Some Animals Are More Equal than Others: Trophic Cascades and Keystone Species

hhmi | BioInteractive

Short Film
Student Handout

NAME_____ **DATE**_____

This handout supplements the short film *Some Animals Are More Equal than Others: Trophic Cascades and Keystone Species*.

1. True/False. All members of a food web are equal in abundance and in their relative effects on one another.

2. Explain the reasoning or evidence you used to answer Question 1.

3. True/False. Every member of a food web is the prey of another member of the food web.

4. Explain the reasoning or evidence you used to answer Question 3.

5. Which statement below explains why the mussels in Mukkaw Bay were able to quickly cover the rockface in Paine's experiment?
   A. The starfish took up most of the room on the rocks, and when the starfish were removed, the mussels occupied the empty spaces.
   B. Paine added more mussels to the rocks, causing the starfish to move to other habitats.
   C. The starfish were competing directly with the mussels for food, and removing the starfish allowed the mussels more access to the food.
   D. Starfish feed on mussels, so when the starfish were removed the mussels no longer had a predator and their populations grew unchecked.

6. In the film, Paine recalls that a year after the starfish had been removed, the number of species decreased from 15 to eight, after three years the number went down to seven, and after another seven years it was almost all only mussels. In the control plots the number and diversity of species was basically unchanged. Which statement(s) best explain(s) these results?
   I. Keystone species are critical to the diversity and stability of an ecosystem.
   II. When a predator is removed, the prey of that predator always increases and species not eaten by the predator always decrease.
   III. The disappearance of producers from an ecosystem can cause the number of predators to increase.

   A. I only
   B. I and II only
   C. II and III only
   D. I, II, and III

7. Before the 1960s, most ecologists thought that the number of producers in an ecosystem was the only variable that limits the number of herbivores. The idea was that every level was regulated by the amount of food from the trophic level below it.

    a. How did the green world hypothesis differ from this "bottom-up" view?

    b. Imagine a simple food chain: Grass -> Grasshoppers -> Mice. If snakes that eat mice are added to the ecosystem, how would you redraw the food chain to represent this change?

    c. After the snakes are added, would you expect the amount of grass to increase or decrease? Explain your reasoning.

