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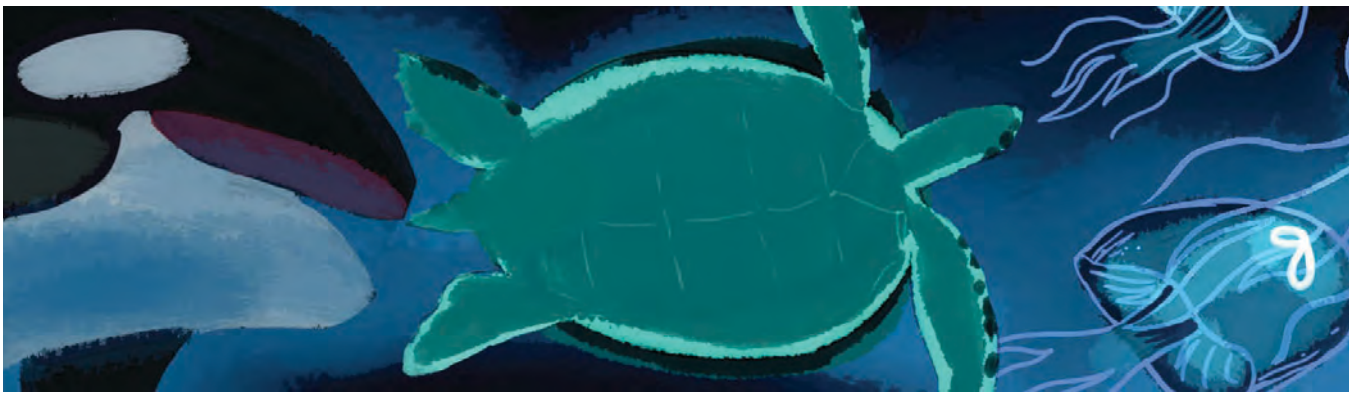

Populations and Resources:

Too Many Moon Jellies

Investigation Notebook with Article Compilation

These materials are based upon work partially supported by the National Science Foundation under grant numbers DRL-1119584, DRL-1417939, ESI-0242733, ESI-0628272, ESI-0822119. The Federal Government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Developed by the Learning Design Group at the University of California, Berkeley's Lawrence Hall of Science.

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Populations and Resources: Too Many Moon Jellies
ISBN: 978-1-947002-96-8
AMP.NA18

Populations and Resources:

Too Many Moon Jellies

Investigation Notebook

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Safety Guidelines for Science Investigations

1. **Follow instructions.** Listen carefully to your teacher's instructions. Ask questions if you don't know what to do.

2. **Don't taste things.** No tasting anything or putting it near your mouth unless your teacher says it is safe to do so.

3. **Smell substances like a chemist.** When you smell a substance, don't put your nose near it. Instead, gently move the air from above the substance to your nose. This is how chemists smell substances.

4. **Protect your eyes.** Wear safety goggles if something wet could splash into your eyes, if powder or dust might get in your eyes, or if something sharp could fly into your eyes.

5. **Protect your hands.** Wear gloves if you are working with materials or chemicals that could irritate your skin.

6. **Keep your hands away from your face.** Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.

7. **Tell your teacher if you have allergies.** This will keep you safe and comfortable during science class.

8. **Be calm and careful.** Move carefully and slowly around the classroom. Save your outdoor behavior for recess.

9. **Report all spills, accidents, and injuries to your teacher.** Tell your teacher if something spills, if there is an accident, or if someone gets injured.

10. **Avoid anything that could cause a burn.** Allow your teacher to work with hot water or hot equipment.

11. **Wash your hands after class.** Make sure to wash your hands thoroughly with soap and water after handling plants, animals, or science materials.

Name: _____ Date: _____

Populations and Resources: Too Many Moon Jellies
Unit Overview

What caused the size of the moon jelly population in Glacier Sea to increase so much? That's what you will figure out as you and your classmates take on the role of student ecologists, analyzing population data and using a digital simulation of an ecosystem to discover what's happening in the Glacier Sea ecosystem. Could the cause of the moon jelly population increase have to do with the leatherback sea turtles in Glacier Sea? The tiny algae? The sea urchins? The orca? The kelp? Or is it something else? By the end of this unit, you will have learned about the concept of Stability and Change in populations, eating relationships, energy, reproduction, and more. You will have gathered the evidence you'll need to create an explanation for the moon jelly mystery, and you'll discuss another population mystery—about endangered parrots on an island in the south pacific.

Name: _____ Date: _____

Chapter 1: Stability and Change in Populations
Chapter Overview

The Glacier Sea moon jelly population is increasing at a rapid rate. You will work as a student ecologist with Glacier Sea Research Center to find out how this mysterious population explosion happened. In this chapter, you will investigate what causes a population's size to increase.

Name: _____ Date: _____

Lesson 1.2: Mysterious Moon Jelly Increase

Welcome to your new assignment as student ecologists! An ecologist is a scientist who studies interactions of organisms with one another and their environment. As a student ecologist, you will be studying a mysterious increase in the number of moon jellies in fictional Glacier Sea. Today, you will watch a short video to learn why changes like the increase in the number of moon jellies are important and how ecologists study them. You will also use the *Populations and Resources* Simulation to investigate what can happen to an organism in a population.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 1 Question

- What caused the size of the moon jelly population in Glacier Sea to increase?

Vocabulary

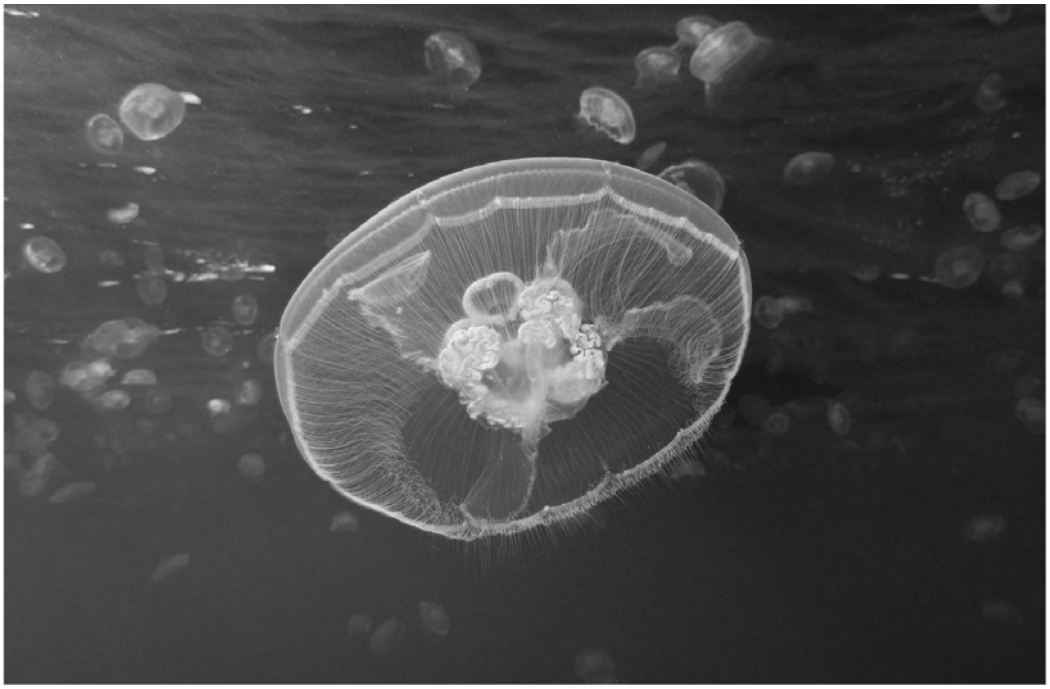
- ecosystem
- population

Digital Tools

- *Populations and Resources* Simulation

Name: _____ Date: _____

Warm-Up



moon jellies drifting underwater

You are about to watch a video about a scientist who studies jellies like the one shown in this image. One thing she investigates is changes to the number of jellies living in an area. What ideas do you have about why the number of organisms in an area might increase?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Introduction to the Glacier Sea Ecosystem

Initial Ideas About the Size of the Jelly Population Increase

Talk to your partner about your initial ideas about the Chapter 1 Question.

Chapter 1 Question: *What caused the size of the moon jelly population in Glacier Sea to increase?*

Name: _____ Date: _____

Exploring the *Populations and Resources* Sim

Part 1: Introducing the *Populations and Resources* Simulation

Talk with your partner as you explore the *Populations and Resources* Simulation (use 3 Populations—Intro mode). Share what you both notice.

As you explore the Sim, discuss the following questions with your partner:

- What do the different buttons do in the Sim?
- What did you notice about what you can change in the Sim?
- What questions do you have about the Sim?

Part 2: Observing Organisms in the Sim

A population is a group of the same kind of organism living in the same area. Use the Sim to observe what organisms in a population do and what can happen to them.

1. Launch the *Populations and Resources* Simulation.
2. Track an individual organism from any of the populations. Observe and record what it does and what happens to it in the table below.
3. Track another organism from another population. Observe it and record what it does and what happens to it in the table below. Repeat until you have observed and recorded the information for at least three organisms.

Things that organisms I tracked did: (example: ate other organisms)	**Things that happened to the organisms I tracked:** (example: was eaten by other organisms)

Name: _____ Date: _____

Homework: Reading *Arctic Ecosystem*

Glacier Sea is not a real place. However, it is based on a real Arctic environment, and the organisms you will study are real organisms. For homework, you will read a chapter about a real Arctic ecosystem and then draw a model to show your initial ideas about what caused the jelly population to explode. Pick the article that you think might help you create your model (and feel free to browse others). Your model can include arrows, labels, and symbols. If you use symbols remember to add a key to explain what they represent. Follow the steps below.

1. Review the different chapters to find the article that you think might help you create your model of what caused the jelly population to increase.
2. Read and annotate the chapter about this population.
3. Based on the reading, draw a diagram of a model that shows your initial ideas about what caused the jelly population to increase.
4. When you are finished, you can choose to read about one or more of the other populations.
5. Which population(s) did you read about? Why do you think this population affected the size of the jelly population? _____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Draw your diagram here:

Name: _____ Date: _____

Lesson 1.3: Births and Deaths in Populations

The Glacier Sea moon jelly population is increasing in size rapidly. As student ecologists at Glacier Sea Research Center, your job is to find out why. Births and deaths must be happening in the jelly population because births and deaths happen in all populations. Today you will use a physical model and a video demonstration to help you investigate how births and deaths affect the size of a population.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 1 Question

- What caused the size of the moon jelly population in Glacier Sea to increase?

Key Concepts

- Within a population organisms are always being born and dying.

Vocabulary

- ecosystem
- population
- stability

Digital Tools

- *Populations and Resources* Data Tool activity: World Population Data

Name: _____ Date: _____

Warm-Up

A group of scientists has been observing a population of meerkats in Botswana. They notice that the size of the population has not changed much between 2000 and 2016.

The population size did not change between 2000 and 2016.

Theo thinks that the population size stayed the same because no new meerkats were born and none died. They were all the same meerkats.

Fabiola thinks that it is not possible that all the same meerkats were in the population for the whole time.

Which person do you most agree with? (check one)

- ☐ Theo
- ☐ Fabiola

Explain your answer.

_____

_____

_____

_____

_____

Name: _____ Date: _____

Birth and Death Token Model

Births and deaths are always happening in a population. How does the number of births and deaths in a population affect its size? To find out, try these missions:

Mission 1: Make the population size **stay the same** over time.

Mission 2: Make the population size **increase** over time.

Mission 3: Make the population size **decrease** over time.

1. Add 14 tokens to the circle on the Token Model Population Circle sheet to start with a population of 14 organisms.
2. Every year 1, 2, or 3 organisms must die and 1, 2, or 3 organisms must be born. How many is up to you and your partner.
   - To make an organism die, remove it from the population and add it back to the cup. Count this as one death.
   - To make an organism be born, add one token from the cup to the circle. Count this as one birth.
3. Repeat until you have modeled 6 years.
4. At the end of every year, record the number of births, deaths, and organisms on the chart and plot the number of organisms on the graph on page 13.
5. At the end of 6 years, add up the total numbers of births and deaths and record it in the total column.
6. After you've completed the graphs, circle your answer to complete the sentences below.

   When the population size **stays the same** over time, the total number of births
   (**equals** / **is less than** / **is greater than**) the total number of deaths.

   When the population size **increases** over time, the total number of births
   (**equals** / **is less than** / **is greater than**) the total number of deaths.

   When the population size **decreases** over time, the total number of births
   (**equals** / **is less than** / **is greater than**) the total number of deaths.

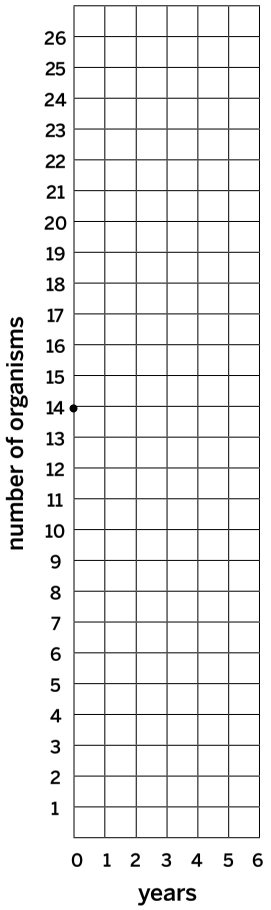
Name: _____ Date: _____

Birth and Death Token Model (continued)

Mission 1: Make the population size **stay the same** over time.

Years (round)	1	2	3	4	5	6	Total
Births							
Deaths							
Organisms							N/A

Population stays the same over time

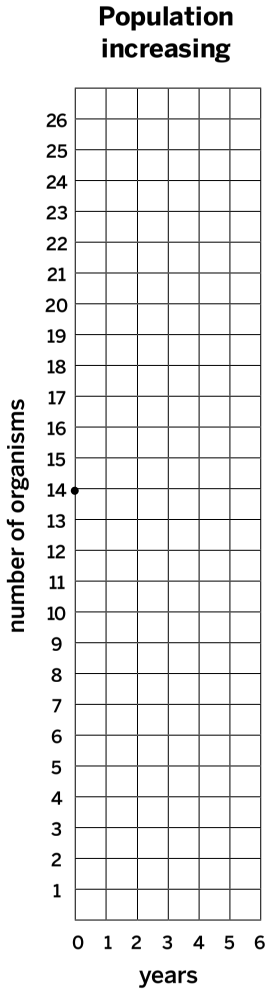


Name: _____ Date: _____

Birth and Death Token Model (continued)

Mission 2: Make the population size **increase** over time.

Years (round)	1	2	3	4	5	6	Total
Births							
Deaths							
Organisms							N/A

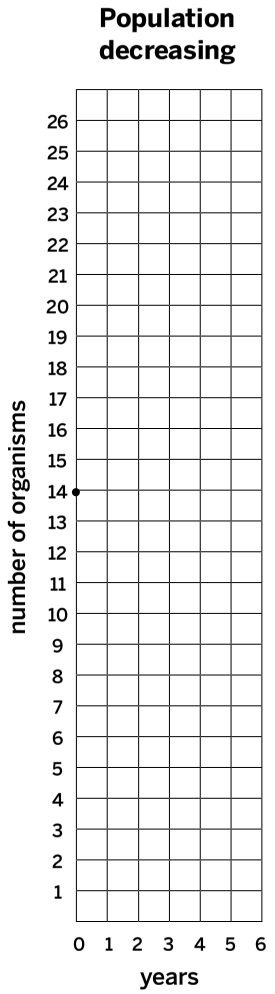


Name: _____ Date: _____

Birth and Death Token Model (continued)

Mission 3: Make the population size **decrease** over time.

Years (round)	1	2	3	4	5	6	Total
Births							
Deaths							
Organisms							N/A



Name: _____ Date: _____

Homework: Reading "How Ecosystems Clean Earth's Water"

Annotate the article as you read, then answer the question below.

Why are *ecosystems* important for humans?

_____

_____

_____

_____

_____

_____

_____

Why is biodiversity important for ecosystems?

_____

_____

_____

_____

_____

_____

_____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 1.4: Births and Deaths in the Jelly Population

We heard that the moon jelly population increased, but how do we really know if we can't possibly count all the jellies in Glacier Sea? Today, you will use what you have learned about why populations change size to come up with some possible explanations for the moon jelly population explosion in Glacier Sea. First, you will watch a video to learn about how ecologists get evidence about a population, and evaluate evidence about the moon jelly population. Then, you will use the strongest evidence to make a model that shows why the population increased.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 1 Question

- What caused the size of the moon jelly population in Glacier Sea to increase?

Key Concepts

- Within a population organisms are always being born and dying.
- A system can be stable even as things are being added to and removed from it. If the amounts being added and being removed are not equal, then the system will change.
- If the number of births and deaths in a given time are equal, then the population size will be stable.
- If there are more births than deaths in a given time, then the size of the population will increase. If there are fewer births than deaths, then the size of the population will decrease.

Vocabulary

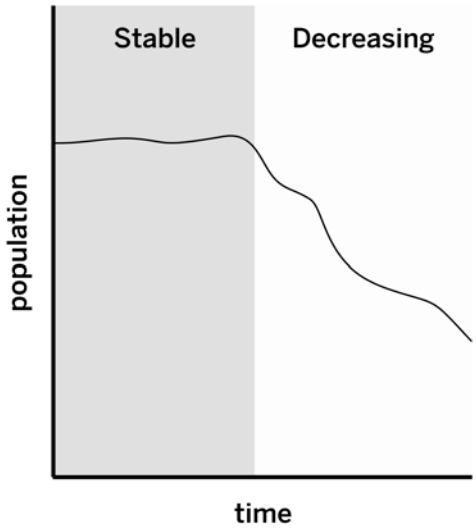
- ecosystem
- population
- sample
- stability

Name: _____ Date: _____

Warm-Up

Look at the graph showing the honeybee population in the United States and then answer the questions.

