**ANSWERS**

* 1. (True/False. All members of a food web are equal in abundance and in their relative effects on one another.
* ***False. Some members of a food web can have effects that are disproportionate to their abundance. For example, keystone species have small populations, but because of what and how much they consume, their absence from the food web could have very large effects on the structure of the ecosystem.***
* 2. Explain the reasoning or evidence you used to answer Question 1.

 ***Some species, like the starfish in Robert Paine’s first experiment, which were not as abundant as some other species, can have large effects on the structure of their ecosystems. When the starfish were absent, populations of their primary prey species (mussels) increased so quickly that they crowded out nearly all of the other species in the ecosystem. Also present is evidence from the presence or absence of sea otters in the kelp-urchin-sea otter food chains.***

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

***False. Apex predators are at the top of food webs and do not have predators.***

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

***The diagram of the food chain in the film shows that the starfish is the top predator and does not itself have predators in the tide pools. Also, the film does not explain this, but the orcas don’t have any predators either. Their populations are regulated from the bottom up by the availability of food.***

1. Which statement below explains why the mussels in Mukkaw Bay were able to quickly cover the rockface in Paine’s experiment?
	1. The starfish took up most of the room on the rocks, and when the starfish were removed, the mussels  occupied the empty spaces.
	2. Paine added more mussels to the rocks, causing the starfish to move to other habitats.
	3. The starfish were competing directly with the mussels for food, and removing the starfish allowed the  mussels more access to the food.
	4. ***Starfish feed on mussels, so when the starfish were removed the mussels no longer had a predator and their populations grew unchecked.***
2. 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 mussels. In the control plots the number and diversity of species was basically unchanged. Which statement(s) best explain(s) these results?
3. Keystone species are critical to the diversity and stability of an ecosystem.
4. When a predator is removed, the prey of that predator always increases and species not eaten by the predator always decrease.
5. The disappearance of producers from an ecosystem can cause the number of predators to increase.
	1. ***I only***
	2. I and II only
	3. II and III only
	4. I, II, and III
6. 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.
	1. How did the green world hypothesis differ from this “bottom-up” view? ***The green world hypothesis*  *explained that the number of herbivores is also limited by predators from the top down****.*
	2. Imagine a simple food chain: Grass -> Grasshoppers -> Mice. If snakes that eat mice are added to this ecosystem, how would you redraw the food chain to represent this change?  ***Grass -> Grasshoppers -> Mice -> Snakes***
	3. *After the snakes are added, would you expect the amount of grass to increase or decrease? Explain your reasoning.* ***Answers will vary, but students should expect the amount of grass to decrease. The snakes will cause a reduction in mouse populations, leading to an increase in grasshoppers that will then eat the grass.***
7. In 1997, which species is the apex predator in the food chain?
	1. ***Killer whales***
	2. Sea otters
	3. Sea urchins
	4. Kelp
8. Which of the following statements describes the data in Figure 1?
	1. ***An increase in sea urchin biomass is associated with more intense grazing.***
	2. An increase in sea urchin biomass is associated with greater kelp density.
	3. Predation of sea otters by killer whales is associated with greater kelp density.
	4. Sea otter abundance was relatively stable from 1972 to 1997.
9. 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 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
	1. decreased, decreased, decreased
	2. ***decreased, increased, decreased***
	3. increased, decreased, increased
	4. increased, increased, increased
10. 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.

***On the left, the sea otters have a large effect on the sea urchins in the absence of the killer whales. The sea urchins have a small effect on the kelp because their numbers are held in check by the sea otters. On the right, the killer whales have a large effect on the sea otters, whose populations then decrease. The effect the sea otters have on the sea urchins is thus weaker, allowing sea urchin populations to grow, and they in turn have a large effect on the kelp.***

12. (Key Concept F) For both the plots with the beetles added and the control plots (no beetles added), estimate the mean tree leaf area per plot that the scientists recorded after running the experiment for 18 months**. *Students should answer about 2,000 cm2 for the control plots and 1,100 cm2 for the plots with the beetles added.***

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.

***Students should describe that the leaf area for the control plots without beetles increased over the 18-month period, but decreased for the plots where the beetle larvae were added. A complete answer will be one in which students also explain that the mean leaf areas were similar through about the first 7 months of the experiment but after that, the differences between the means may be significant. (A statistical test, like the student’s t-test, is needed to determine whether the difference is indeed statistically significant.***

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

Control Experimental

***piper plants* *caterpillars* *ants piper plants* *caterpillars* *ants* *beetles***

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

***The beetles eat the ants. With fewer ants there are more caterpillars. The caterpillars eat more leaves.***

1. Which statement do Letourneau and Dyer’s results support?
	1. Adding beetles reduced ant numbers and triggered a trophic cascade that increased the mean leaf area  left on plants.
	2. Adding beetles had little effect on this ecosystem, showing that it is primarily regulated from the bottom  up.
	3. ***Adding beetles reduced ant numbers and triggered a trophic cascade that decreased the mean leaf area left on plants.***
	4. 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.

***The experiment supports the green world hypothesis because changes in plant leaf area were caused by predators controlling herbivore numbers from the top down. Adding beetles decreased ant predation on caterpillars and led to increased caterpillar herbivory and decreased plant leaf area.***