

NAME _____ KEY _____

Some equations that you might find useful:

$$N_t = N_0 \lambda^t$$

$$N_t = N_0 e^{rt}$$

$$e^r = \lambda, \text{ or } r = \ln(\lambda)$$

$$dN/dt = rN$$

$$dN/dt = r_{\max} N(1-N/K)$$

$$PV = FV / (1+r)^t$$

Also, many of the questions below are short answer questions and/or request brief explanation. "Brief" means a sentence or two. 60 points total.

1. This two part question focuses on externalities:

a) (4 pts) Provide a definition for a negative externality and an example related to salmon restoration.

A negative externality is a cost imposed on a party not involved in the decision or transaction. For example, a farmer may clear a field for planting – not being aware of or considering the effects of the action on salmon and salmon fishers.

b) (4 pts) Construct a diagram to show how, when external costs are not accounted for, market outputs tend to be too high.

See Figure 6-3 on page 91 of Field.

2. (6 pts) What is the concept of opportunity cost and why is it so important when thinking about policies for salmon restoration? (Define the concept very briefly and then briefly explain why it is important in the context of this class.)

Opportunity cost is the value of the next best alternative (what you forego or give up when you make a decision). For example, when we spend money on salmon restoration, we give up the opportunity to do other things with that money – such as improve our parks or help feed families in need.

3. (5 pts) Calculate the present value for the following sequence of willingness to pay: this year \$100; next year , \$150; year 2, \$150; and year 3, \$50. Use a discount rate of 5 percent. Recalculate the present value using a discount rate of 8%. Discuss very briefly the effect of using a higher discount rate when analyzing options to restore salmon habitat.

With $i = 0.05$, the present value of the stream of values is $100 + 143 + 136 + 43 = 422$

With $i = 0.08$, the present value of the stream of values is $100 + 139 + 129 + 40 = 407$

Using a higher discount rate reduces the present value of payments received in the future. Having a higher rate means money invested today will grow faster – so less is needed today to grow to a given amount in the future. With salmon restoration, high discount rates can be problematic because they mean we do not value the future as much (we discount the future more).

4. One of the study questions focused on the open-access beach problem. The question was how many people would use the beach if the cost of doing so was \$15 per day... and how many people would maximize the net benefits of the beach.

a) (3 pts) What rule would (or did you) use to determine the number of people that would maximize the net benefits of the beach?

In a one period problem, you can find the optimal quantity (in this case the number of people that would generate the most benefits) by finding the point where marginal benefits = marginal costs.

b) (2 pts) Is the number of people that would use the beach higher or lower than the number that would maximize the net benefits? Explain very briefly.

The number that would use the beach is higher than the optimal number, because people do not typically consider externalities (costs they impose on others, sometimes unknowingly) such as congestion.

5. a. (3 pts.) What are three ways that life history varies within a single salmon species? For each, state what it is and give a brief description.

1. *Timing of outmigration – fry for Chinook may start to head for the ocean and smoltify anywhere from several weeks to 2 years after birth, even for different individuals from the same run and location.*
2. *Time to maturity – Chinook may spend anywhere from 2-6 years in the ocean before returning to spawn, even for different individuals from the same run and location.*
3. *Run timing – salmon may start heading up river in spring, summer, or fall. These typically form different breeding populations.*
4. *Location of spawning – individuals typically return to the stream of birth, meaning that individual from different locations often form separate populations, though these may be connected by straying.*

b. (4 pts) What are the four main habitat forming processes relevant to streams and salmon? For each, state what it is and give a brief description of how it influences at least one aspect of salmon survival and/or reproduction.

1. *Riparian vegetation – shade to keep stream water temps cool, allochthonous production that feeds insects that feed fish (2 examples, there are more).*
2. *Coarse woody debris – cover from predators, channel stabilization for spawning sites, create pools for resting (a few examples)*
3. *Stream morphology – sinuosity for flow variation, side channels for spawning & rearing*
4. *Disturbance regime – input of coarse woody debris, maintenance of vegetation diversity (for insect food)*

c. (2 pts) Briefly explain how disturbances can cause salmon mortality in the short-term, but be beneficial to salmon survival in the long-term. Give an example.

Floods or landslides can kill fish or eggs by scouring streambeds or sedimentation of nesting sites in the short term. However, in the long-term, they provide input of coarse woody debris that contributes to cover, channel stabilization, etc.

d. (2 pts) How might the genetic diversity referred to in part (a) above be adaptive in response to the disturbances referred to in parts (b) and (c)?

Variation in timing and location of when different individuals are in the stream means that “not all the eggs are in one basket.” If a disturbance occurs, not all offspring are of a given population are likely to be in the same location; even if some are lost, others will eventually return to spawn.

e. (2 pts) Give two examples of human activities that impinge on those habitat forming processes. In what ways are these disturbances different from the natural disturbances to which salmon are fairly resilient?