US Honeybee Population Decrease



The graph shows that the honeybee population was stable and then decreased. Which statement describes births and deaths when the honeybee population was **stable?** (check one)

- ☐ There was the **same amount** of births and deaths.
- ☐ There were **more** births than deaths.
- ☐ There were **fewer** births than deaths.

Which statement describes births and deaths when the population was **decreasing?** (check one)

- ☐ There was the **same amount** of births and deaths.
- ☐ There were **more** births than deaths.
- ☐ There were **fewer** births than deaths.

Name: _____ Date: _____

Evaluating Moon Jelly Population Evidence

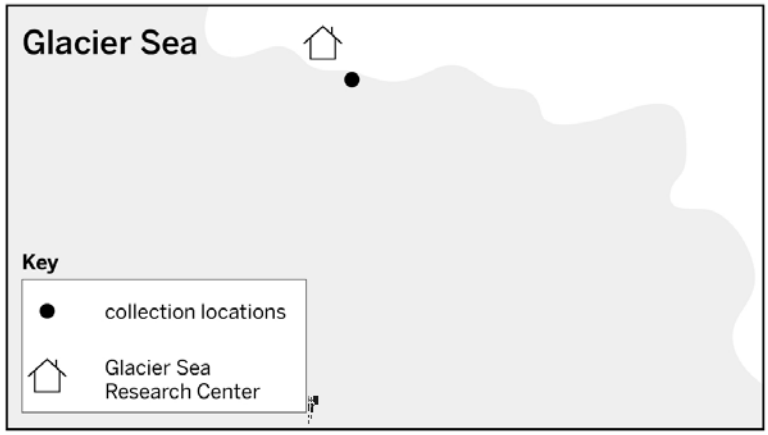
One way scientists evaluate evidence is to determine how well a sample represents the population.

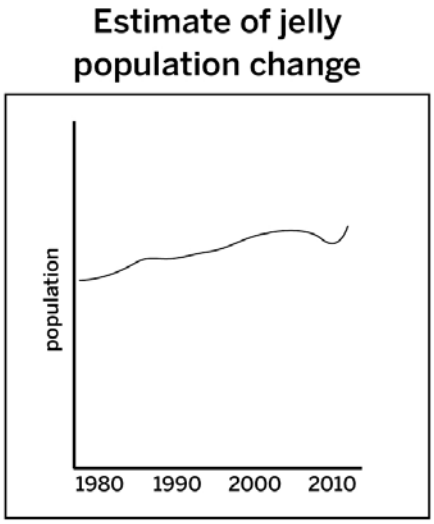
Samples that represent as much of the whole as possible provide stronger evidence.

The evidence below describes a sample that ecologists used to learn about the jelly population. Read and annotate Moon Jelly Evidence A and B and then talk to your partner about which sample represents more of the whole population.

Moon Jelly Evidence A

- Every year between 1980 and 2010, ecologists counted moon jellies in Glacier Sea.
- The jellies are counted in one location near the shore.



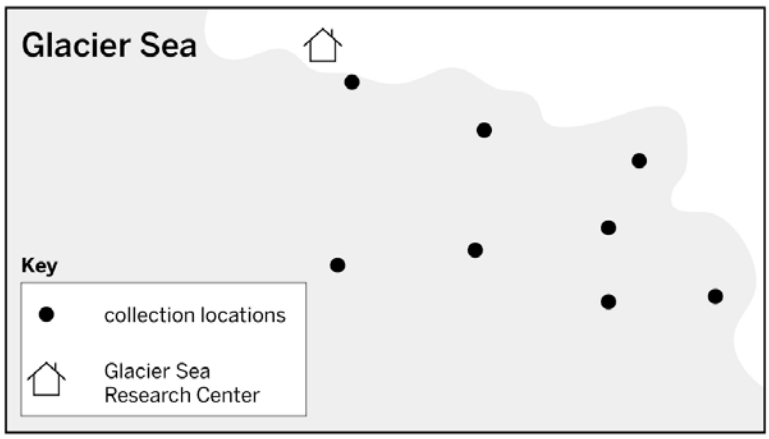


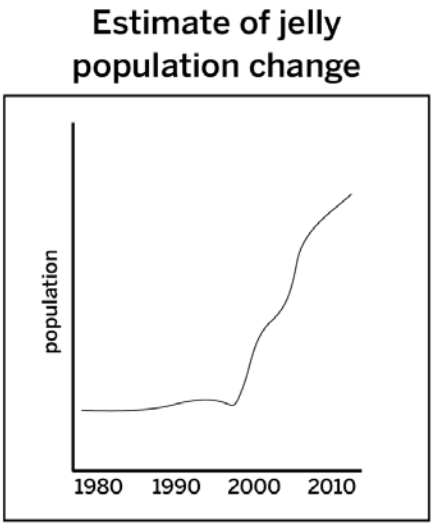
Name: _____ Date: _____

Evaluating Moon Jelly Population Evidence (continued)

Moon Jelly Evidence B

- Every year between 1980 and 2010, ecologists counted moon jellies in Glacier Sea.
- The jellies are counted in eight different locations throughout Glacier Sea.

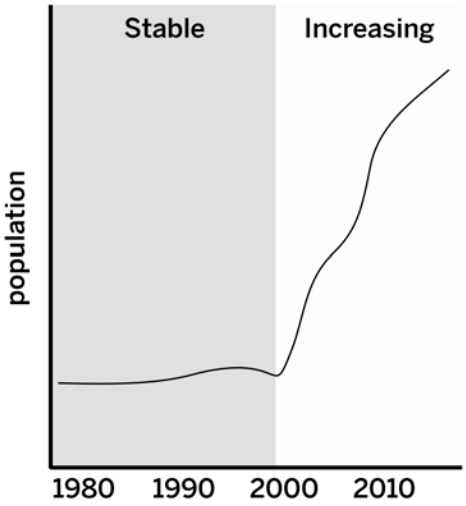




Name: _____ Date: _____

Modeling Births and Deaths in the Moon Jelly Population

Estimate of Jelly Population Change



You have been investigating the question *How do births and deaths in a population affect its size?* Use the Modeling Tool activity: Births and Deaths in the Moon Jelly Population on the next page to show your thinking about this question. Follow the instructions below.

Goal: Show the births and deaths in the moon jelly population when it was stable and when it was increasing.

Do:

- Draw boxes and write a "B" inside to show births.
- Cross out boxes to show deaths.
- Annotate your model as needed to explain your ideas.

Tips:

- There is more than one way to create this model.
- It is not important exactly how many births and deaths you show, but you should think about how births compare to deaths in the population when it was stable and when it was increasing.

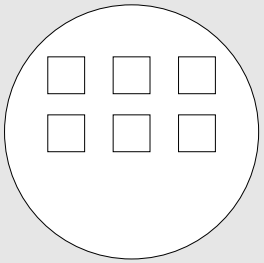
Name: _____ Date: _____

Modeling Births and Deaths in the Moon Jelly Population (continued)

Goal: Show the births and deaths in the moon jelly population when it was increasing.

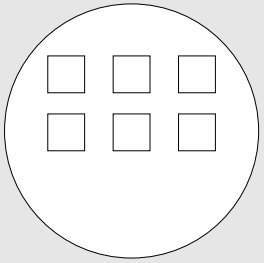
Stable

moon jelly population



Increasing

moon jelly population



Key

organism in population 

Cross out a box to show a death. 

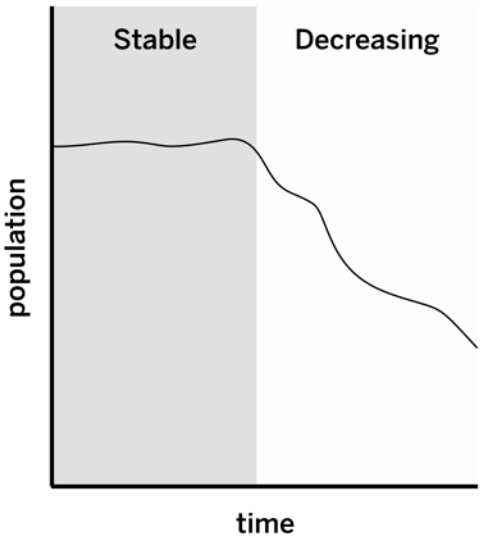
Draw a new box with a "B" in it to show a birth. 

Name: _____ Date: _____

Homework: Modeling Births and Deaths in the Honeybee Population

Review the information about the US honeybee population. Then, follow the instructions below to show how the population has changed. Use the Modeling Tool on the next page.

US Honeybee Population Decrease



Goal: Show the births and deaths in the honeybee population when it was stable and when it was decreasing.

Do:

- Draw boxes and write a "B" inside to show births.
- Cross out boxes to show deaths.
- Annotate your model as needed to explain your ideas.

Tips:

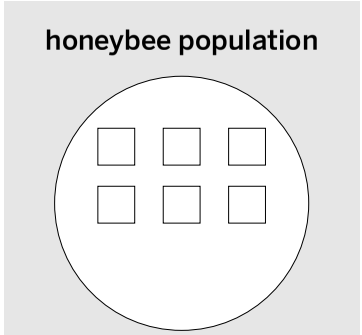
- There is more than one way to create this model.
- It is not important exactly how many births and deaths you show, but you should think about how births compare to deaths in the population when it was stable and when it was decreasing.

Name: _____ Date: _____

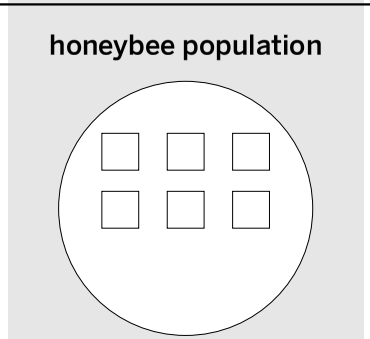
Homework: Modeling Births and Deaths in the Honeybee Population (continued)

Goal: Show the births and deaths in the honeybee population when it was stable and when it was decreasing.

Stable



Decreasing



Key

organism in population	☐
Cross out a box to show a death.	☒
Draw a new box with a "B" in it to show a birth.	B

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

Scientists investigate in order to figure things out. Are you getting closer to understanding why the size of the Glacier Sea moon jelly population has increased?

1. I understand what is happening within the moon jelly population when the size of the moon jelly population is stable. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

2. I understand what could change the size of the moon jelly population. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

3. I understand how a change in the size of the moon jellies' resource population can change the number of births in the moon jelly population. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand how a change in the size of the moon jellies' consumer population can change the number of deaths in the moon jelly population. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

5. I understand how a change in the size of a population that is not the moon jellies' consumer or resource population can affect the moon jelly population. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

6. What do you still wonder about why the size of the moon jelly population has increased?

_____

_____

_____

_____

Name: _____ Date: _____

Chapter 2: Energy and Changes to Populations
Chapter Overview

For the moon jelly population to increase, there had to be more births than deaths. But what can change the amount of births and deaths in a population? This is the question you will investigate in this chapter.

Name: _____ Date: _____

Lesson 2.1: Reproduction and Energy

Congratulations on your progress in investigating the changes to the moon jelly population in Glacier Sea! You have determined that the population increased because there were more births than deaths in the moon jelly population since the year 2000. However, what could have caused births to increase or deaths to decrease? Today, you will read the *Reproduction and Energy* article set to begin to learn more about what can cause the amount of reproduction in a population to change.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 2 Question

- What could have caused the births to increase or the deaths to decrease in the moon jelly population?

Vocabulary

- ecosystem
- energy
- population
- reproduction
- sample
- stability

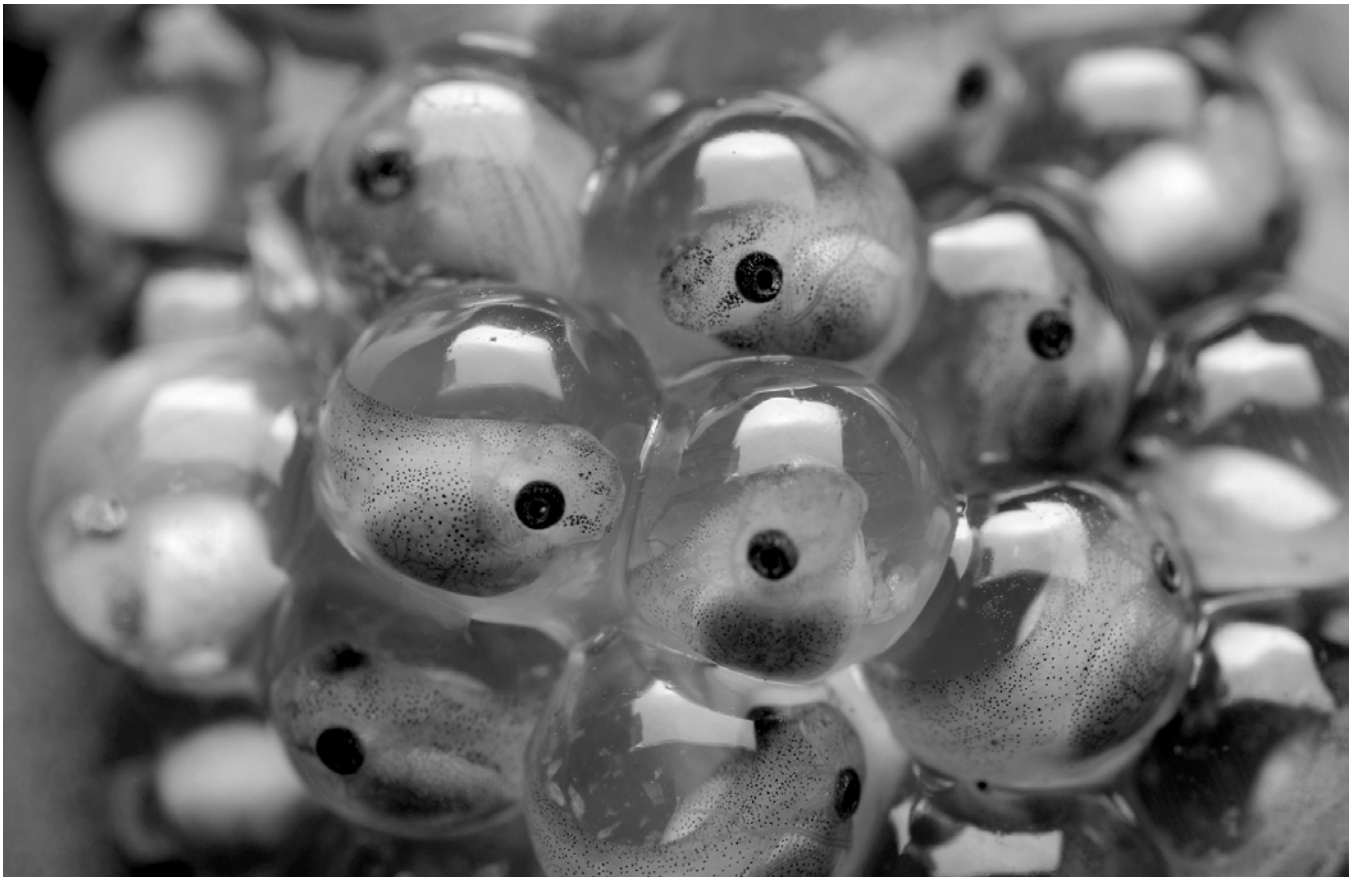
Digital Tools

- *Populations and Resources* Simulation

Name: _____ Date: _____

Warm-Up

This image shows tree frog tadpoles about to hatch.



What ideas do you have about what could cause the number of births to increase in a population?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Reading *Reproduction and Energy*

Read and annotate the introduction of the *Reproduction and Energy* article set and then choose the article about the population you are most interested in.

I am going to read about: (check one)

- ☐ sockeye salmon.
- ☐ emperor penguins.
- ☐ fireflies.
- ☐ elephant seals.

1. Read and annotate the article about the population you chose.
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Homework: Investigating Energy in the Sim

Use the Sim to investigate what happens to an organism's energy storage molecules when it reproduces and then answer the questions below.

1. Launch the *Populations and Resources* Simulation (select 3 Populations mode).
2. Select an animal and follow it until it reproduces. Focus on what happens to its energy storage molecules when it reproduces. You can also use the Tracking Activity menu to select organisms that are reproducing.
3. Follow at least two more animals and observe what happens to their energy storage molecules when they reproduce. Note: You can observe the animals' energy storage tank as well as the animals' pop-up indicator.

Describe what happens to an organism's energy storage molecules when it reproduces.

_____

_____

Based on what you learned from the *Reproduction and Energy* article set, why do you think this happens? You can review the article again to be more sure about your response.

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 2.2: Energy Storage Molecules

Was there an increase in the number of births in the moon jelly population? If so, what might have caused it? Reproduction takes a lot of energy, so if the number of jelly births did increase, then the jellies had to get that energy from somewhere. In the last lesson, you read an article about reproduction and energy. In this lesson, you will look back at that article to better understand where populations get the energy they need to reproduce. You will also conduct an experiment with yeast, a living organism, to learn more about energy and reproduction.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 2 Question

- What could have caused the births to increase or the deaths to decrease in the moon jelly population?

Vocabulary

- consumer population
- ecosystem
- energy
- energy storage molecule
- population
- reproduction
- resource population
- sample
- stability

Name: _____ Date: _____

Warm-Up

Reread the excerpt from the introduction to the *Reproduction and Energy* article set below and then answer the question that follows.

> "Organisms get the energy they need from energy storage molecules such as glucose, starch, and fat. These molecules store energy that can be released in the bodies of organisms when they need it. Plants and other producers can make their own energy storage molecules through photosynthesis, but other organisms can't do that—to get energy storage molecules, they need to eat food."

What do organisms need in order to reproduce?

