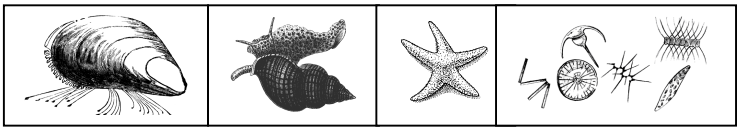
Ecology – *Interactions, Energy, Nutrients, and Change in the Intertidal Community*

Ecologist: _____

Date:_____Period:____



Activity 3 - The Non-consumptive Effect Game

Objectives:

1. Students will be able to define non-consumptive effects and give one example.
2. Students will be able to collect and analyze data from a predator-prey simulation game.
3. Students will be able to compare the impact of consumptive and non-consumptive effects of a predator on its prey population.
4. Students will be able to explain the significance of non-consumptive effects in predator-prey interactions.
5. Students will be able to apply their understanding of non-consumptive effects of predators to determine how to best manage an ecosystem.

Predator-Prey Relationships

In any ecosystem, organisms interact with each other in a number of ways. Organisms can be in competition, predator-prey relationships, or in different types of symbiotic relationships including commensalism, mutualism, and parasitism.

When studying predator-prey relationships, ecologists have long focused on how predation affects the prey population. Recently, ecologists, including Steven Gosnell at the University of California, Santa Barbara's department of Ecology, Evolution, and Marine Biology, have begun researching the non-consumptive effects predators have on their prey.

Non-consumptive effects are the impacts that predators have on the members of the prey population that aren't being eaten. For an example, let's consider the relationship of sea stars and mussels in tide pools. The mussels can detect chemical signals in the water released by the sea stars that alert the mussels to the presence of the predator.

The very presence of the Ochre Sea Star around their primary prey organisms, *Mytilus californianus* (mussels), is a stressor that causes important changes in the mussel's physiology. Mussel's may close their shells and devote more energy to muscle growth to keep the sea stars from prying them open. Both of these responses represent important trade-offs in for the mussels. Closing their shell limits how much time the mussels spend filter-feeding, excreting waste, and collecting Calcium carbonate to strengthen their shells. Devoting more energy to muscle development, takes away energy usually devoted to reproduction. In general, the result of the stress on prey from the presence of a predator is a set of behavior and physiological modifications that shorten the lifespan and lower the reproduction rate.

These non-consumptive effects have been shown to impact prey populations to an even greater extent than actual predation.

One important application of researching non-consumptive effects of predators on their prey is in the field of aquaculture. Mussels are farmed commercially and sold for food. What if mussels develop more muscle or meat in response to the presence of a sea star? Mussel farmers could increase their yields and profits by growing their mussels in cages that allow them to introduce the sea stars and their non-consumptive effects while keeping the sea stars from consuming any of the mussels. Scientific research can offer valuable insights into the optimum number of sea stars that would result in the lowest expense and greatest results in terms of their non-consumptive effects on the mussels.

To demonstrate how predators exert non-consumptive effects on their prey, each student in your class will play the part of one of three different organisms in this ecosystem; plankton, mussels, or sea stars.

This game of tag will demonstrate how the very presence of a predator can lower its prey population beyond the number of prey organisms actually consumed.

Pre-game questions:

1. **What is the top predator of the intertidal zone?** _____
2. **What is their main prey?** _____
3. **How are these prey alerted to the presence or the predator?** _____
4. **How can a predator affect a prey without eating it?** _____

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5. **What do we call this effect?** _____
6. **What is one non-consumptive effect that sea stars have on mussels?** _____

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How to Play:

