Ecologists Educators and Schools: Partners in GK-12 Education

ECOS Inquiry

1. Contributor's Name: Matthew Corsi and Flo Gardipee

2. Name of Inquiry: Go Big or Stay Home? Simulation of cutthroat trout life history strategies as a roll of the dice.

3. Goals and Objectives:

a. Inquiry Questions: Why do trout, salmon, and other fishes have variable life history strategies? Why do some fish from one population migrate and others stay in their natal (home) stream?

b. Ecological Theme(s): Trout life history, population biology and ecology, ecological modeling.

c. General Goal: Develop an understanding of the role of random events in shaping the structure of a wild population.

d. Specific Objectives: 1. Introduce the concept of mathematical modeling to students. 2. Learn about trout life history strategies.

e. Grade Level: 5-12

f. Duration/Time Required:

→ **Prep time:** minimal
→ **Implementing Exercise During Class:** 1 hour
→ **Assessment:** 15 minutes

4. Ecological and Science Context:

a. Background (for Teachers): Trout, salmon, and their relatives, as well as other organisms, are often forced to make important trade-offs that determine how likely they are to survive to a certain age and how many offspring they are likely to have. An animal's fitness is controlled by its ability to survive and by the number of offspring it produces during its lifetime. Some individuals in a population of trout will migrate and others will stay in the stream they were born for their entire lives. Offspring from the same family may exhibit both life history strategies. Usually, a trout that migrates can grow to a much larger size than a trout that stays in the home stream. Very large trout are capable of producing exponentially more eggs (offspring) than small trout. It is more likely, however, that a trout that migrates will die before it gains the opportunity to reproduce. Thus, there is a trade-off between migrating and staying in a home stream. Both strategies are viable, and there may be periods of time when one strategy is better than another. For example, if a major debris dam blocks migration pathways for a period of several years, it does not pay for a population to produce migratory fish. On the other hand, if a stream freezes solid two years out of every three, it would not pay for fishes spawned there to remain year-round and migratory forms would have an advantage. We can use a mathematical model to demonstrate these phenomena to students and to better understand them as scientists.

b. Background (to present to Students): Please present the ecological context described above to the students, then present the following:

It is very difficult for scientists to study many wild organisms for long periods of time. In order to overcome this difficulty, it is important to learn how to develop models that are a representation of nature. Models are easier to control, study, and are simpler than nature. For example, to better understand why an organism such as a trout would have multiple life history forms, we can develop a mathematical model to represent what is actually occurring in nature. A fish cannot predict when or how it will be killed any more than you can predict what number will come up for any roll of the dice. As scientists, however, we can use dice to decide whether an imaginary fish will live or die.

A fish has a certain probability that it will migrate or stay in the stream it was born in. A fish has a certain probability of dying as a result of predation, a flood, or drought. A fish also has a certain probability that it will survive to breed once, twice, three times, or even more. We will use the dice to make all of these decisions for us, at random, without controlling what happens on our own. In other words we can get a glimpse of how a population will change in nature by playing a game with dice in the classroom.

5. Motivation and Incentive for Learning: This exercise is very game-like, so students will enjoy learning about science and using their mathematics skills. This exercise can be operated as a self guided inquiry, where students can make hypothesis and get the opportunity to test their hypothesis using the model.

6. Vocabulary:

Model – A simplified representation of nature.
Life History – The series of behavioral shifts, maturation processes, and life stages that shape and define the life of an organism
Resident – For the purposes of this inquiry, a trout that lives in its natal (home) stream its entire life.
Migrant – For the purposes of this inquiry, this represents a trout that leaves its natal stream to go to a habitat where it can grow larger than if it stayed.
Fluvial – A migratory life history strategy where a trout leaves its natal stream to use a larger river habitat to grow large before returning to the natal stream to spawn (reproduce)
Adfluvial – A migratory life history strategy where a trout leaves its natal stream to grow large in a lake or reservoir habitat before returning to the natal stream to spawn.
Fecundity – The number of offspring an organism can produce in a single reproduction event.
Survival – The probability that an organism will survive a given length of time. For the purpose of this inquiry, survival is measured in years.
Fitness – The ability of an organism to survive and reproduce offspring. For example, a trout that survives for three breeding seasons and produces 10 surviving offspring has a higher fitness than a trout that only survives for one breeding season and can only produce 2 surviving offspring.