_____

_____

_____

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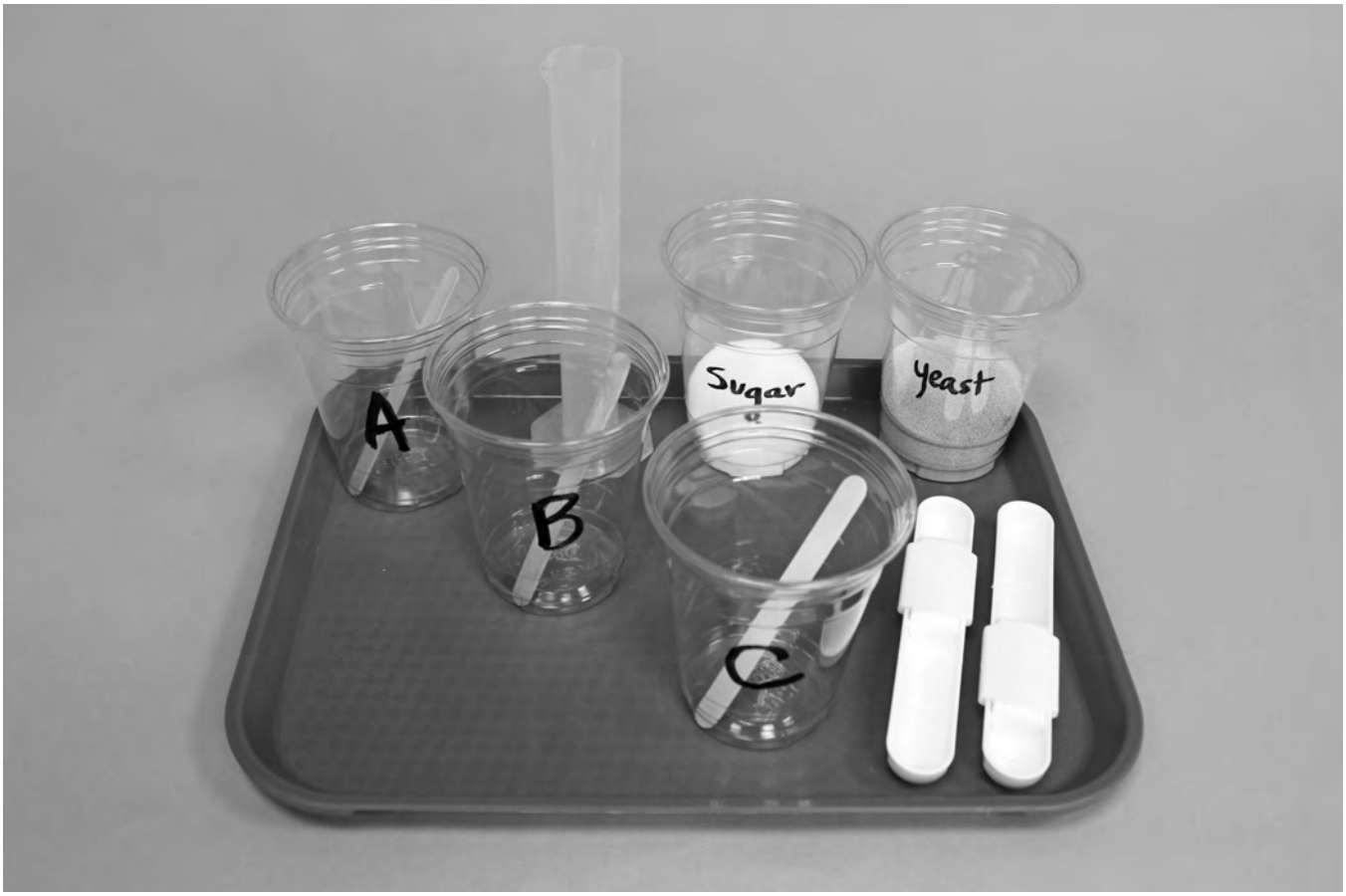
Name: _____ Date: _____

Setting Up the Yeast Experiment



Instructions

1. Place the following amounts of sugar in the cups:
    - Cup A: none
    - Cup B: 1 pinch
    - Cup C: 1 teaspoon
2. Place 1 tablespoon of yeast into each cup.
3. Add 40 mL of warm water to each cup.
4. Use a wooden stir stick to combine the mixture until it is completely wet.
5. Set aside the experiment to observe later.

Name: _____ Date: _____

Second Read of *Reproduction and Energy*

Find the excerpt from the *Reproduction and Energy* article set you read in the previous lesson. As you reread, highlight activities the animal you read about needs to do in order to reproduce. Then, answer the question below.

Where do the animals you read about get the energy storage molecules they need to do the activities required for reproduction?

_____

_____

_____

_____

_____

_____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Returning to the Yeast Experiment

Earlier you mixed different amounts of sugar (an energy storage molecule) with yeast and warm water. It is time to make and discuss your observations.

Discussion Questions

Which cup of yeast showed evidence of releasing the most energy? Explain your answer.

Which cup of yeast most likely reproduced the most? Explain your answer.

Name: _____ Date: _____

Homework: Cricket Reproduction Video

Watch the *Crickets and Energy Storage Molecules* video in the Digital Resources, then answer the questions below.

What was different about the two groups of crickets shown in the video?

_____

_____

_____

_____

_____

_____

Which group of crickets reproduced more? Why did they reproduce more?

_____

_____

_____

_____

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_____

Name: _____ Date: _____

Lesson 2.3: Births Changing in a Population

You know that organisms need energy from energy storage molecules to reproduce and that they get energy storage molecules by eating organisms from resource populations. How will a change to a resource population affect its consumer population? In this lesson, you will use the Sim to investigate this question.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 2 Question

- What could have caused the births to increase or the deaths to decrease in the moon jelly population?

Key Concepts

- Organisms need to release energy from energy storage molecules in order to reproduce.
- Organisms in consumer populations get energy storage molecules from eating organisms in resource populations.
- The more energy storage molecules available to a population, the more the organisms in that population can reproduce.

Vocabulary

- consumer population
- ecosystem
- energy
- energy storage molecule
- population
- reproduction
- resource population
- sample
- stability

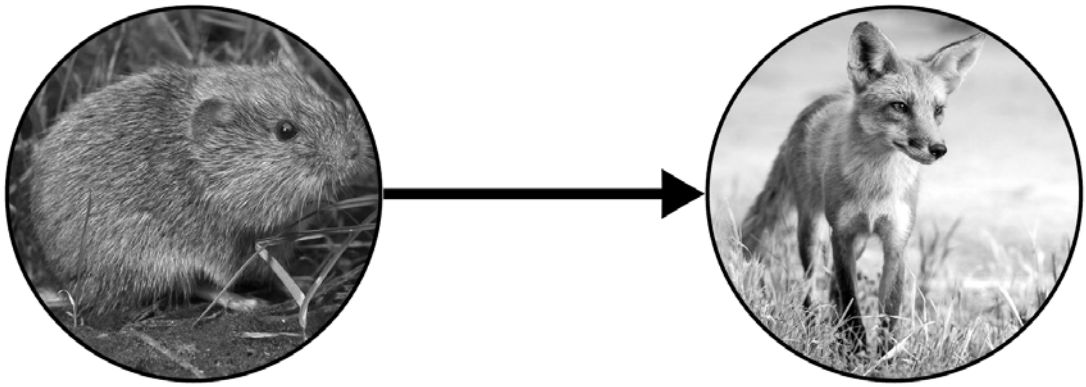
Digital Tools

- *Populations and Resources* Simulation

Name: _____ Date: _____

Warm-Up

Small animals called voles are found in the same ecosystem as red foxes.



vole fox

The diagram above is called a food web. It shows the relationship between foxes and voles. What does the food web show? (check one)

- ☐ foxes eat voles
- ☐ voles eat foxes

What do you think the arrow tells you about energy storage molecules?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Changing the Number of Births in the Sim

Part 1: Energy Storage Molecules in Ecosystems

Organisms get energy storage molecules to reproduce from the resource populations that they eat. Today you will investigate the weebug population in the Sim. First you need to figure out where weebugs get the energy storage molecules they need to reproduce.

1. Launch the *Populations and Resources* Simulation (use 3-Population mode).
2. Observe weebugs. Be sure to also look at Food Web Overlay.
3. Discuss the following questions with your partner.

Discussion Questions

How are energy storage molecules represented in different parts of the Sim?

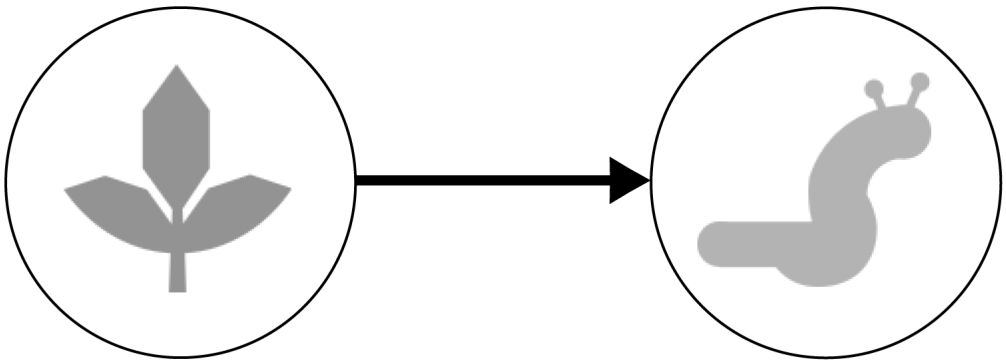
Where are energy storage molecules found in an ecosystem?

Where do weebugs get energy storage molecules in the Sim ecosystem? What is your evidence?

Part 2: Changing the Number of Births in a Population

What can change the number of births in a population? Use the Sim to find out.

In the Sim, weebugs eat greenleafs.



Name: _____ Date: _____

Changing the Number of Births in the Sim (continued)

Weebugs get energy storage molecules from eating greenleafs. What change to the greenleaf population could increase the number of births in the weebug population? (check one)

- ☐ increase greenleafs
- ☐ decrease greenleafs

Review the steps below.

What will you change (the independent variable) in the test? _____

What will be observed and recorded (the dependent variable)? _____

What will be kept the same (control) in the test? _____

1. Launch the *Populations and Resources* Simulation (use 3 Populations mode).
2. Press Play, run the Sim for 20 time units, and then press Pause.
3. Open Food Web Overlay.
4. Make the change to the greenleaf population that you predicted would increase the number of births in the weebug population. Observe how the number of energy storage molecules in the greenleaf population changes as you make the change. (**Hint:** Make a big change to see the biggest effect.)
5. Lock the greenleaf population.
6. Press Play and run the Sim for at least 20 more time units.
7. Press Analyze and use the range window to review the number of births before and after the change. Record the number of births in the data table.

Data Table:

	Number of births
20 time unit range *before* change	
20 time unit range *after* change	

Complete the sentences below by circling the option that makes the sentence true.

(**Increasing** / **Decreasing**) the greenleaf population led to (**more** / **fewer** / **the same amount of**) energy storage molecules in the greenleaf population.

After the change, the weebug births (**increased** / **decreased** / **stayed the same**).

What would that change mean for the size of the population?

8. Use the range window to compare the number of births with deaths after the change.

Name: _____ Date: _____

Changing the Number of Births in the Sim (continued)

Complete the sentences below by circling the option that makes the sentence true.

After the change, there were (**more births than deaths** / **fewer births than deaths** / **the same number of births and deaths**) in the weebug population.

After the change, the weebug population (**increased** / **decreased** / **remained stable**).

Explain why a change to the greenleaf population caused the weebug population to change in size. Be sure to use births, deaths, and energy storage molecules in your answer.

_____

_____

_____

_____

_____

_____

Given your results from above, what change would decrease the number of births in the weebug population?

- ☐ increase greenleafs
- ☐ decrease greenleafs

Explain your answer.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Reflecting on Changing Births

Use evidence from the article you read in the previous lesson and the Sim to discuss the following question with your partner.

> Why does a change in the size of a resource population lead to a change in the number of births in its consumer population?

Discuss the following question with a partner and then select an answer.

How can a change to births affect the population size? (check one)

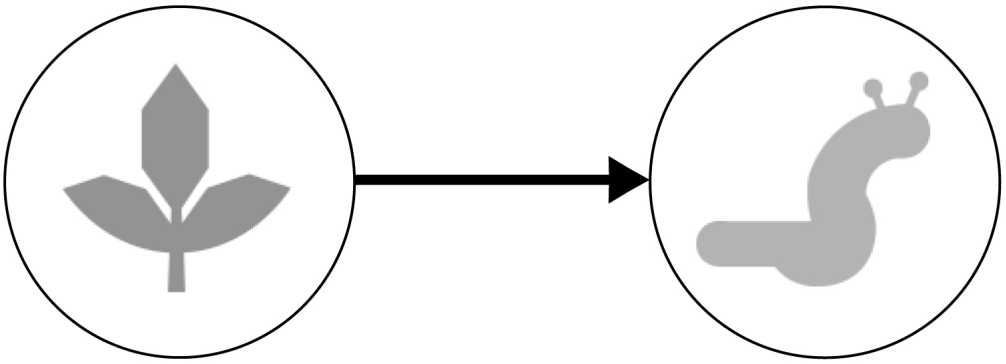
- ☐ An increase in births always leads to an increase in the population size.
- ☐ An increase in births leads to an increase in the population size if there are more births than deaths.
- ☐ An increase in births leads to an increase in the population size if there are fewer births than deaths.

Name: _____ Date: _____

Homework: Changing the Number of Births in a Population

You have been investigating what can change the number of births in a population. You already simulated increasing the number of births in a population, now you will try to simulate decreasing the number of births in a population.

In the Sim, weebugs eat greenleafs.



Weebugs get energy storage molecule from eating greenleafs. What change to the greenleaf population could decrease the number of births in the weebug population? (check one)

- ☐ increase greenleafs
- ☐ decrease greenleafs

1. Launch the *Populations and Resources* Simulation.
2. Press Play and run the Sim for 20 time units.
3. Go to Run.
4. Make the change to the greenleaf population that you predicted would decrease the number of births in the weebug population. Observe the number of energy storage molecules in the greenleaf population as you make the change. (**Hint:** Make a big change to see the biggest effect.)
5. Lock the greenleaf population.
6. Press Play and run the Sim for at least 20 more time units.
7. Press Analyze and use the range window to review the number of births before and after the change.
8. Use the range window to compare the number of births with deaths after the change.

Name: _____ Date: _____

Homework: Changing the Number of Births in a Population
(continued)

Complete the sentences below by circling the option that makes the sentence true.

(**Increasing** / **Decreasing**) the greenleaf population led to (**more** / **fewer** / **the same amount of**) energy storage molecules in the greenleaf population.

After the change, the weebug births (**increased** / **decreased** / **stayed the same**).

After the change, there were (**more births than deaths** / **fewer births than deaths** / **the same number of births and deaths**) in the weebug population.

After the change, the weebug population (**increased** / **decreased** / **remained stable**).

Use what you learned from Sim investigations about greenleafs and weebugs to answer the following question: What can change the number of births in a population?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 2.4: Deaths Changing in a Population

You have learned about how the number of births can change in a population. But we are not sure that the births in the jelly population did increase. A decrease in deaths could have also led to an increase in the size of the jelly population. Today you will investigate what can cause the number of deaths in a population to change.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 2 Question

- What could have caused the births to increase or the deaths to decrease in the moon jelly population?

Key Concepts

- Organisms need to release energy from energy storage molecules in order to reproduce.
- Organisms in consumer populations get energy storage molecules from eating organisms in resource populations.
- The more energy storage molecules available to a population, the more the organisms in that population can reproduce.
- The larger the resource population the more energy storage molecules are available for its consumer populations.

Vocabulary

- consumer population
- ecosystem
- energy
- energy storage molecule
- population
- reproduction
- resource population
- sample
- stability

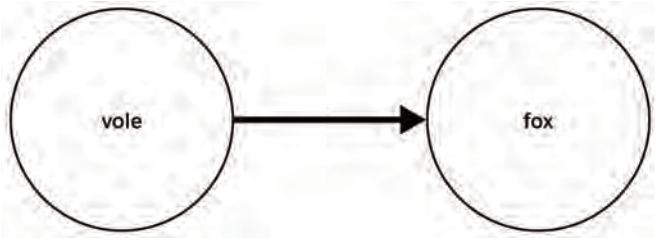
Digital Tools

- *Populations and Resources* Simulation

Name: _____ Date: _____

Warm-Up

Foxes eat small animals called voles. In southern Sweden, scientists observed that when the vole population decreased, the fox population also decreased.



Explain why the fox population decreased when the vole population decreased. Be sure to talk about births and deaths in your answer.

_____

_____

_____

_____

_____

_____

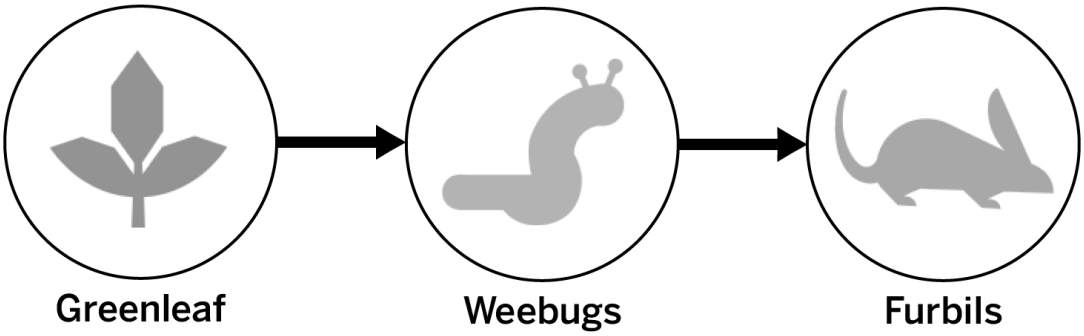
Name: _____ Date: _____

Changing the Number of Deaths in a Population

Part 1

What can change the number of deaths in a population? Use the Sim to find out.

