyone else's use. Exclusion is whether it is easy to limit access or impossible.

	low subtractability	**high subtractability**
difficult exclusion	public goods	common pool resources
easy exclusion	toll goods	private goods

Maximum sustainable yield and over harvest. The amount of fish that is taken in any season is the "yield". Ecosystem managers calculate the maximum sustainable yield (MSY) as the maximum value of the population times the growth rate. (Ecosystem managers actually use much more sophisticated models than the “maximum sustainable yield”, but these models have essentially the same features, i.e. estimation of a population growth under conditions of high natural variability.) At low population size the number of reproducing fish limits the yield. At high populations the yield is limited by the decrease in the growth rate from inter- and intra-specific competition for resources. The maximum sustainable yield is the theoretical maximum point that is half of the carrying capacity. Over harvest can happen in two ways, either the maximum yield is an overestimate or a correct MSY could be taken too early when the population is still too small. Over harvest decreases that population such that the growth for the next season will be decreased. Thus, over harvest and early-harvest are related processes.

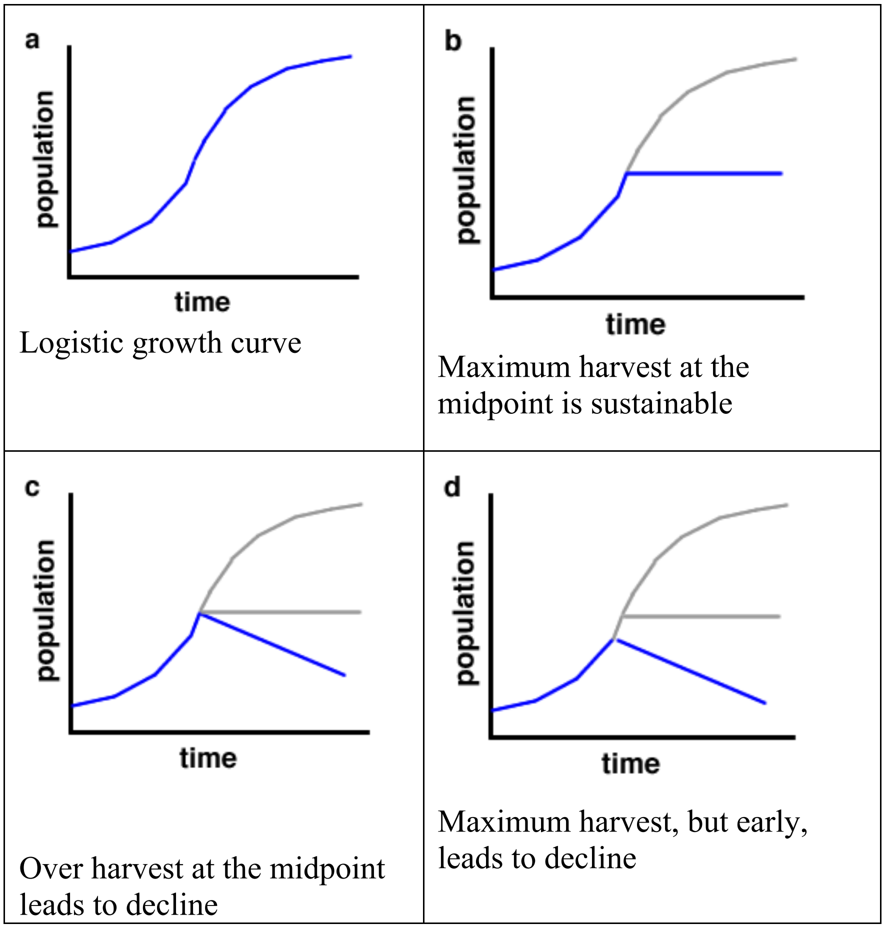

Figure 9-1 Theoretical optimal sustainable yield for a population going through a logistic growth transition. Early in the growth phase, rapid growth rate and the number of fish control the population growth. Later, the population growth (yield) is dominated the decrease in the intrinsic growth rate as the population reaches the carrying capacity. The middle of the curve (the area with the steepest slope) has the population value that will give the highest yield. b - when the maximum sustainable yield is initiated just as the population gets to the midpoint, the population will stay constant. c- if the harvest is higher than the maximum sustainable yield, the population will decrease. d- Applying the maximum harvesting rate before the population has reached the mid-point will also result in a decrease in the population.

Actual harvest rates should be below this theoretical maximum yield for several reasons. First, the process of harvesting can degrade the conditions necessary for optimal growth (see X). Too many roads in the forest, catching too many non-target fish or trampling of a pasture are examples of this type of damage. It reduces the ability of the environment to grow the resource without directly showing up in the harvest. Second, natural variability in the conditions should also be accounted for in calculating the actually yield that can be tolerated. Variations in weather or other populations in the ecosystem can result in good and bad seasons for growth. Maximal harvesting during a bad year can decrease the population below the sustainable level. Often the variability is a source of uncertainty for ecosystem managers. Still, managers need to be able to make decisions to set a harvest rate and to take precautions against the collapse of the fishery.