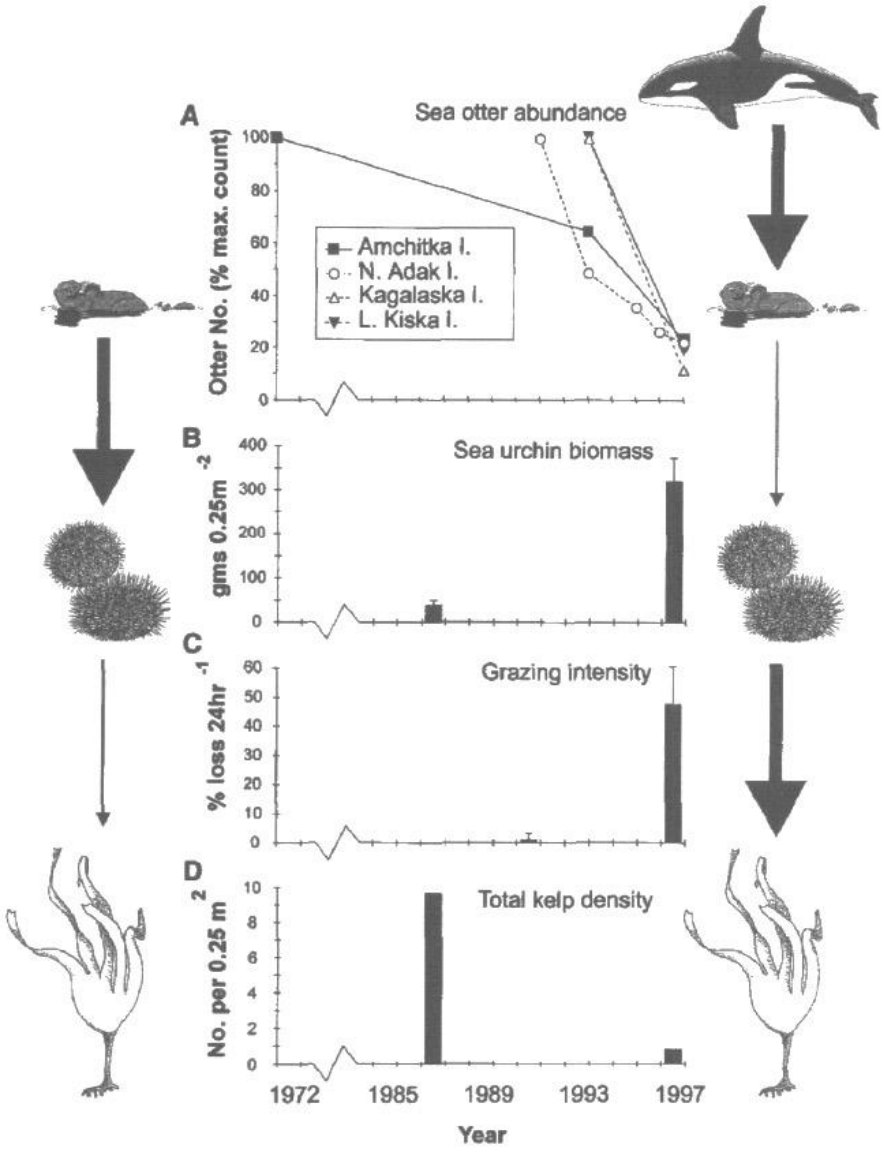

Figure 1. Since 1972, Dr. Jim Estes had been studying a food chain of kelp -> urchins -> sea otters, and then in the early 1990s orcas began eating the sea otters. The data collected by Dr. Estes are shown. Panel A shows sea otter abundance around four different islands from 1972 to 1997. Panel B shows the amount of sea urchins (sea urchin biomass) in 1987 and 1997. Panel C shows the amount of kelp that sea urchins ate over a 24-hour period (grazing intensity) in 1991 and 1997. Panel D shows the number of kelp plants within a specific area (density of kelp) in 1987 and 1997. The thickness of the arrows illustrates the strength of the effect one species has on the species below it in the food web.

Refer to Figure 1 for questions 8 through 11 below.

8. In 1997, which species is the apex predator in the food chain?
    A. Killer whales
    B. Sea otters
    C. Sea urchins
    D. Kelp

9. Which of the following statements describes the data in Figure 1?
    A. An increase in sea urchin biomass is associated with more intense grazing.
    B. An increase in sea urchin biomass is associated with greater kelp density.

C. Predation of sea otters by killer whales is associated with greater kelp density.
D. Sea otter abundance was relatively stable from 1972 to 1997.

10. Complete the following sentence. Figure 1 illustrates that when orcas started eating sea otters, the sea otter population _____, the urchin population _____, and the kelp population _____.
    A. Decreased, decreased, decreased
    B. Decreased, increased, decreased
    C. Increased, decreased, increased
    D. Increased, increased, increased

11. The arrows on the left and right sides of Figure 1 show the effects of one species on the species that are on lower trophic levels. Thicker arrows indicate a large effect and thin arrows a smaller effect. The arrows on the left show a system in which there are a lot of sea otters. The arrows on the right show a system in which there are few otters. Explain why the down-pointing arrows on the left side of the figure look different from the arrows on the right side of the figure.

In the 1990s, ecologists Deborah Letourneau and Lee Dyer studied a tropical forest shrub called the piper plant and the various species of insects that live on and near the shrub. A species of ant uses the piper plant as a home by hollowing out some of its branches and building colonies inside the hollow branch cores. The ants do not eat the plant's leaves. Instead, the leaves are consumed mostly by caterpillars. When the ants encounter caterpillars or caterpillar eggs on the plant's leaves, they either eat them or kick them off. Letourneau and Dyer added beetles that eat ants. Figure 2 shows the results of one of Letourneau and Dyer's experiments in which they compared the leaf area of piper plants in control plots to that of experimental plots to which they had added beetles that eat ants.