In the Sim, furbils eat weebugs and weebugs eat greenleafs.



What change(s) would decrease the number of deaths in the weebug population? Check all answers you think are correct.

- ☐ increase greenleafs
- ☐ decrease greenleafs
- ☐ increase furbils
- ☐ decrease furbils

Explain your answer.

_____

_____

_____

Plan an investigation to test your ideas.

What will you change (the independent variable) in your test(s)? _____

What will you observe and record (the dependent variable) in your test(s)? _____

What will you keep the same (control) in your test(s)? _____

Part 2

1. Work with your partner to use your responses on this page to decide how you will carry out your investigation. Describe your steps in the space provided on the next page.
2. Create a data table to record the results of your test.
3. Conduct your investigation and record your results. Then, answer the questions on the next page.

Name: _____ Date: _____

Changing the Number of Deaths in a Population (continued)

Steps:

_____

_____

_____

_____

_____

_____

Data Table: (Draw your data table in the space below)

What change(s) decreased the number of deaths in the weebug population? Check all that apply.

- ☐ increase greenleafs
- ☐ decrease greenleafs
- ☐ increase furbils
- ☐ decrease furbils

After the change, the weebug population (**increased** / **decreased** / **remained stable**) because there were (**more births than deaths** / **fewer births than deaths** / **the same number of births and deaths**) in the weebug population.

Given your results from above, what change(s) would increase the number of deaths in the weebug population? Check all answers you think are correct.

- ☐ increase greenleafs
- ☐ decrease greenleafs
- ☐ increase furbils
- ☐ decrease furbils

Explain your answer.

_____

_____

_____

Name: _____ Date: _____

Write and Share: Discussing Changes to Ecosystems

Find the sheet that has the number you were assigned (1, 2, or 3). Follow the instructions below to participate in the Write and Share routine.

1. Carefully read and annotate the information you are given.
2. Answer your prompt, using the vocabulary words listed in the Word Bank.
3. After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
4. While one student is presenting, the other two listen carefully.
5. After each student presents, the other students in the group can ask questions or make comments.

Word Bank

energy storage molecules	consumer population	resource population

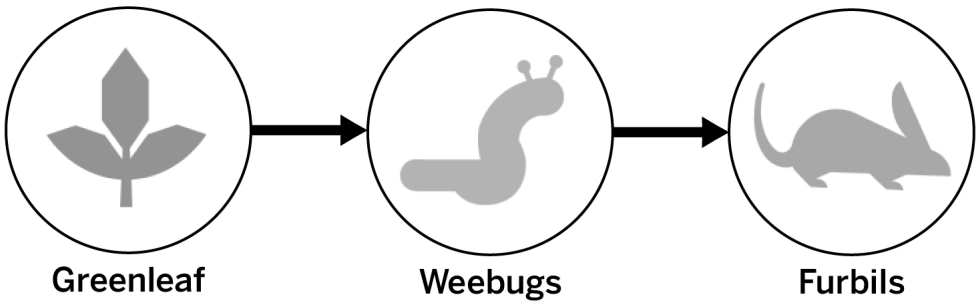
Name: _____ Date: _____

Homework: Changing the Number of Deaths in a Population

Part 3

You have been investigating what can change the number of deaths in a population. You already simulated decreasing the number of deaths in a population, now you will try to simulate increasing the number of deaths in a population.

In the Sim, furbils eat weebugs and weebugs eat greenleafs.



What change(s) would increase the number of deaths in the weebug population? Check all answers you think are correct.

- ☐ increase greenleafs
- ☐ decrease greenleafs
- ☐ increase furbils
- ☐ decrease furbils

1. Launch the *Populations and Resources* Simulation (use 3 Populations mode).
2. Run the Sim for 20 time units.
3. Make one change to a population that you predicted would increase the number of deaths in the weebug population.
4. Lock the population that you changed.
5. Press Play and run the Sim for at least 40 time units.
6. Go to Analyze and use the range window to review the number of deaths before and after the change.
7. Use the range window to compare the number of births with the number of deaths after the change and circle your choices on the next page.
8. If you predicted that more than one change could increase the number of deaths, reset the Sim and repeat the steps above.

Name: _____ Date: _____

Homework: Changing the Number of Deaths in a Population
(continued)

After the change, weebug deaths (**increased** / **decreased** / **stayed the same**).

After the change, there were (**more births than deaths** / **fewer births than deaths** / **the same number of births and deaths**) in the weebug population.

After the change, the weebug population (**increased** / **decreased** / **remained stable**).

What can increase the number of deaths in a population? Explain your answer.

_____

_____

_____

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_____

Name: _____ Date: _____

Lesson 2.6: Revisiting Key Concepts

Today you will take a break from thinking about the moon jelly population to solve the puzzle of a different population that has changed size. Working with a partner, you will try to figure out why a population changed size, using evidence specific to your population along with everything that you have learned about ecosystems so far. Investigating these population puzzles will help you to better understand what could have caused the mysterious moon jelly population increase.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 2 Question

- What could have caused the births to increase or the deaths to decrease in the moon jelly population?

Key Concepts

- If the number of births and deaths in a given time are equal, then the population size will be stable.
- If there are more births than deaths in a given time, then the size of the population will increase. If there are fewer births than deaths, then the size of the population will decrease.
- Organisms need to release energy from energy storage molecules in order to reproduce.
- Organisms in consumer populations get energy storage molecules from eating organisms in resource populations.
- The more energy storage molecules available to a population, the more the organisms in that population can reproduce.
- The larger the resource population, the more energy storage molecules are available for its consumer populations.
- The larger the consumer population, the more energy storage molecules it will need. Therefore, it will eat more, causing more deaths in the resource population.

Vocabulary

- consumer population
- ecosystem
- energy
- energy storage molecule
- population
- reproduction
- resource population
- sample
- stability

Name: _____ Date: _____

Warm-Up

A boomslang is a type of snake. This image shows a boomslang eating a frog.

Ecologists gather a lot of evidence from ecosystems. One useful piece of evidence is what each population eats. How do you think knowing "what eats what" helps ecologists to explain changes in population size? Write your answer below.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Purple Group: Caribou Population Puzzle

Caribou are large hoofed animals with antlers. In 2010, ecologists observed a decrease in the size of the caribou population in the Glacier Sea area. Use the evidence they collected to explain why the population decreased.

Initial Evidence

- Caribou eat lichen.
- Caribou are eaten by wolves.

Why did the size of the caribou population decrease? Use the initial evidence to explain why the size of the caribou population decreased.

_____

_____

_____

Get Purple Evidence Card A from your teacher. Use Evidence Card A to create a more complete explanation about why the size of the caribou population decreased.

_____

_____

_____

Get Purple Evidence Card B from your teacher. Use Evidence Card B to create an even more complete explanation about why the size of the caribou population decreased.

_____

_____

_____

Name: _____ Date: _____

Green Group: Orca Population Puzzle

Orcas are a type of whale. In the summer of 2007, ecologists observed that the number of orcas in Glacier Sea had decreased. Use the evidence they collected to explain why the population decreased.

Initial Evidence

- Ecologists found a normal number of adult orcas in the ecosystem, but they found fewer orca calves (babies) were being born.
- Ecologists did not notice any change to the number of deaths in the orca population.

Why did the size of the orca population decrease? Use the initial evidence to explain how the number of births and deaths caused the size of the population to decrease during the summer of 2007.

_____

_____

_____

_____

Get Green Evidence Card A from your teacher. Use Evidence Card A to create a more complete explanation of why the size of the orca population decreased.

_____

_____

_____

_____

Name: _____ Date: _____

Green Group: Orca Population Puzzle (continued)

Get Green Evidence Card B from your teacher. Use Evidence Card B to create an even more complete explanation of why the size of the orca population decreased.

_____

_____

_____

_____

_____

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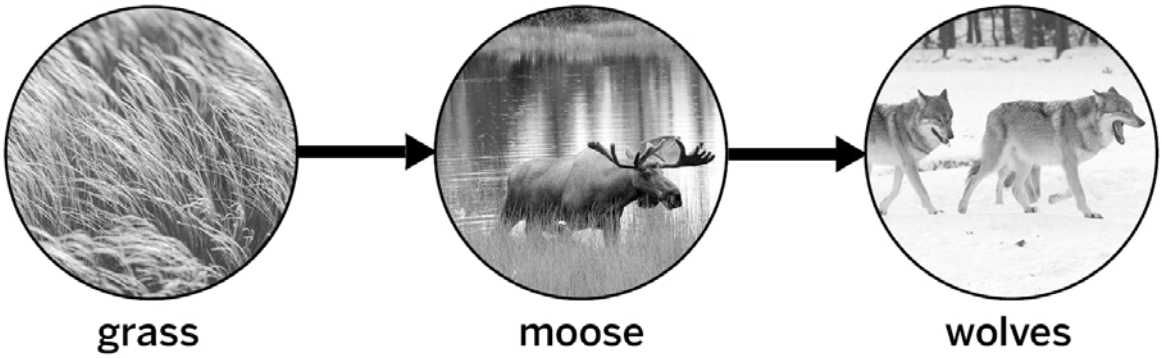
Name: _____ Date: _____

Blue Group: Moose Population Puzzle

Moose are large hoofed animals with antlers. In 2010, ecologists observed a decrease in size of the moose population in the Glacier Sea area. Use the evidence they collected to explain why the population decreased.



Initial Evidence

- Moose eat grass.
- Moose are eaten by wolves.
- It was unusually warm in 2010.

Why did the size of the moose population decrease? Use the initial evidence to explain why the size of the moose population decreased.

_____

_____

_____

_____

Get Blue Evidence Card A from your teacher. Use Evidence Card A to create a more complete explanation about why the size of the moose population decreased.

_____

_____

_____

_____

Name: _____ Date: _____

Blue Group: Moose Population Puzzle (continued)

Get Blue Evidence Card B from your teacher. Use Evidence Card B to create an even more complete explanation about why the size of the moose population decreased.

_____

_____

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Name: _____ Date: _____

Sharing Population Puzzles and Solutions

Share what you learned about your Population Puzzle with a student from a different group. Remember they read about a different population so you need to explain your scenario completely.

Discussion Prompt

Why did the population you learned about decrease in size? Be sure to point out all of the evidence that helped you answer this question.

Name: _____ Date: _____

Lesson 2.7: Claims About the Jelly Increase

Did the size of the moon jelly population increase because births increased or because deaths decreased? In this lesson, you will apply what you have learned so far as you support one of these claims. First, you will use the Modeling Tool to show what could have caused births to increase in the moon jelly population and what could have caused deaths to decrease. Then you will evaluate new evidence about other populations in the Glacier Sea ecosystem to help you decide which claim is best supported. For homework, you will use the strongest evidence to write your argument.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 2 Question

- What could have caused the births to increase or the deaths to decrease in the moon jelly population?

Key Concepts

- Organisms need to release energy from energy storage molecules in order to reproduce.
- Organisms in consumer populations get energy storage molecules from eating organisms in resource populations.
- The more energy storage molecules available to a population, the more the organisms in that population can reproduce.
- The larger the resource population, the more energy storage molecules are available for its consumer populations.
- The larger the consumer population, the more energy storage molecules it will need. Therefore, it will eat more, causing more deaths in the resource population.

Vocabulary

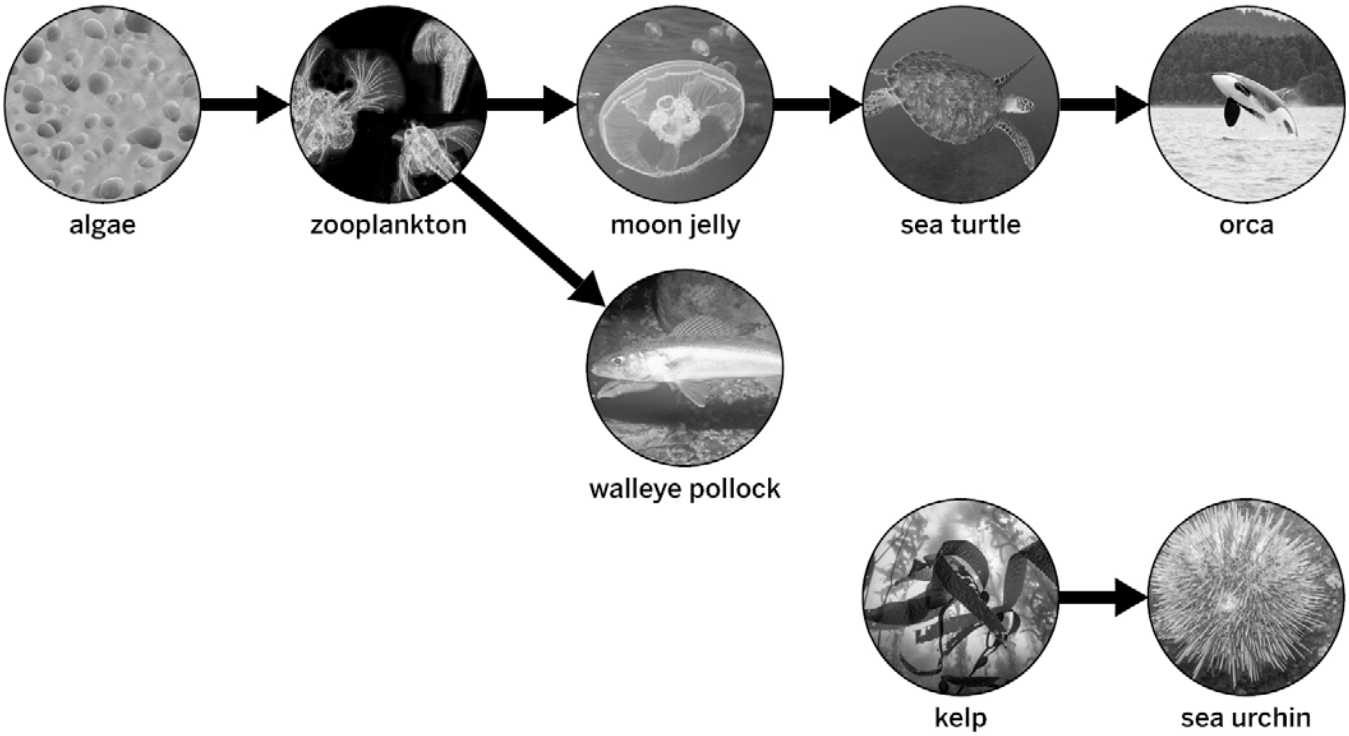
- consumer population
- ecosystem
- energy
- energy storage molecule
- population
- reproduction
- resource population
- sample
- stability

Name: _____ Date: _____

Warm-Up

Review the Glacier Sea food web. Respond to the questions below based on what you have learned so far.

Glacier Sea Food Web



What could have caused births to increase in the moon jelly population?

_____

_____

_____

_____

_____

What could have caused deaths to decrease?

_____

_____

_____

_____

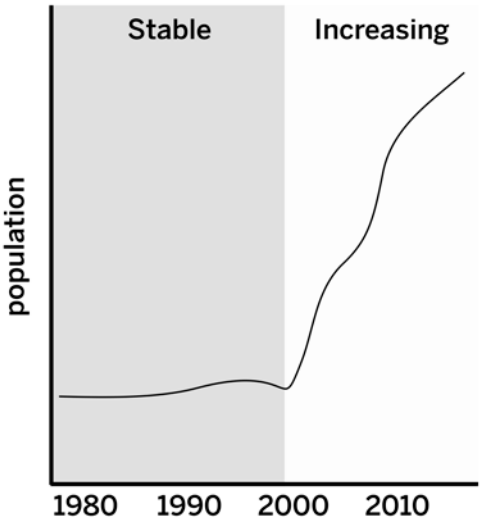
_____

Name: _____ Date: _____

Modeling the Jelly Ecosystem

Part 1: Increasing Births in the Moon Jelly Population

Estimate of Jelly Population Change



You have been investigating the question *What could have caused the births to increase or the deaths to decrease in the moon jelly population?* Use the Modeling Tool activity: Increasing Births in the Moon Jelly Population on page 64 to show your thinking about this question. Follow the instructions below.

Goal: Show how a change to the zooplankton population could have caused births to increase in the moon jelly population.

Do:

- Use the given information about births and deaths in the stable ecosystem to show how births and deaths changed in both populations when the jelly population increased.
- Draw boxes and write a "B" inside them to show births.
- Cross out boxes to show deaths.
- Indicate the amount of energy storage molecules being transferred between the populations by drawing more or fewer dots on the arrows.
- Annotate your model as needed to explain your ideas.