Variability in fishery production. Even healthy natural environments undergo swings in the overall productivity and especially growth of one species in the food web. You may recall that this variability was a key component of our attempt to understand food webs using a network view (see Chapter 7). The degree of variability can be quite large even in healthy populations. However, with artificially harvest superimposed on top of natural variability, the results can be disastrous. The following simulations (Figure 9-2) demonstrate the effects of a population that is either fished, or perturbed by a density dependent loss, or both. Each simulation run represents one possible trajectory through time with random events. There is a range of outcomes, and each can be predicted roughly from the probability of the loss (Figure 9-3). Given the dynamic nature of natural ecosystems, it may not be possible to determine the probability of loss to any degree of certainty, i.e. the loss may be uncertain no matter how much of this population is studied.

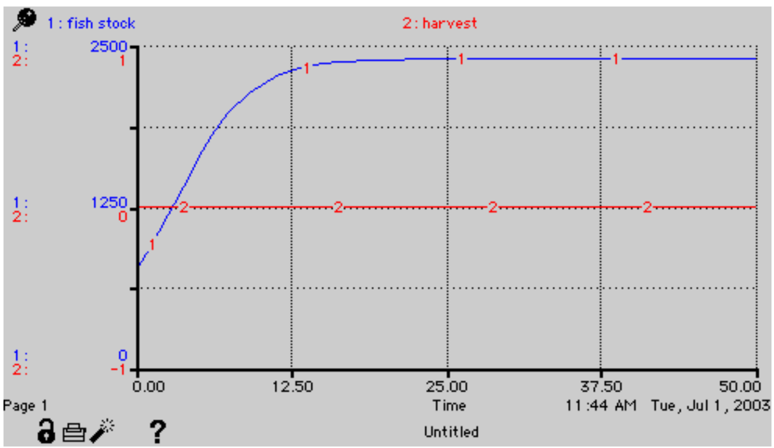

fig9-2a - no harvest

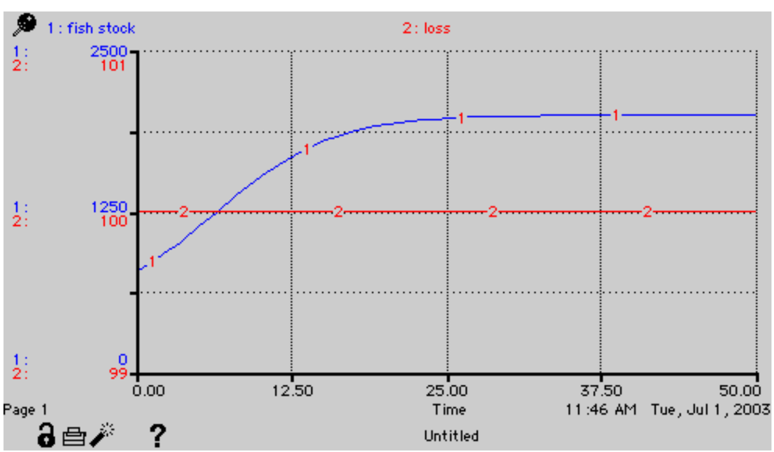

fig9-2b - harvest rate of 100

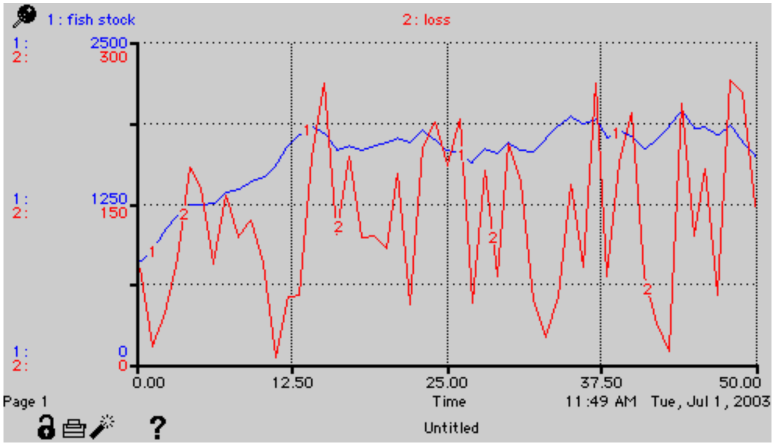

fig9-2c - one example run with a stochastic loss of up to 10% of the population per time