Bank armoring, channelization, or development or agriculture directly adjacent to a stream – all reduce inputs of CWD, reduce flow variation, and in some cases (dams, culverts) block access to spawning habitat. The key point is that these disturbances are both widespread and permanent compared to natural disturbances, which tend to occur in only a few locations at a time and usually are reversible by natural processes.

6. a. (4 pts.) A population of salmon has 200 individuals (100 spawning pairs). Careful management of this small population has improved recruitment, on average, to 1.1 individuals for each individual per year. Say you needed at least 10,000 fish before you could legally open up a harvest. Assuming nonoverlapping generations and constant reproduction rates over time, would you expect to be harvesting in a) 10 years? b) What about in 40 years? Show your work, including any equations used and explicitly what numbers go where in those equations.

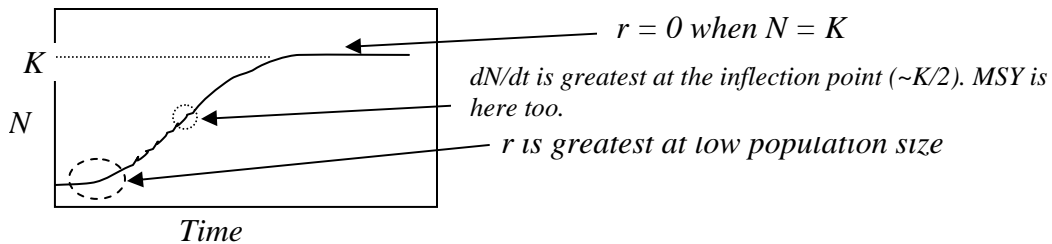
$$N_t = N_0 * \lambda^t$$

a) $N_{10} = 200 * (1.1)^{10} = \sim 519$ individuals after 10 years: no harvest yet.

b) $N_{40} = 200 * (1.1)^{40} = \sim 9052$ individuals after 40 years: no harvest yet.

As a couple people pointed out, it would take ~42 years to get to the minimum harvestable population given these parameters.

b. (4 pts.) Sketch the general logistic growth curve. Label the axes and the following points: the carrying capacity, the point where realized r is greatest, the point where the number of individuals added per unit time (dN/dt) is greatest, and the point where realized r becomes zero. Label and briefly describe the theoretical optimum population size for maximizing yield of a managed fish population.



Choose one of the following two short essay questions. Clearly indicate which one you are answering. (15 points)

7. You are the lead manager in charge of determining appropriate harvest regimes for Chinook from the Nooksack River drainage. Describe at least four considerations that you would need to account for in determining harvest levels and escapement for a terminal, directed fishery on these stocks. Include in your assessment Lower Abundance Thresholds and Upper Management thresholds. Be sure to define any key terms or use them in a way that makes it clear you know what they mean. (Current abundances are ~200 fish for the North/Middle Fork population and ~200 fish for the South Fork population. The Lower Abundance Threshold is 1000 fish in each population, and long term goals for recovery are for 2000-3000 wild spawners in each population.)

OR

8. What is the tragedy of the commons, as defined by Garrett Hardin? How might the history of salmon in Europe, as described by David Montgomery, relate to this situation?

7. Four considerations:

a. What is the abundance relative to the Lower Abundance Threshold (below which, stringent fishing limitations are required) and the Upper Management Threshold (above which populations have a harvestable surplus).

b. How accurate are the data for a stock-recruitment curve?

c. What other sources of fishing mortality might be incurred

- in mixed-stock ocean fisheries (e.g., in AK or CA)?

- as bycatch in fisheries for other species?

- in sport fisheries?

- for cultural and subsistence fishing?

(I took any of these as separate considerations).

d. Habitat conditions that might limit carrying capacity (either in freshwater or oceans).

8. Tragedy of the Commons, according to Hardin: A common resource is degraded by overuse because the benefits accrue to individuals, but costs are shared among all users. A key point is not just that all the users are “greedy” (though they may be), but that each is being “rationale” in the sense of pursuing their own best interest in the sense of pursuing an activity (and ignoring externalities) until Marginal Costs = Marginal Benefits. Hardin applied this concept to the issue of population growth, but the issue of salmon in Europe illustrates it as well. Examples:

- unenforced laws that were ignored by those with financial gain at stake (dams, industrial pollution, overfishing).

- fishing pressures that ratcheted up, even as salmon populations crashed, because of premium prices paid by the wealthy.

- gradual eroding of habitat and salmon populations by many small acts by many people who individually were just looking out for their own interests, with no eye on the externalities.

A brief explanation of any of these examples, as elaborated in Ch. 5 of Montgomery, was necessary for full credit.