Tips:

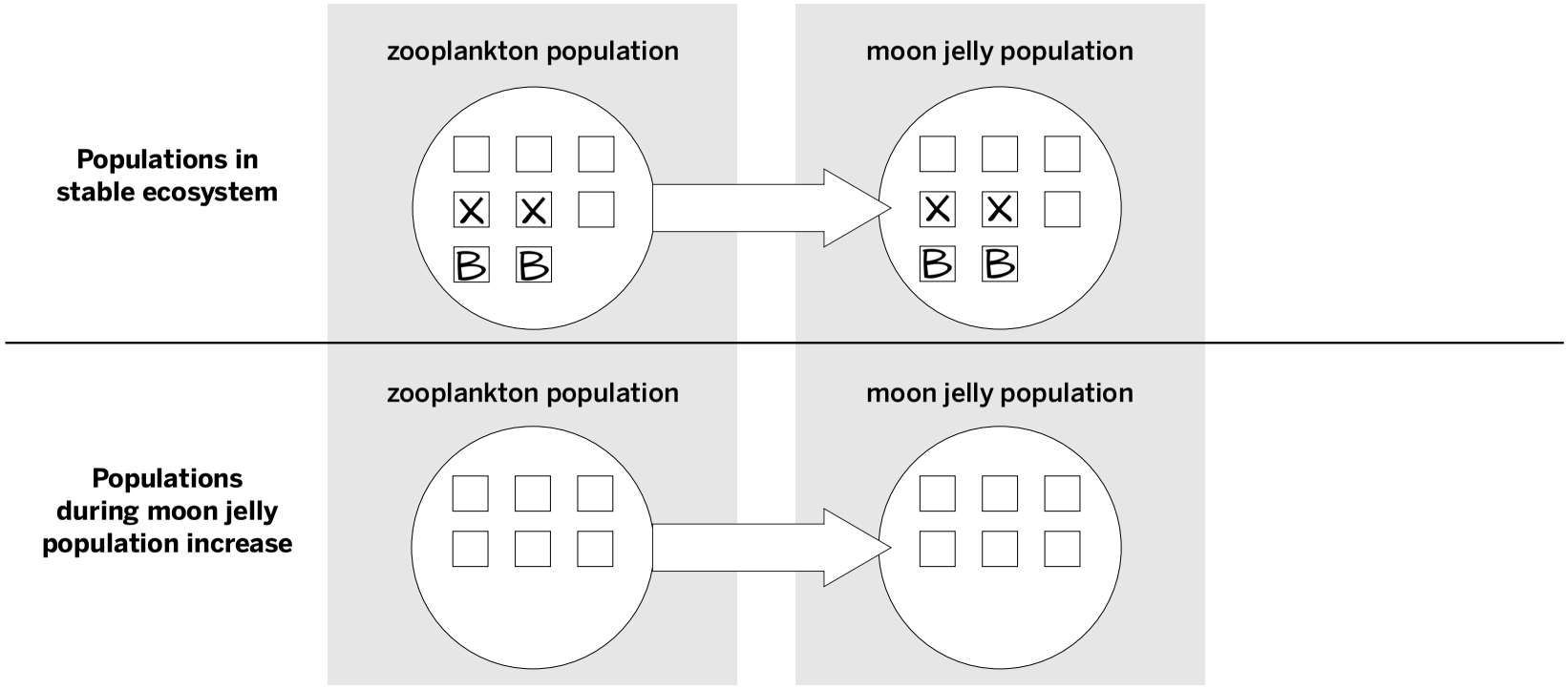
- There is more than one way to create this model.
- Don't worry about the exact number of the births, deaths, or energy storage molecules. Instead, focus on how they compare when the populations are stable and when the jelly population is increasing.

Name: _____ Date: _____

Modeling the Jelly Ecosystem (continued)

Increasing Births in the Moon Jelly Population

Goal: Show how a change to the zooplankton population could have caused births to increase in the moon jelly population.



Key

organism in population

Cross out a box to show a death.

Draw a new box with a "B" in it to show a birth.

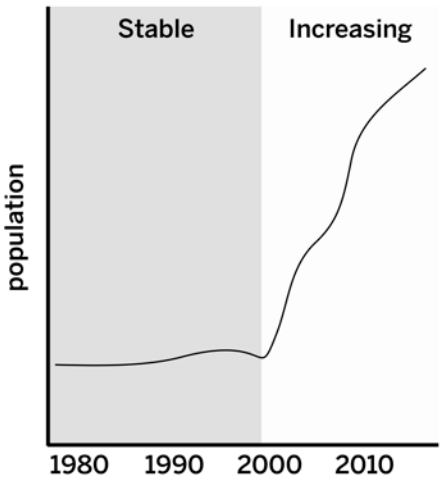
Draw dots to show energy storage molecules.

Name: _____ Date: _____

Modeling the Jelly Ecosystem (continued)

Part 2: Decreasing Deaths in the Moon Jelly Population

Estimate of Jelly Population Change



Goal: Show how a change to the sea turtle population could have caused deaths to decrease in the moon jelly population.

Do:

- Use the given information about births and deaths in the stable ecosystem to show how births and deaths changed in both populations when the jelly population increased.
- Draw boxes and write a "B" inside them to show births.
- Cross out boxes to show deaths.
- Indicate the amount of energy storage molecules being transferred between the populations by drawing more or fewer dots on the arrows.
- Annotate your model as needed to explain your ideas.

Tips:

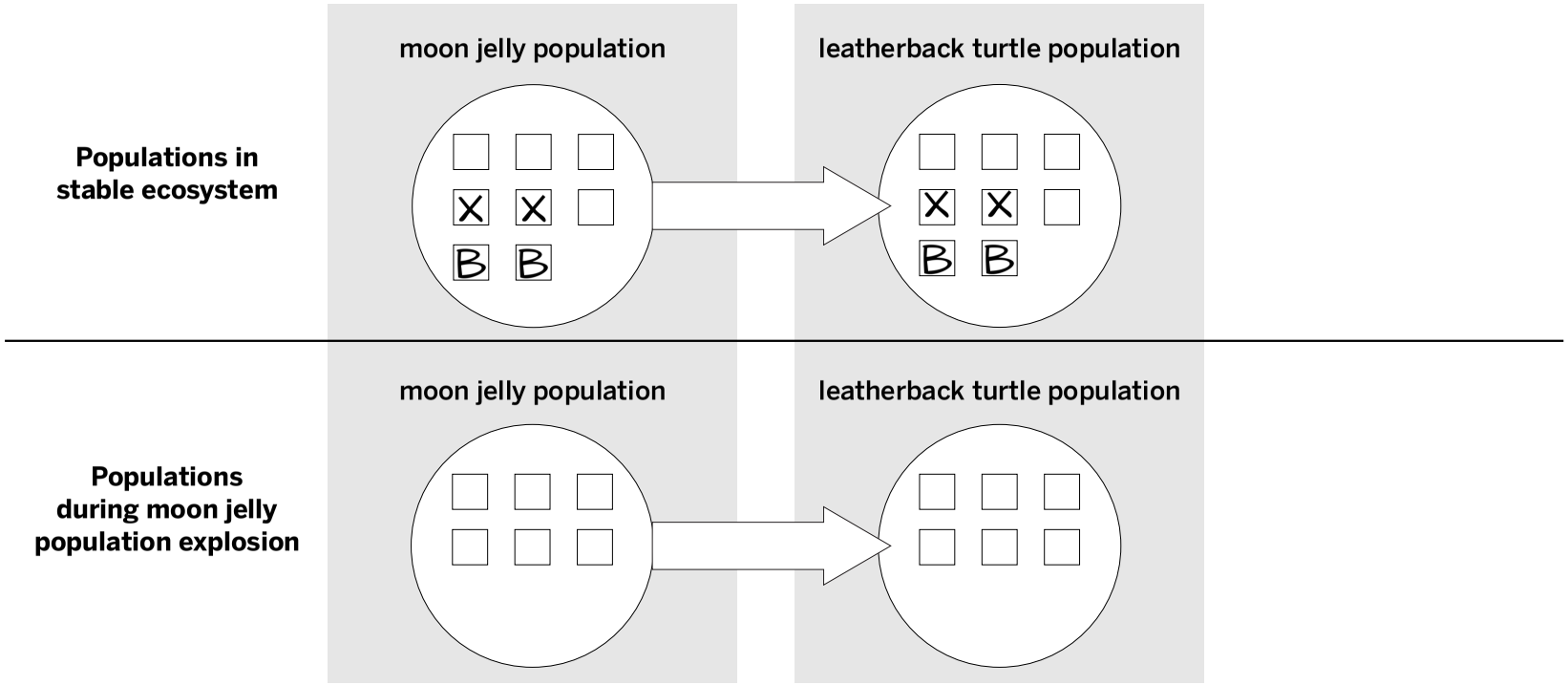
- There is more than one way to create this model.
- Don't worry about the exact number of the births, deaths, or energy storage molecules. Instead, focus on how they compare when the populations are stable and when the jelly population is increasing.

Name: _____ Date: _____

Modeling the Jelly Ecosystem (continued)

Decreasing Deaths in the Moon Jelly Population

Goal: Show how a change to the sea turtle population could have caused deaths to decrease in the moon jelly population.



Key

organism in population		Cross out a box to show a death.	X
Draw a new box with a "B" in it to show a birth.	B	Draw dots to show energy storage molecules.	

Name: _____ Date: _____

Evaluating Evidence

Review the Evidence Criterion below and then follow the directions to sort the Glacier Sea Ecosystem Evidence Cards.

Evidence Criterion: Samples that represent as much of the whole as possible provide stronger evidence.

1. **Read and annotate each Evidence Card.** Use the questions below to guide you:
    - How are the samples described on each card different?
    - Which sample best represents the whole population? Note that both the zooplankton and sea turtle populations can be found throughout Glacier Sea.

2. **Discuss your annotations with your partner.** Make sure to talk about how well each sample represents the whole population.

3. **Sort the Evidence Cards.** With your partner, place one set of the Evidence Cards on the Evidence Gradient based on how strong you think the evidence is. One partner should put aside their set of Evidence Cards for now.

Name: _____ Date: _____

Homework: Writing an Argument About the Moon Jelly Population Increase

Write an argument about what could have caused the moon jelly population to increase. Follow the instructions below.

1. Review the evidence to decide which claim or claims you think are supported. Remember to think about which sample best represents the whole population.
2. Look back at the models you completed in class that show the claim you will support. You can use one or both models to help you plan your argument.
3. Write your argument
    - State your claim.
    - Describe your evidence.
    - Make your argument as convincing as possible by making sure you explain how your evidence supports your claim.
4. Read over your completed argument. Is it convincing? Did you use science words such as *consumer population*, *resource population*, and *energy storage molecules*?

Question: *What could have caused the size of the moon jelly population to increase?*

The population increased because . . .

Claim 1: A change to the zooplankton population caused **births to increase** in the moon jelly population.

Claim 2: A change to the sea turtle population caused **deaths to decrease** in the moon jelly population.

Name: _____ Date: _____

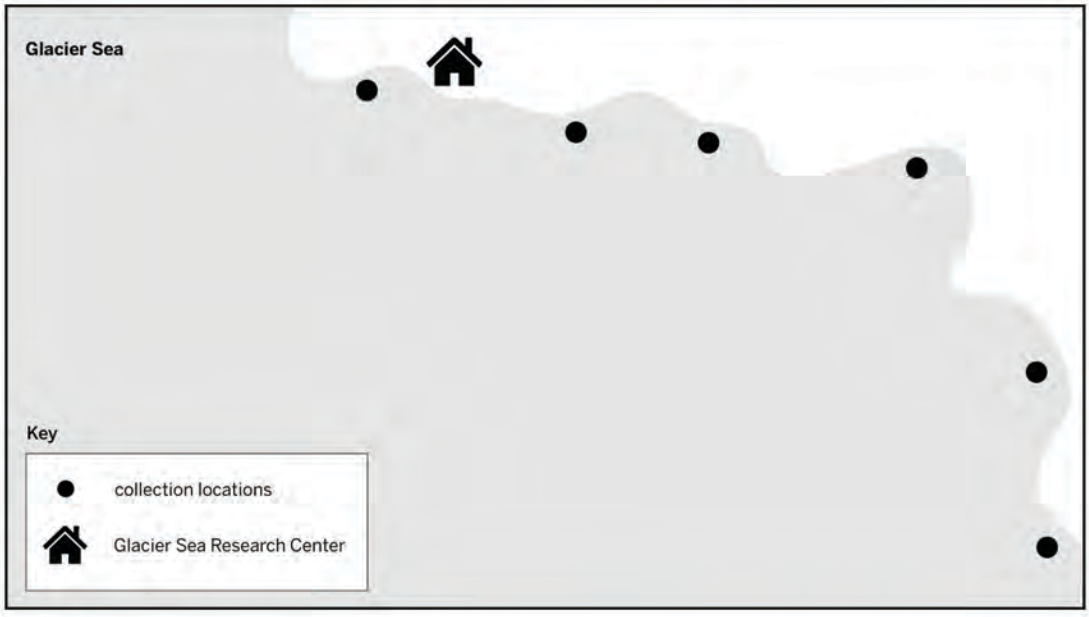
Homework: Writing an Argument About the Moon Jelly Population Increase (continued)

Evidence Card A: Zooplankton

- Every year between 1980 and 2000, ecologists counted zooplankton in six different locations throughout Glacier Sea.
- They concluded that the population was stable and then started to increase around 2000.

Evidence Card B: Zooplankton

- Every year between 1980 and 2000, ecologists counted zooplankton in six different locations along the coast of Glacier Sea.
- They concluded that the population was stable and then started to increase around 2000.



Name: _____ Date: _____

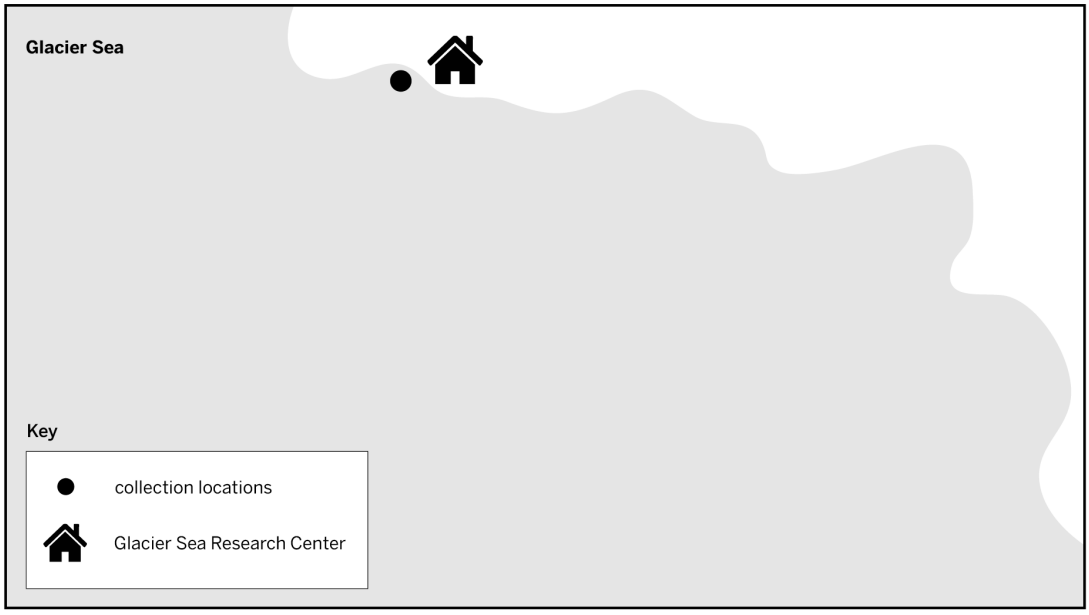
Homework: Writing an Argument About the Moon Jelly Population Increase (continued)

Evidence Card C: Leatherback Sea Turtles

- Every year between 1980 and 2000, ecologists recorded sightings of leatherback sea turtles from Glacier Sea Research Center and two other locations in the middle of Glacier Sea.
- They concluded that the population was stable and started to decrease around 2000.

Evidence Card D: Leatherback Sea Turtles

- Every year between 1980 and 2000, ecologists recorded sightings of leatherback sea turtles from Glacier Sea Research Center.
- They concluded that the population stayed stable.



Name: _____ Date: _____

Homework: Writing an Argument About the Moon Jelly Population Increase (continued)

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

Scientists investigate in order to figure things out. Are you getting closer to understanding why the size of the Glacier Sea moon jelly population has increased?

1. I understand what is happening within the moon jelly population when the size of the moon jelly population is stable. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

2. I understand what could change the size of the moon jelly population. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

3. I understand how a change in the size of the moon jellies' resource population can change the number of births in the moon jelly population. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand how a change in the size of the moon jellies' consumer population can change the number of deaths in the moon jelly population. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

5. I understand how a change in the size of a population that is not the moon jellies' consumer or resource population can affect the moon jelly population. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

6. What do you still wonder about why the size of the moon jelly population has increased?

_____

_____

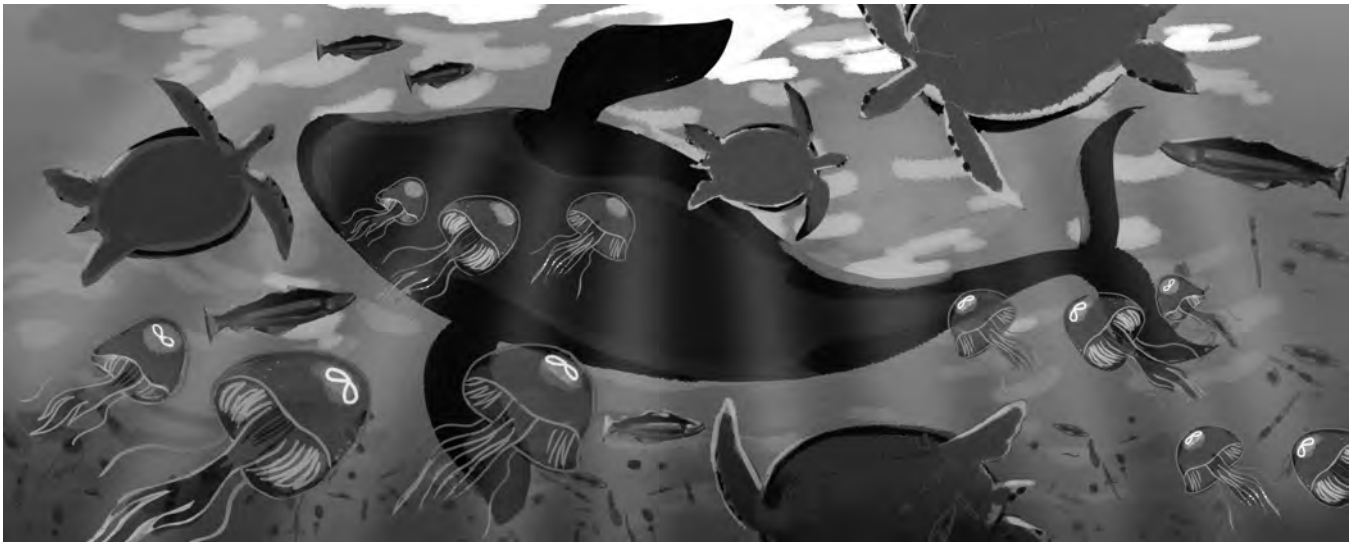
_____

_____

Name: _____ Date: _____

Chapter 3: Indirect Effects in Ecosystems
Chapter Overview

Changes to the size of the moon jellies' resource or consumer populations might have caused the moon jelly population to increase. However, could other populations in the Glacier Sea ecosystem have also caused the moon jelly population explosion? In this chapter, you will read an article and use the Sim to find out more.