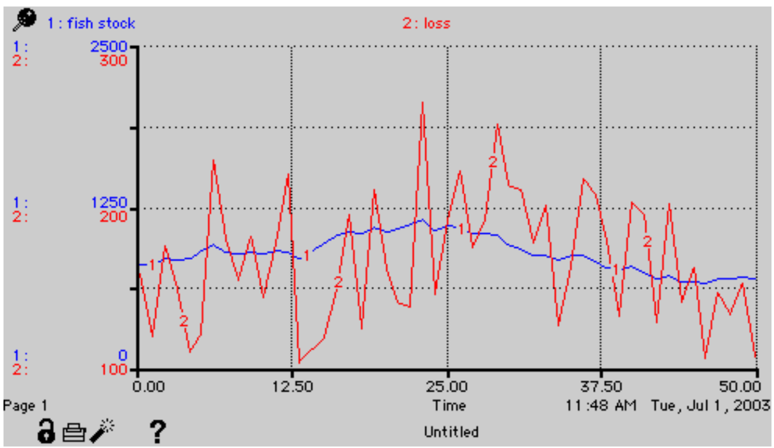

fig9-2d - another example run with both a constant harvest of 100 and a stochastic loss of up to 10% of the population per time.

Figure 9-2. Simulation results for a fish stock that is growing with and with harvest and stochastic loss terms. The parameters for all models are r=.3, K=2400, initial population =800. The population is controlled by the logistic equation. The stochastic loss is a random percent loss (up to the maximum of a 10% loss) times the population. a- growth with no fishing. b - growth with a harvest of 100. c. stochastic loss only. d- harvest and up to a 10% stochastic loss combined.

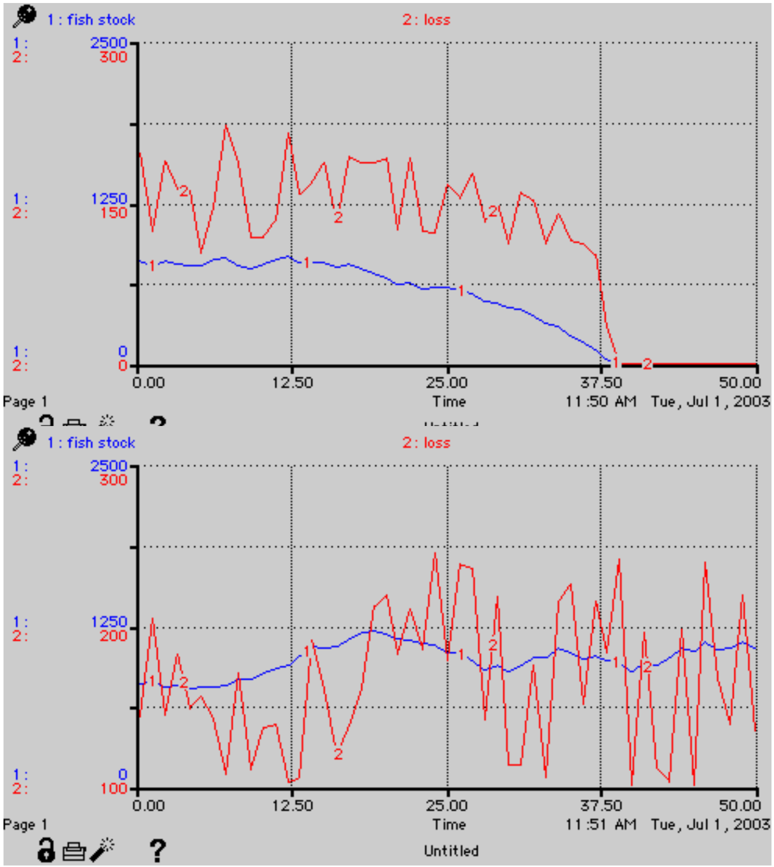

Figure 9-3. With any stochastic loss there are multiple trajectories for the population. a - one selected output that shows a collapse of the population. b - another selected output that shows increase in the population over the period shown. We would use many runs of the same model to understand what the possible risk of collapse is. It might only be one out of a hundred runs.

There are many ways to cause extinction. Just as it was claimed that "all roads lead to Rome", it seems that for our current civilization, all roads lead perilously close to causing extinction and collapse of our natural resources. Any plan to exploit natural resources (i.e. harvest for our use) must be accompanied with a plan for taking responsibility for our actions and the consequences for the environment.

Our society faces two fundamental decisions when we use natural resources. First, if the resource is a "common pool resource", we have to decide how we will adjust our use to that of other users. How will we know if we are over-exploiting the resource? The second question we face is how to deal with the uncertainty in the system and whether to make decisions based on the "precautionary principle" (which states that in the face of uncertainty, choose the path that will do the least damage).