1. Designate approximately ¾ of the class to be plankton, designate ¼ of the class to be mussels, and two people to be a sea star.
2. Record the initial mussel population on the chart below. In a classroom or on an outdoor court with boundaries, make one side the high tide line and the opposite side the low tide line.
3. Arrange the mussels in a line, evenly spaced across the class or court half way between the high and low tide lines. Once they are placed, they cannot move (Their bissell fibers are attached to the rocky substrate of the intertidal zone)!
4. All of the plankton start on the low tide line of the area.
5. To begin the game, the plankton will be washed by the waves (run) to the high tide line without being caught (tagged with two hands) by a mussel. If a plankton is caught by a mussel, they have to stand by the mussel for the remainder of the round while they are being digested. If a mussel catches three plankton, the mussel gets to select one to become a mussel for the next round. When mussels are well-fed, reproduction increases. The other two return to be plankton.
6. Each mussel must catch at least one plankton each round or else they die and become plankton. The nutrients recycled by decomposers are used by plankton to grow and reproduce, so the dead mussels get to return to the game as plankton.
7. One round is complete each time the plankton washes from low tide to high tide and back again. After each round, record the final mussel population on the chart below and calculate the change in population size and the percentage change. Do this three times and calculate the average percent change in the population. Listen for your teacher's signal to begin and end each round.
8. Now you will add a predator (a sea star) to the game to see how it affects the size of the mussel population. Remember to still record the initial population of the mussels.
9. The sea star will be represented by two people standing back-to-back and tied together at the waist. The sea star gets to start each round in the center of the game area. The goal of the sea star is to eat (tag with two hands) as many mussels as possible each round. If a mussel is tagged, they will become plankton for the next round.
10. To avoid predation, the mussels can tuck into a crouched position on the ground and cover their heads. This means that they are "safe" and the sea star cannot tag them. However, the mussels cannot tag plankton while crouching.
11. After each round, record the final mussel population on the chart below and calculate the change in population size and the percentage change. Do this three times and calculate the average percent change in the population. **Listen for your teacher's signal to begin and end each round.**

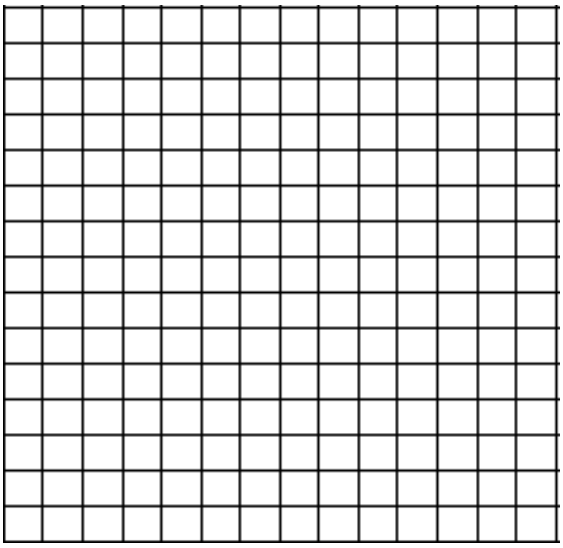
	Round #	Column A Initial Mussel Population	Column B # of mussels consumed	Column C Final Mussel Population	Column D Change in Population **(Column A – Column C) =**	Column E Percent Change **(Column D / Column A) x 100 =**
Without Predator	1		0			
	2		0			
	3		0			
	Average		0			
With Predator	4					
	5					
	6					
	Average					

Analysis and Conclusion

1. Create a bar graph comparing the average percent change in the population of the mussels with and without predators in the space provided.

Remember S.U.L.T.A.N. when making Graphs.

(**S**cale, **U**nits, **L**abels, **T**itle, **A**ccuracy, and **N**eatness)



2. Was the average percent change in population of the mussels greater with or without the presence of the sea star?

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3. When predators were present, how many organisms were consumed on average during each round? _____ What was the average change in population (column D)? _____ Are these numbers the same? _____

4. When the sea stars were present in the game, what could the mussels do to avoid predation?

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5. In tide pools, what do mussels actually do when they are alerted to the presence of a sea star?

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6. In this activity, you should have noticed that when a predator is present, the population of mussels goes down. You should have also noticed that the decrease in population was not due only to predation. What do we call the effect a predator has on prey organisms that aren't eaten?

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7. The National Park Service in Yellowstone National Park is concerned that the elk population has grown too large and overgrazing of the grasslands is threatening the nesting habitat of several bird species. Ecological studies indicate that to reverse this effect and maintain suitable nesting sites for the birds, the optimal elk population needs to be reduced by 100 elk every year. The NPS is considering introducing wolves into the park to prey on the elk. Ecologists know that one wolf eats 10 elk a year on average. Using what you've learned from this activity, explain how many wolves the NPS should introduce into the park and why.

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Extension: Researchers do not yet have a complete understanding of how mussels respond to the presence of sea stars in the ecosystem. For example, to avoid predation, mussels might develop a calcium carbonate thicker shell. This would require them to stay open more to filter calcium carbonate from the water. They may also respond by closing their shell, making it more difficult for the stars to pry them open. If you were a mussel, which would you try to do and why?

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Write a hypothesis in the, "*If…, then…***" form stating how you think mussels responsed to predators. For example, "***If mussels are present, then mussels will…***" Then, design an experiment to test your hypothesis. Identify the independent and dependent variables and describe your control.**

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