Name: _____ Date: _____

Lesson 3.1: "Jelly Population Explosion"

You have learned about how the size of the moon jelly population might be affected by its consumer and resource populations. But there are other populations in the Glacier Sea ecosystem. Can a population that is not a consumer population or a resource population have caused the increase in moon jellies? In this lesson, you will read an article to find out more about how populations in an ecosystem that are not directly connected on a food web can affect one another.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 3 Question

- How could a population besides the zooplankton or sea turtles have caused the moon jelly population to increase?

Vocabulary

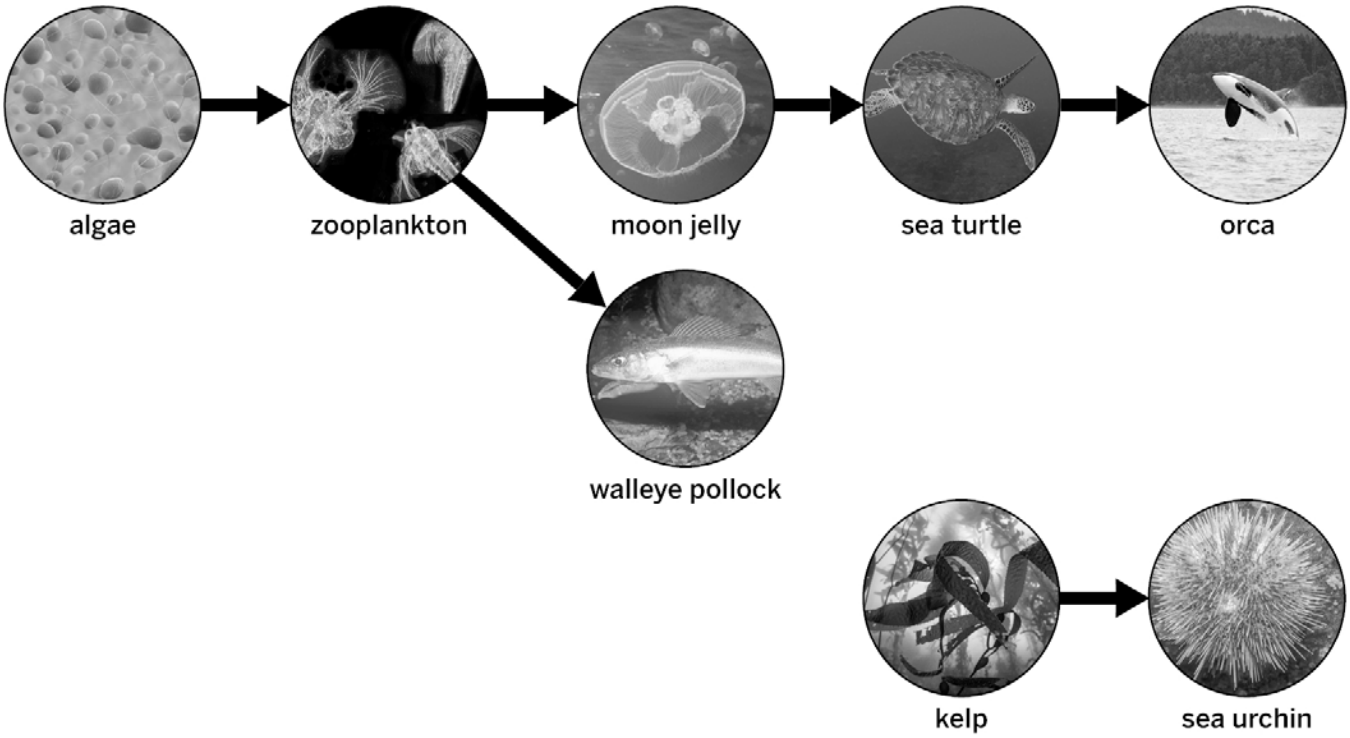
- consumer population
- ecosystem
- energy
- energy storage molecule
- population
- reproduction
- sample
- stability

Name: _____ Date: _____

Warm-Up

Review the food web and then answer the question below.

Glacier Sea Food Web



Do you think a population besides the moon jellies' consumer population (sea turtles) and resource population (zooplankton) could have caused the moon jelly population to increase in size? Why or why not?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Reading "Jelly Population Explosion"

1. Read and annotate the article "Jelly Population Explosion."
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 3.2: Competition in Ecosystems

One population can be impacted by changes to its consumer and resource populations, but are these the only changes that can affect population size? In this lesson, you will reread part of the article "Jelly Population Explosion" and use the Sim to understand that while populations may not be directly connected to one another on the food web, they are still able to impact one another.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 3 Question

- How could a population besides the zooplankton or sea turtles have caused the moon jelly population to increase?

Vocabulary

- competition
- consumer population
- ecosystem
- energy
- energy storage molecule
- indirect effect
- population
- reproduction
- resource population
- sample
- stability

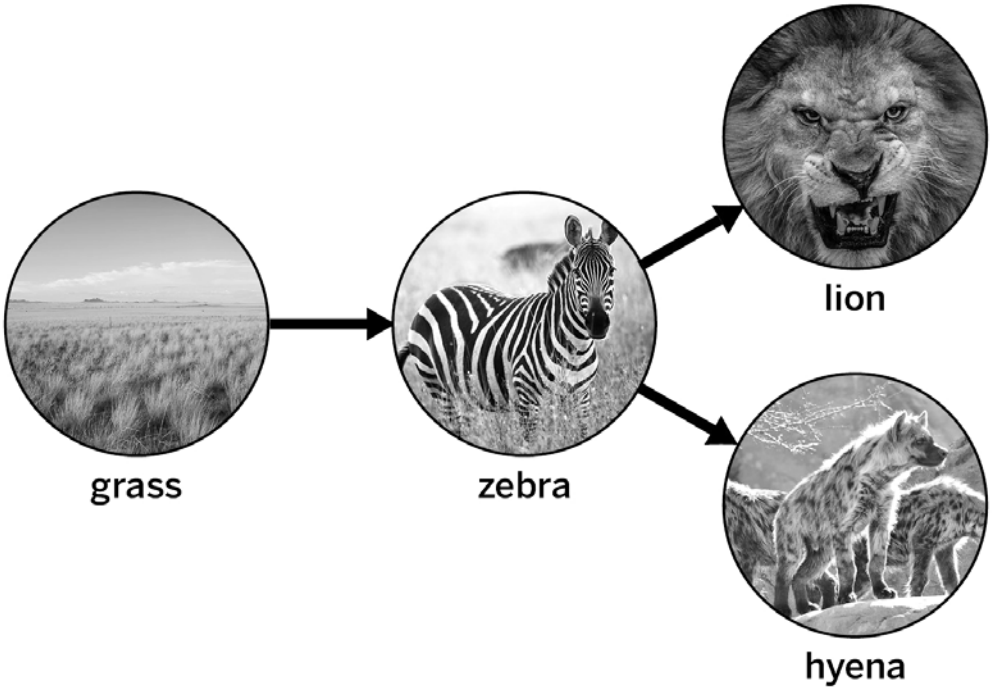
Digital Tools

- *Populations and Resources* Simulation

Name: _____ Date: _____

Warm-Up

Use the food web to answer the questions below.



What do you think would happen to the lion population if the hyena population increases in size? Assume that the populations were stable before this change. (check one)

- ☐ The lion population would **increase.**
- ☐ The lion population would **decrease.**
- ☐ The lion population would **not change.**

Explain your answer.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Rereading "Jelly Population Explosion"

You will reread a section of the "Jelly Population Explosion" article to help you answer the Investigation Question: *What can affect the size of a population besides its resource or consumer populations?*

1. Reread and annotate the first three paragraphs in the last section of the article titled "Competition for Food."
2. As you read and annotate, highlight information that helps you answer the question below.
3. When you are done reading, discuss your ideas with a partner. Then record your thinking below.

The sardines are not the jellies' resource population or consumer population, but they still caused the jelly population in North Benguela to increase. How did this happen?

_____

_____

_____

_____

_____

_____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Competition in the Sim

Part 1: Investigating Competition in the Sim

Some populations use the same resource, such as eat the same resource population (or food). In this Sim mission you will first find two populations that compete for the same resource. Then you will try to increase one population by changing the other.

1. Open the *Populations and Resources* Sim and go to 6 Populations mode.
2. Go to the food web overlay.
3. Find two populations that compete for the same resource.

Complete this sentence using the words in the Word Bank.

The _____ population and the _____ population compete for the

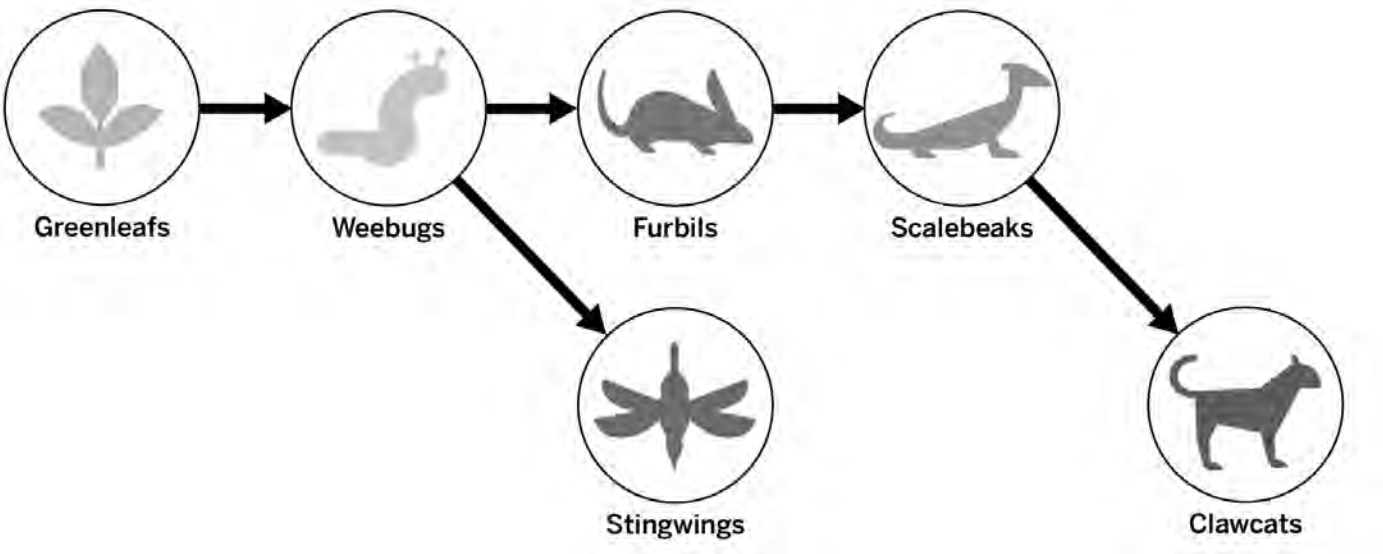
_____ population.

Word Bank

greenleaf	stingwing	weebug
furbil	scalebeak	clawcat

Part 2: Investigating Competition in the Sim

Sim Mission: Make a change to the furbils that will cause the stingwing population to increase.



Name: _____ Date: _____

Competition in the Sim (continued)

Plan the change you will make to increase the stingwing population. (circle one)

(**Increasing** / **Decreasing**) the furbil population will cause the stingwing population to increase.

1. Launch the *Populations and Resources* Sim and go to 6 Populations mode.
2. Let the Sim run for 40 time units.
3. Make the change to the furbils that you selected above. (Remember that making a bigger change will cause a bigger effect!) **Note:** You can lock the furbil population.
4. Press Play and let the Sim run for another 100 time units.
5. Go to Analyze and use the range window to observe the population sizes after the change.

After the change: (circle your choice)

weebugs (**increased** / **decreased** / **remained stable**).

stingwings (**increased** / **decreased** / **remained stable**).

Explain why the change you made caused the stingwing population to change. Use energy storage molecules to explain your answer.

_____

_____

_____

_____

_____

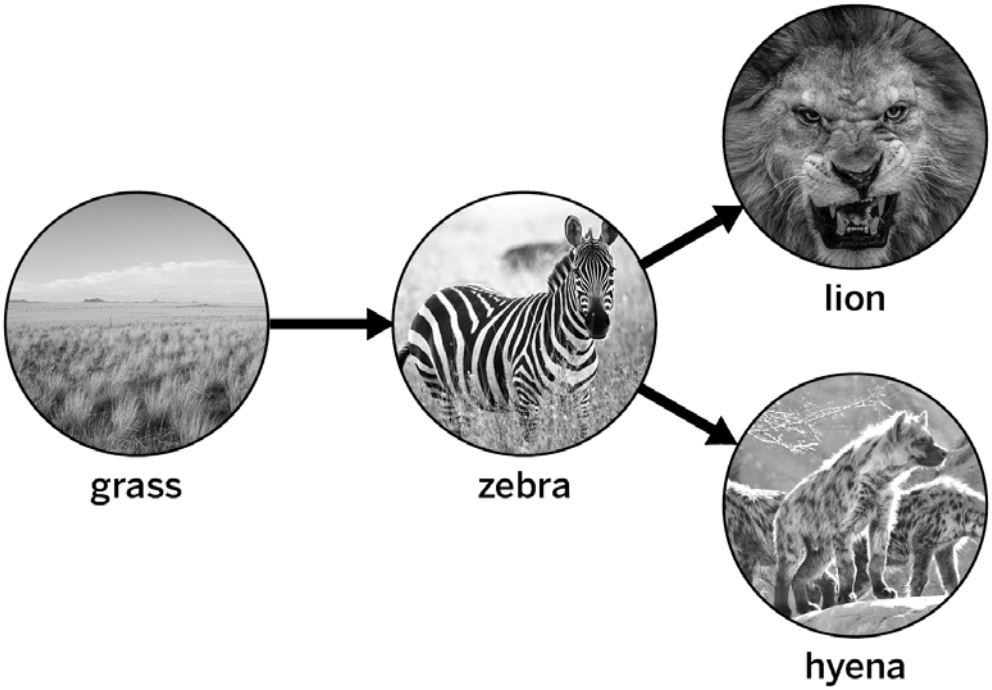
_____

What change would cause a decrease to the stingwing population? (**Increasing** / **Decreasing**) the size of the furbil population would cause the stingwing population size to decrease. (circle one)

Name: _____ Date: _____

Thinking About Indirect Effects

Use the food web to answer the questions below.



What do you think would happen to the lion population if the hyena population increases? Assume that the populations were stable before this change. (check one)

- ☐ The lion population would **increase**.
- ☐ The lion population would **decrease.**
- ☐ The lion population would **not change.**

Discuss your answer with a partner. Use energy storage molecules to explain your answer.

Name: _____ Date: _____

Homework: Investigating Competition in the Sim

Part 3

Sim Mission: In class you increased the stingwing population by changing the furbil population. Now you will make a change to the furbil population that will cause the stingwing population to decrease.

Plan the change you will make to decrease the stingwing population. (circle one)
(**Increasing** / **Decreasing**) the furbil population will cause the stingwing population to decrease.

1. Launch the *Populations and Resources* Sim.
2. Let the Sim run for 40 time units.
3. Make the change to the furbils that you selected above. (Remember that making a bigger change will cause a bigger effect!) **Note:** You can lock the furbil population.
4. Press Play and let the Sim run for another 100 time units.
5. Go to Analyze and use the range window to observe the population sizes after the change.

After the change: (circle your choice)

weebugs (**increased** / **decreased** / **remained stable**).

stingwings (**increased** / **decreased** / **remained stable**).

Explain why the change you made caused the stingwing population to decrease. Use energy storage molecules to explain your answer.

_____

_____

_____

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_____

_____

Name: _____ Date: _____

Lesson 3.3: More Indirect Effects

In the previous lesson, you read about how populations that are not directly connected on a food web can still affect one another. In this lesson, you will investigate more indirect effects by completing two missions in the Sim and writing predictions about the Glacier Sea ecosystem using specific words.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 3 Question

- How could a population besides the zooplankton or sea turtles have caused the moon jelly population to increase?

Key Concepts

- Two populations can compete for the same resource population. A change to one of these populations affects the size of the other.