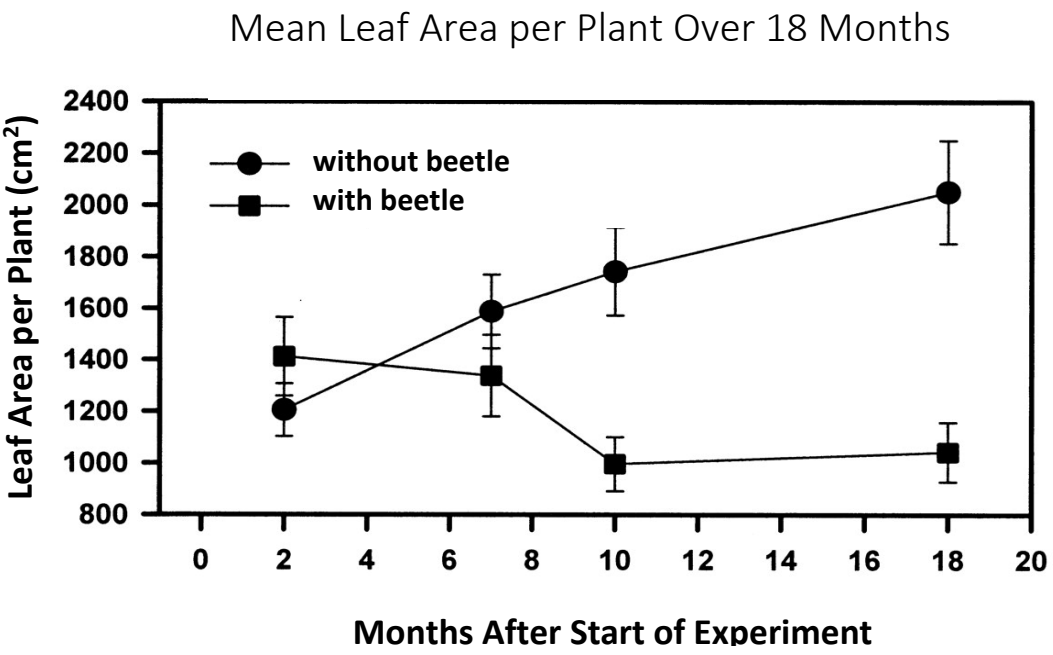

Figure 2. Mean leaf area per tree. Initial measurements were taken before (0 to 2 months) and after (7 to 18 months) beetles were added to 40 of 80 plants. The light gray round markers represent measurements taken of the control plots, to which beetles were not added. The black square markers represent measurements taken of the experimental plots, to which beetles were added. Measurements were made on all leaves to calculate the mean leaf area per plant. Error bars represent standard error of the mean.

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Refer to the figure to answer questions 12 through 17.

12. For both the plots with the beetles added and the control plots, state the mean tree leaf area per plot that the scientists recorded after running the experiment for 18 months.

13. Compare the trends in mean tree leaf area per plot for both the plots with the beetles added and the control plots over the 18 months of the experiment.

14. Draw two diagrams that show the food chains for both the experimental and control plots. Include interactions among predatory beetles (if present), ants, caterpillars, and piper plants.

Control

Experimental

15. Describe the impact of adding the beetles on each species in the food chain above.

16. Which statement do Letourneau and Dyer's results support?
    A. Adding beetles reduced ant numbers and triggered a trophic cascade that increased the mean leaf area left on plants.
    B. Adding beetles had little effect on this ecosystem, showing that it is primarily regulated from the bottom up.
    C. Adding beetles reduced ant numbers and triggered a trophic cascade that decreased the mean leaf area left on plants.
    D. Adding beetles reduced ant numbers and increased the caterpillar population size, proving that the caterpillars are a keystone species in this habitat.

17. Do the results of the Letourneau and Dyer experiment support or refute the green world hypothesis? Explain your answer.