7. Safety Information: n/a

8. Materials List (including any handouts or transparency masters):

Simulation Instruction Sheet (see below)
Simulation Data Sheet and thought questions (see below)
One set of dice for each group of students

9. Methods/Procedure for students:

a. Pre-investigation work: A short lecture is needed to describe the concept of variable life histories in trout. It is a good idea to use a native local trout/char species as the example fish for this exercise. Cutthroat trout work well in the northwestern United States. If you are uncertain what your local native trout species are, contact your local fish and game management agency. If you live in a region that does not have native trout, other fishes, reptiles, or amphibians may be substituted with minor changes to the probability protocol.

b. Investigation work:

1) What evidence (data, samples) do students collect? The number of groups will be determined by the number of sets of dice. Students will record the results of each run of the simulations, as well as the total offspring produced for each run (see Instruction Sheet below).

2) How do students present the evidence (data)? Students will collect data and make conclusions on the simulation data sheet

3) What conclusions are drawn from the evidence students collect? What is the best life history strategy? Did one group get a different answer than the other? Students should be able to answer these questions with an understanding of the ecological meanings of their conclusions.

4) Include examples of data sheets. (See below)

10. Assessment: The simulation data sheets can be collected to discern student understanding of the material. Also a class discussion of the data and conclusions drawn by each group of students will elucidate the effectiveness of the inquiry.

11. Extension Ideas: There are several possible extensions that are not limited to the following list:

- Play with the number of survival or death scenarios for each life history strategy. How drastically do they shift the results? How could a fishery manager use such a model to decide management strategies?
- Advanced high-school students capable of computer modeling could program this model or a more advanced one as a class project. The computer model could then be run thousands of times or with adjusted parameters to learn more about the ecology of trout populations.
- Use this inquiry in a math class as a real-world application of probability

12. Scalability: The inquiry presented here was implemented in a 5th grade class, but it could be scaled to any grade level where students are capable of carefully recording data and multiplication. Many levels of complexity could be added to this model to scale it to upper grade levels.

13. Science Standards Accomplished:

5-8

Reproduction and Heredity
Regulation and Behavior
Populations and Ecosystems
Diversity and Adaptations of Organisms
Risks and Benefits

9-12

Biological Evolution
Behavior of Organisms
Natural Resources

14. References:

15. List of Experts and Consultants:

16. Evaluation/Reflection by Fellows and Teachers of how it went: This inquiry was well received by students and instructors alike. Comments, thoughts, and conclusions made by the 5th grade classroom were surprisingly insightful. Many of the students and teachers that participated in the simulation observed that the life history trade-offs had both benefits and drawbacks, such as short life span and high fecundity for the migrant, and a longer life span with lower fecundity for the resident. However, the simulations of both life histories usually produced about the same amount of offspring with a few exceptions.

Go Big or Stay Home?
Simulation Instruction Sheet

1) Roll dice to determine which life history the fish will have: Odd numbers are migrant life history; even numbers are resident life history.

2) Roll the dice each "year" to determine whether the fish survives to the next year or not:

	Resident	Migrant
1	Survive	Survive
2	Survive	Survive
3	Survive	Survive
4	Survive	Survive
5	Eaten by Predator	Eaten by Predator
6	Survive	Survive
7	Killed by Flood	Killed by Flood
8	Survive	Survive
9	Survive	Eaten by Predator
10	Survive	Survive
11	Survive	Drought - You are Dried Up!
12	Survive	Survive

Whenever a fish dies, put an X through the box.

3) If a fish survives to breeding age (for the purpose of this simulation, this is year 3 for all Cutthroat Trout), roll the dice to determine the number of offspring they will produce during that year. Resident fish roll both dice and **add** the two numbers, while migrant fish roll two dice then **multiply** the two numbers. Write the number of offspring in the box for that year.

4) After the fish breeds, roll again to see if it survives to the next year.

5) Add the number of offspring for each fish and put the total in the offspring column.

6) The simulation ends when the table is full for one life history type.

7) Discuss and compare the outcome of the simulation for each life history strategy.

Cutthroat Simulation Data sheet

Resident Cutthroat Life History Type

Fish	Year 1	Year 2	Year 3 (Breed)	Year 4 (Breed)	Year 5 (Breed)	Total Offspring
1	0	0				
2	0	0				
3	0	0				
4	0	0				
5	0	0				
6	0	0				
7	0	0				
8	0	0				
9	0	0				
10	0	0				
					Totals:	

Migrant Cutthroat Life History Type

Fish	Year 1	Year 2	Year 3 (Breed)	Year 4 (Breed)	Year 5 (Breed)	Total Offspring
1	0	0				
2	0	0				
3	0	0				
4	0	0				
5	0	0				
6	0	0				
7	0	0				
8	0	0				
9	0	0				
10	0	0				
					Totals:	

1) Did one life history strategy end up with higher numbers of offspring? Why did this occur?

2) Why do you think cutthroat trout have more than one life history strategy?