Vocabulary

- competition
- consumer population
- ecosystem
- energy
- energy storage molecule
- indirect effect
- population
- reproduction
- resource population
- sample
- stability

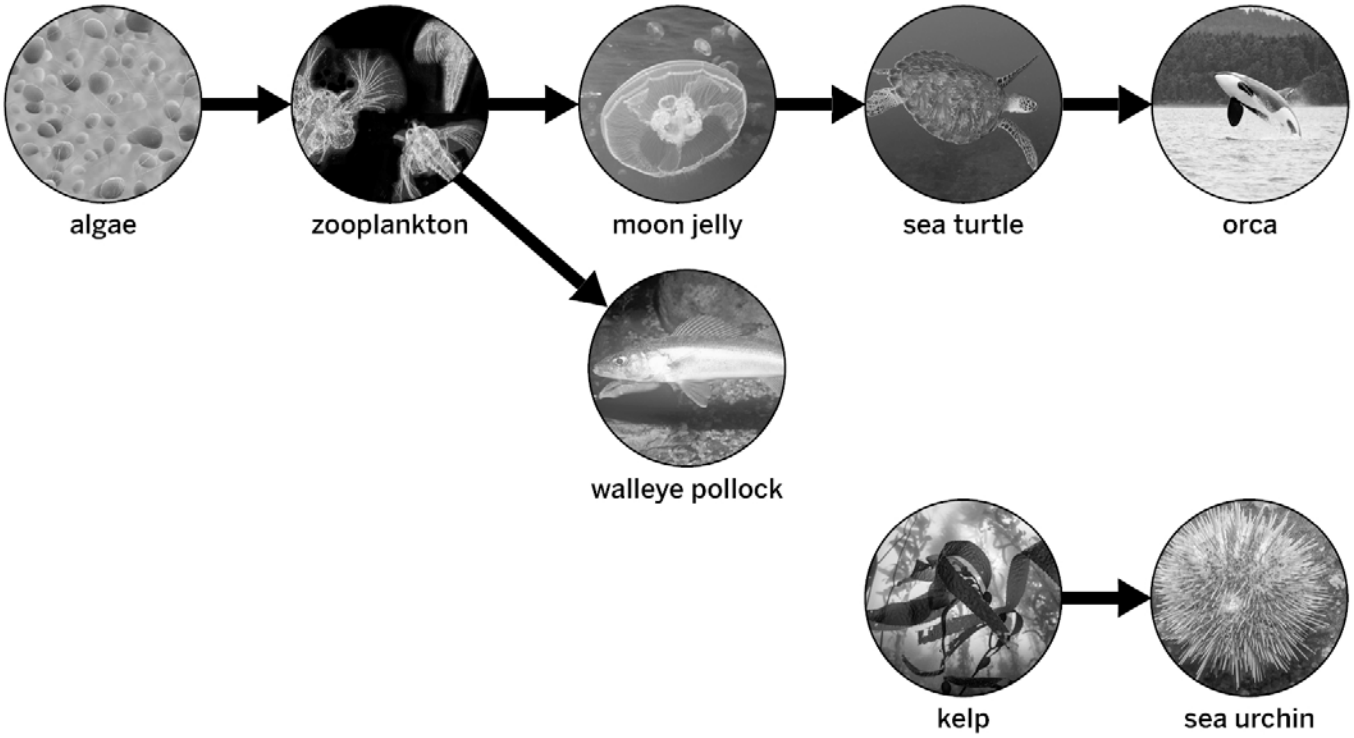
Digital Tools

- *Populations and Resources* Simulation

Name: _____ Date: _____

Warm-Up

Glacier Sea Food Web



You've already discussed how the zooplankton and sea turtle populations might have caused the size of the moon jelly population to increase. Which other populations do you think could have caused the size of the moon jelly population to increase? (You may check more than one.)

- ☐ walleye pollock
- ☐ algae
- ☐ orca
- ☐ sea urchin
- ☐ kelp

Explain your thinking.

_____

_____

_____

_____

_____

Name: _____ Date: _____

More Indirect Effects in the Sim

Mission: Indirect Effects

Populations that are not directly connected on a food web can still affect one another. Complete each mission and demonstrate how that is possible.

Mission 1: Find a way to increase the size of the clawcat population without changing the size of scalebeak population.

1. Open the *Populations and Resources* Sim and go to the food web overlay.
2. Plan the change you will make to increase the clawcat population (without changing oxygen or the size of the scalebeak population).
3. Record your idea below. (circle your choices)

   (**Increasing** / **Decreasing**) the (**greenleaf** / **weebug** / **furbil**) population will cause the clawcat population size to increase.
4. Start the Sim.
5. Let the Sim run for 20 time units.
6. Make the change that you selected above. (**Remember:** Making a bigger change will cause a bigger effect!)
7. Lock the population you changed.
8. Press Play and let the Sim run for another 200 time units.
9. Go to Analyze and use the range window to observe the population sizes after the change.

Describe the change that you made that led to the increase in the size of the clawcat population. Explain why the change led to an increase in the clawcat population size.

_____

_____

_____

_____

Name: _____ Date: _____

More Indirect Effects in the Sim (continued)

Mission 2: Find a way to decrease the size of the greenleaf population without changing the size of the weebug population.

1. Go to the food web overlay in the Sim.
2. Plan the change you will make to decrease the greenleaf population size (without changing oxygen or the size of the weebug population).
3. Record your idea below (circle your choices).

   (**Increasing** / **Decreasing**) the (**stingwing** / **furbil** / **scalebeak**) population will cause the greenleaf population size to decrease.
4. Start the Sim.
5. Let the Sim run for 20 time units.
6. Make the change that you selected above. (**Remember:** Making a bigger change will cause a greater effect!)
7. Lock the population you changed.
8. Press Play and let the Sim run for another 200 time units.
9. Go to Analyze and use the range window to observe the population sizes after the change.

Describe the change that you made that led to the decrease in the size of the greenleaf population. Explain why the change led to a decrease in the greenleaf population size.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Discussing Indirect Effects in Glacier Sea

Find the sheet that has the number you were assigned (1, 2, or 3). Follow the instructions below to participate in the Write and Share routine.

1. Carefully read and annotate the information you are given.
2. Answer your prompt, using the words in the Word Bank.
3. After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
4. While one student is presenting, the other two listen carefully.
5. After each student presents, the other students in the group can ask questions or make comments.

Word Bank

consumer population	energy storage molecules	indirect effect
resource population	competition/compete	

Name: _____ Date: _____

Homework: Reading "The Ant and the Acacia"

Annotate the "The Ant and the Acacia" article as you read, then answer the questions below.

The ant and the acacia have a *mutualistic* relationship. What does this mean?

_____

_____

_____

_____

What do the acacia ants get from the bullhorn acacia tree?

_____

_____

_____

What do the bullhorn acacia trees get from the acacia ants?

_____

_____

_____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 3.4: Final Arguments About the Jelly Increase

By now, you know that changes to many different populations could have caused the Glacier Sea moon jelly population to increase. You are almost ready to write a final argument about exactly what happened in the Glacier Sea ecosystem that caused the moon jelly population explosion. First, you will evaluate and analyze new evidence. Then, you will write a final argument to convince the ecologists at Glacier Sea Research Center about what caused the moon jelly increase.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 3 Question

- How could a population besides the zooplankton or sea turtles have caused the moon jelly population to increase?

Key Concepts

- Two populations can compete for the same resource population. A change to one of these populations affects the size of the other.
- The size of a population can be affected by any population that is connected to it in a food web, even if they are not directly connected.

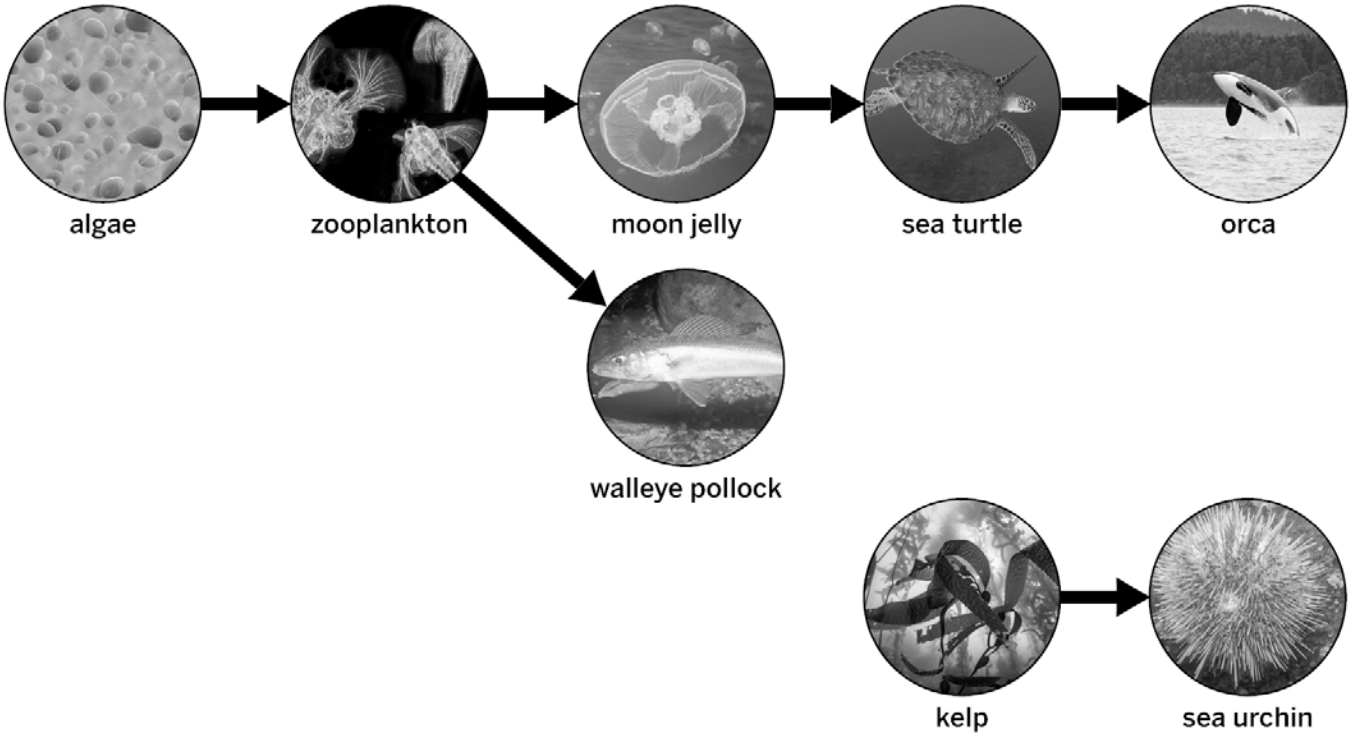
Vocabulary

- competition
- consumer population
- ecosystem
- energy
- energy storage molecule
- indirect effect
- population
- reproduction
- resource population
- sample
- stability

Name: _____ Date: _____

Warm-Up

Glacier Sea Food Web



The algae, walleye pollock, and orca populations could have all affected the moon jelly population. What additional evidence do you need to determine which of these populations might have caused the size of the moon jelly population to increase?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Evaluating and Analyzing Evidence

Part 1: Evaluating Evidence

Review the Evidence Criterion below and then follow the directions to evaluate the new evidence.

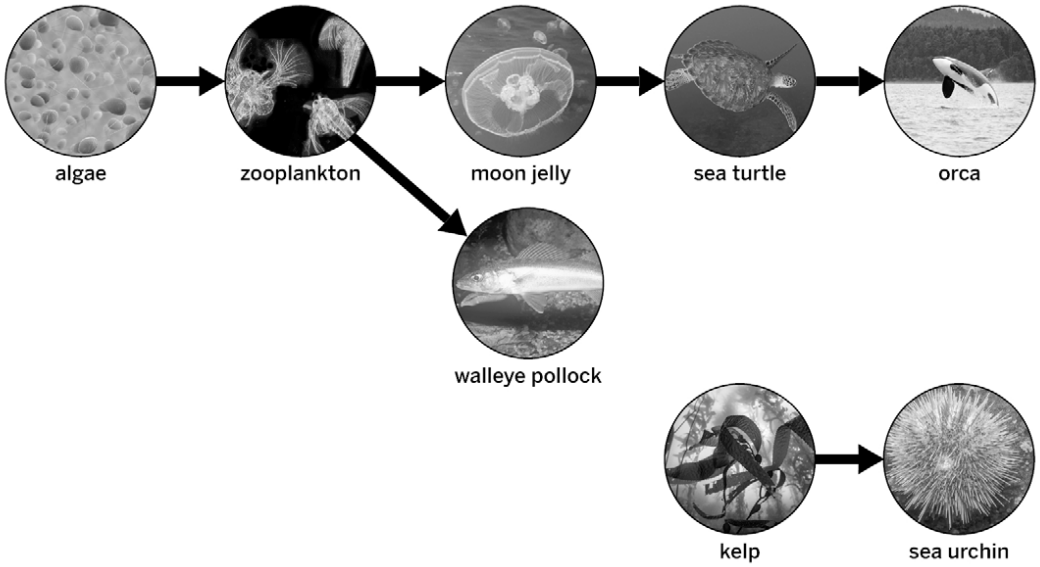
Evidence Criterion: Samples that represent as much of the whole as possible provide stronger evidence.

1. **Read and annotate each Evidence Card.** Use the questions below to guide you:
   - How are the samples described on each card different?
   - Which sample best represents the whole population? Note that the algae, walleye pollock, and orcas can be found throughout Glacier Sea.
2. **Discuss your annotations with your partner.** Make sure to talk about how well each sample represents the whole population.

Part 2: Analyzing Evidence

Talk to your partner about whether each piece of evidence supports or goes against the claims.

Glacier Sea Food Web



What could have caused the size of the moon jelly population to increase?

The population increased because . . .

Claim 1: The size of the algae population changed.

Claim 2: The size of the walleye pollock population changed.

Claim 3: The size of the orca population changed.

Name: _____ Date: _____

Writing Final Arguments

Write a final argument about what could have caused the size of moon jelly population to increase. Follow the instructions below.

1. Review the evidence to decide which claim or claims you think are supported. Remember to think about which sample best represents the whole population.
2. Write your argument.
   - State your claim. You can support one or both claims.
   - Describe your evidence.
   - Make your argument as convincing as possible by making sure you explain how your evidence supports your claim or claims.
3. Read over your completed argument. Is it convincing? Did you use science terms such as *competition*, *consumer population*, *resource population,* and *energy storage molecules?*

Question: *What could have caused the size of the moon jelly population to increase?*

Claim 1: A change to the size of the algae population caused the jelly population to increase.

Claim 2: A change to the size of the walleye pollock population caused the jelly population to increase.

Write your argument in the space below and on the next page.

Name: _____ Date: _____

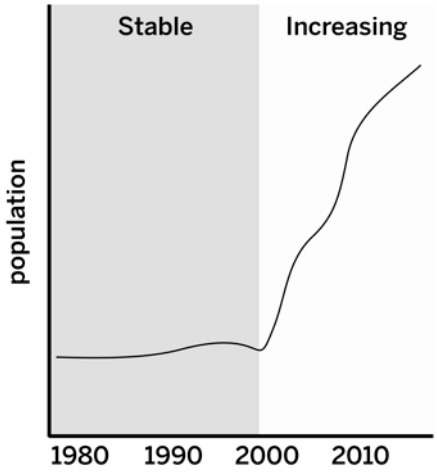
Writing Final Arguments (continued)

Name: _____ Date: _____

Beginning Final Models of the Population Increase

Modeling a Final Claim About the Moon Jelly Population Increase

Estimate of Jelly Population Change



You have been investigating the question *How could a population besides the zooplankton or sea turtles have caused the moon jelly population to increase?* Use either the Modeling Tool: Walleye Pollock Claim or Modeling Tool: Algae Claim to show your thinking about this question. Follow the instructions below.

Goal: Show how a change to the algae or walleye pollock populations could have caused the size of the moon jelly population to increase.

Do:

- Choose the Modeling Tool sheet that shows the population you think caused the size of the moon jelly population to increase.
- Use the given information about births and deaths in the stable populations to show how births and deaths changed in all three populations when the jelly population increased.
- Draw boxes and write a "B" inside to show births.
- Cross out boxes to show deaths.
- Label the first, second, and final change on the second row.
- Indicate the amount of energy storage molecules being transferred between the populations by drawing more or fewer circles on the arrows.
- Annotate your model as needed to explain your ideas.

Tips:

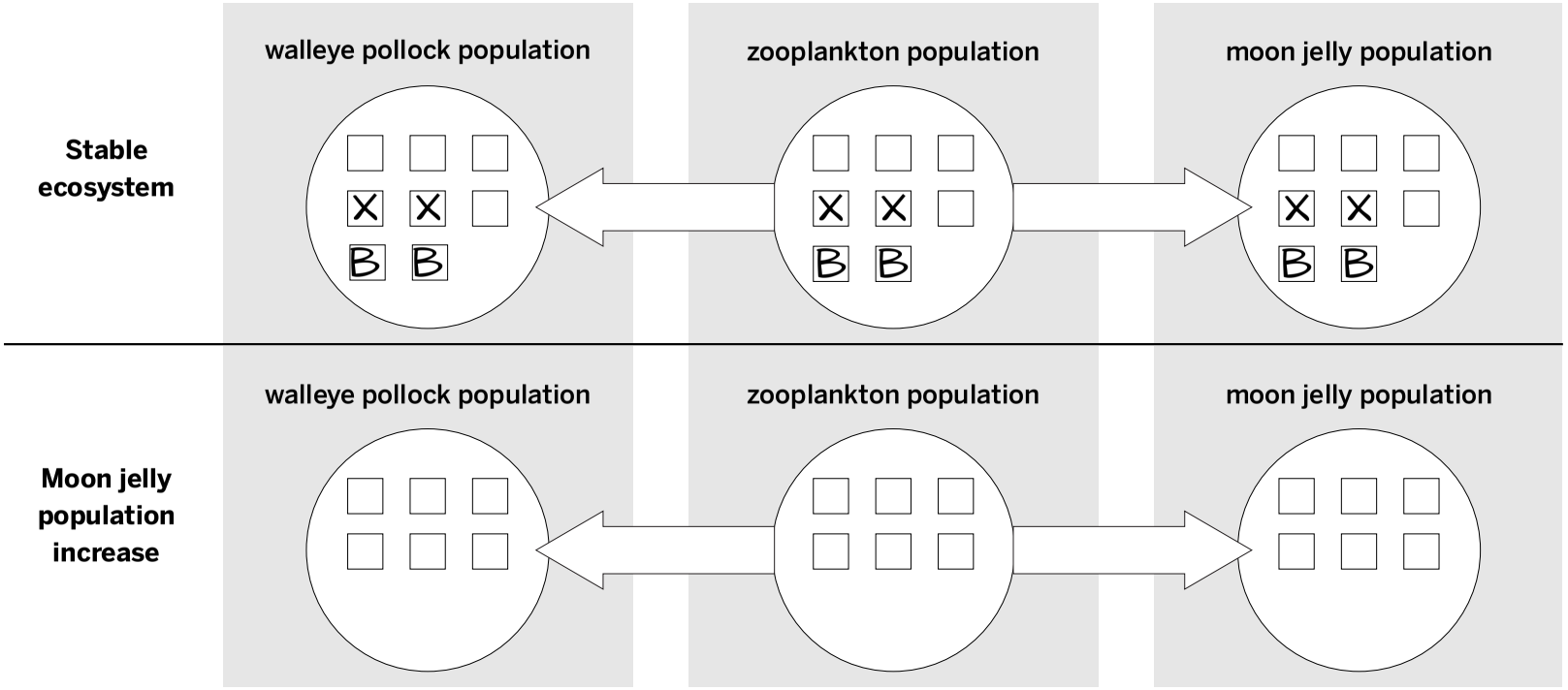
- There is more than one way to create this model.
- Don't worry about the exact number of the births, deaths, or energy storage molecules. Instead, focus on how they compare when the populations are stable and when the jelly population is increasing.

Name: _____ Date: _____

Populations and Resources Modeling Tool

Walleye Pollack Claim

Goal: Show how a change to the walleye pollock population may have caused an increase in the moon jelly population.



Key

organism in population

Draw a new box with a "B" in it to show a birth.

Cross out a box to show a death.

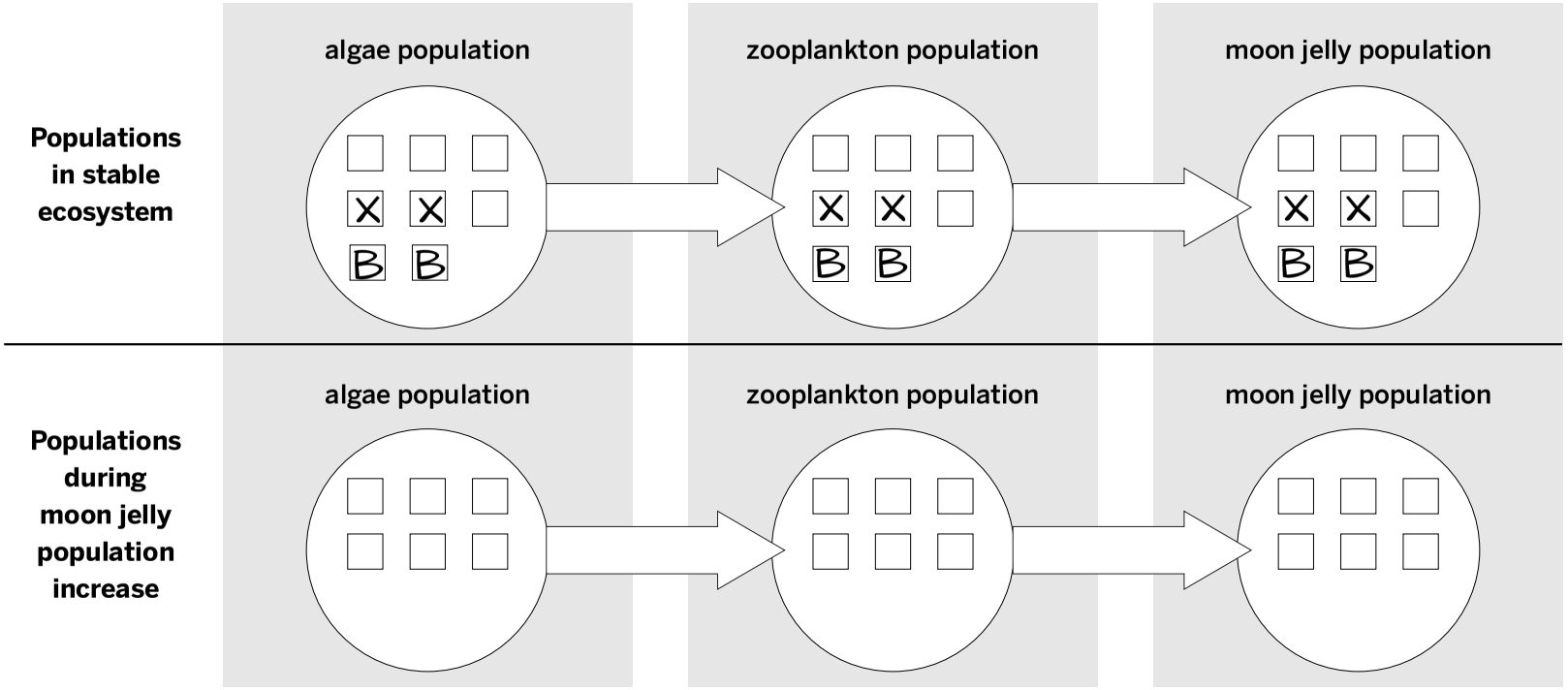
Draw dots to show energy storage molecules.

Name: _____ Date: _____

Populations and Resources Modeling Tool

Algae Claim

Goal: Show how a change to the algae population may have caused an increase in the moon jelly population.



Key

organism in population

Cross out a box to show a death.

Draw a new box with a "B" in it to show a birth.

Draw dots to show energy storage molecules.

Name: _____ Date: _____

Homework: Completing Your Model

Complete your model of what caused the size of the moon jelly population to increase. Follow the steps below.

- Add any missing information or annotations that help show how the population you chose caused the size of the moon jelly population to increase.
- Reread your argument. Now that you have completed your model, is there any information that is missing from your argument? What can you add to make your argument clearer and more convincing?

Consider the following questions as you review your argument:

- Does your argument clearly explain why a change to the size of the algae population or a change to the size of the walleye pollock population would have caused the jelly population to increase?
- Do you describe your supporting evidence?
- Do you thoroughly explain how the evidence supports your claim?

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

Scientists investigate in order to figure things out. Are you getting closer to understanding why the size of the Glacier Sea moon jelly population has increased?

1. I understand what is happening within the moon jelly population when the size of the moon jelly population is stable. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

2. I understand what could change the size of the moon jelly population. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

3. I understand how a change in the size of the moon jellies' resource population can change the number of births in the moon jelly population. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand how a change in the size of the moon jellies' consumer population can change the number of deaths in the moon jelly population. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

5. I understand how a change in the size of a population that is not the moon jellies' consumer or resource population can affect the moon jelly population. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

6. What do you still wonder about why the size of the moon jelly population has increased?

_____

_____

_____

_____

Name: _____ Date: _____

Chapter 4: Science Seminar
Chapter Overview

Dr. Tiana Washington, the head ecologist at Glacier Sea Research Center, has one final mission for you. Ecologists are working to understand another population change in an ecosystem on an island off the coast of Australia. The size of the orange-bellied parrot population has decreased drastically. In fact, there are only 70 of these birds left in the wild. The ecologists on the island are trying to figure out what could be causing this decrease and need your help.

Name: _____ Date: _____

Lesson 4.1: The South Pacific Island Ecosystem

Dr. Tiana Washington, the head ecologist at Glacier Sea Research Center, has one final mission for you. Ecologists are working to understand another population change in an ecosystem on an island off the coast of Australia. The size of the orange-bellied parrot population has decreased drastically. In fact, there are only 70 of these birds left in the wild. The ecologists on the island are trying to figure out what could be causing this decrease. They need your help.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 4 Question

- What was the main cause of the decrease in the size of the orange-bellied parrot population?

Key Concepts

- Within a population organisms are always being born and dying.
- A system can be stable even as things are being added to and removed from it. If the amounts being added and being removed are not equal, then the system will change.
- If the number of births and deaths in a given time are equal, then the population size will be stable.
- If there are more births than deaths in a given time, then the size of the population will increase. If there are fewer births than deaths, then the size of the population will decrease.
- Organisms need to release energy from energy storage molecules in order to reproduce.
- Organisms in consumer populations get energy storage molecules from eating organisms in resource populations.
- The more energy storage molecules available to a population, the more the organisms in that population can reproduce.
- The larger the resource population, the more energy storage molecules are available for its consumer populations.
- The larger the consumer population, the more energy storage molecules it will need. Therefore, it will eat more, causing more deaths in the resource population.
- Two populations can compete for the same resource population. A change to one of these populations affects the size of the other.
- The size of a population can be affected by any population that is connected to it in a food web, even if they are not directly connected.

Name: _____ Date: _____

Lesson 4.1: The South Pacific Island Ecosystem (continued)

Vocabulary

- competition
- consumer population
- ecosystem
- energy
- energy storage molecule
- indirect effect
- population
- reproduction
- resource population
- sample
- stability

Name: _____ Date: _____

Warm-Up

Read the message from the head ecologist and answer the question below. Don't worry if you're not sure about your answer. You will learn more about this new ecosystem over the next few days.

Glacier Sea
Research Center

To: Student Ecologists
From: Dr. Tiana Washington, Head Ecologist
Subject: New Question: South Pacific Island Ecosystem

Thank you for your excellent work! We appreciate your help in solving the mystery of the moon jelly population explosion here in Glacier Sea.

Now I have a new mission for you. Ecologists are working on an island in the South Pacific Ocean and have reported a decrease in the size of orange-bellied parrot population over the past 30 years. We hope you can help us figure out why this is happening. I'll be sending you some data soon.

What are some of your initial ideas about why the size of this parrot population might be decreasing?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Introducing the Science Seminar

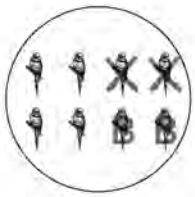
Part 1: Island Ecosystem Claims

Science Seminar Question: *What was the main cause of the decrease in the size of the orange-bellied parrot population?*

Science Seminar Claims:

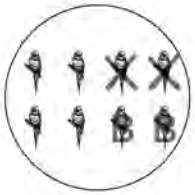
The population decreased because . . .

Claim 1: Births decreased.



fewer births

Claim 2: Deaths increased.



more deaths

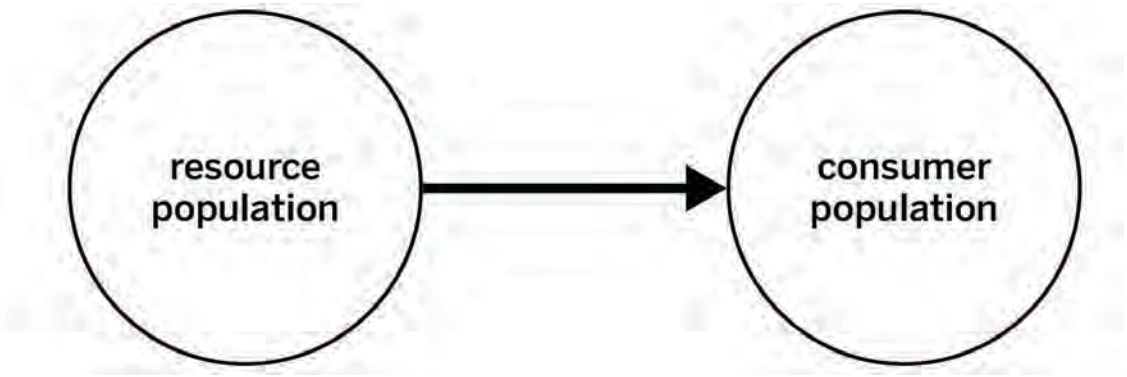
Part 2: Discussing the Island Ecosystem Food Web

Follow the instructions below to create the Island Ecosystem food web.

1. Pass out three cards to each student.
2. Read over your Population Cards.
3. Have each member of your group share the information on their cards.
4. Work with your group to figure out how these organisms are connected.
5. Add arrows to the Island Ecosystem Food Web on the next page to show which populations eat which other populations.
6. Remember the arrow points from the resource population to the consumer population.

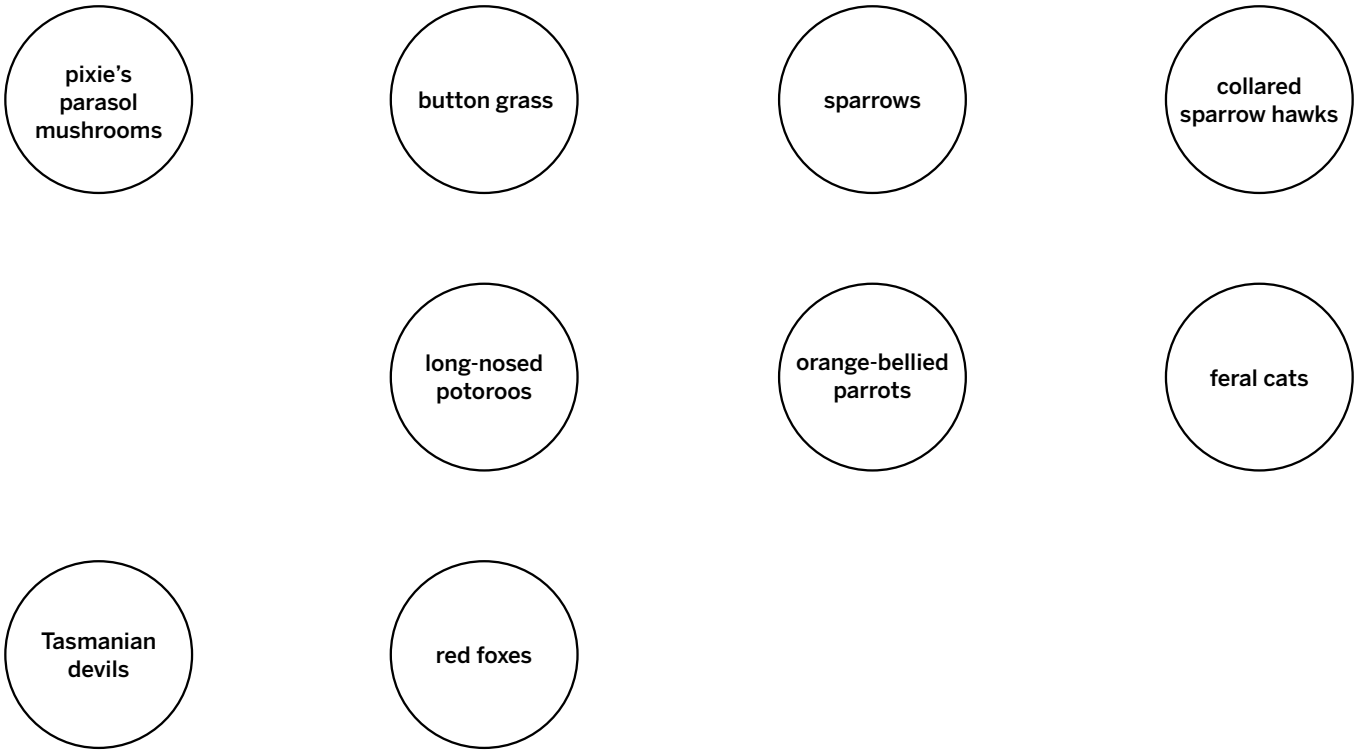
Name: _____ Date: _____

Introducing the Science Seminar (continued)



Island Ecosystem Food Web

Use the Island Population Cards to help you add arrows to the food web. Remember to add the arrows pointing from the resource populations to the consumer populations.



Name: _____ Date: _____

Evaluating Evidence

Review the Evidence Criterion below and then follow the instructions to evaluate the Island Evidence Cards.

Evidence Criterion: Samples that represent as much of the whole as possible provide stronger evidence.

1. **Read and annotate each Evidence Card.** Use the questions below to guide you:
   - How are the samples described on each card different?
   - Which sample best represents the whole population? Note that all of the organisms can be found throughout the island.
2. **Discuss your annotations with your partner.** Make sure to talk about how well each sample represents the whole population.
3. **Place the Evidence Cards.** With your partner, place one set of the Evidence Cards on the Evidence Gradient based on how strong you think the evidence is. One partner should put aside their set of Evidence Cards for now.

Name: _____ Date: _____

Homework: Making Connections

Think of another science topic you have studied earlier. How does that topic connect to what we have learned about populations and resources? Be creative! Consider how something else you have studied in science might be affected by the resources available. Perhaps you have studied another topic where stability and change is important?

Name: _____ Date: _____

Lesson 4.2: Analyzing Claims and Evidence

What was the main cause of the decrease in the size of the orange-bellied parrot population? Are births decreasing or are deaths increasing? In this lesson, you will use the evidence you evaluated in the previous lesson to figure out what is causing the size of the orange-bellied parrot population to decrease. You will use the evidence to annotate the Island Ecosystem Food Web, and then you will sort the Evidence Cards based on the claim you think they best support. You will also get one new piece of evidence to help you prepare for the Science Seminar in the next lesson.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 4 Question

- What was the main cause of the decrease in the size of the orange-bellied parrot population?

Key Concepts

- Within a population organisms are always being born and dying.
- A system can be stable even as things are being added to and removed from it. If the amounts being added and being removed are not equal, then the system will change.
- If the number of births and deaths in a given time are equal, then the population size will be stable.
- If there are more births than deaths in a given time, then the size of the population will increase. If there are fewer births than deaths, then the size of the population will decrease.
- Organisms need to release energy from energy storage molecules in order to reproduce.
- Organisms in consumer populations get energy storage molecules from eating organisms in resource populations.
- The more energy storage molecules available to a population, the more the organisms in that population can reproduce.
- The larger the resource population, the more energy storage molecules are available for its consumer populations.
- The larger the consumer population, the more energy storage molecules it will need. Therefore, it will eat more, causing more deaths in the resource population.
- Two populations can compete for the same resource population. A change to one of these populations affects the size of the other.
- The size of a population can be affected by any population that is connected to it in a food web, even if they are not directly connected.

Name: _____ Date: _____

Lesson 4.2: Analyzing Claims and Evidence (continued)

Vocabulary

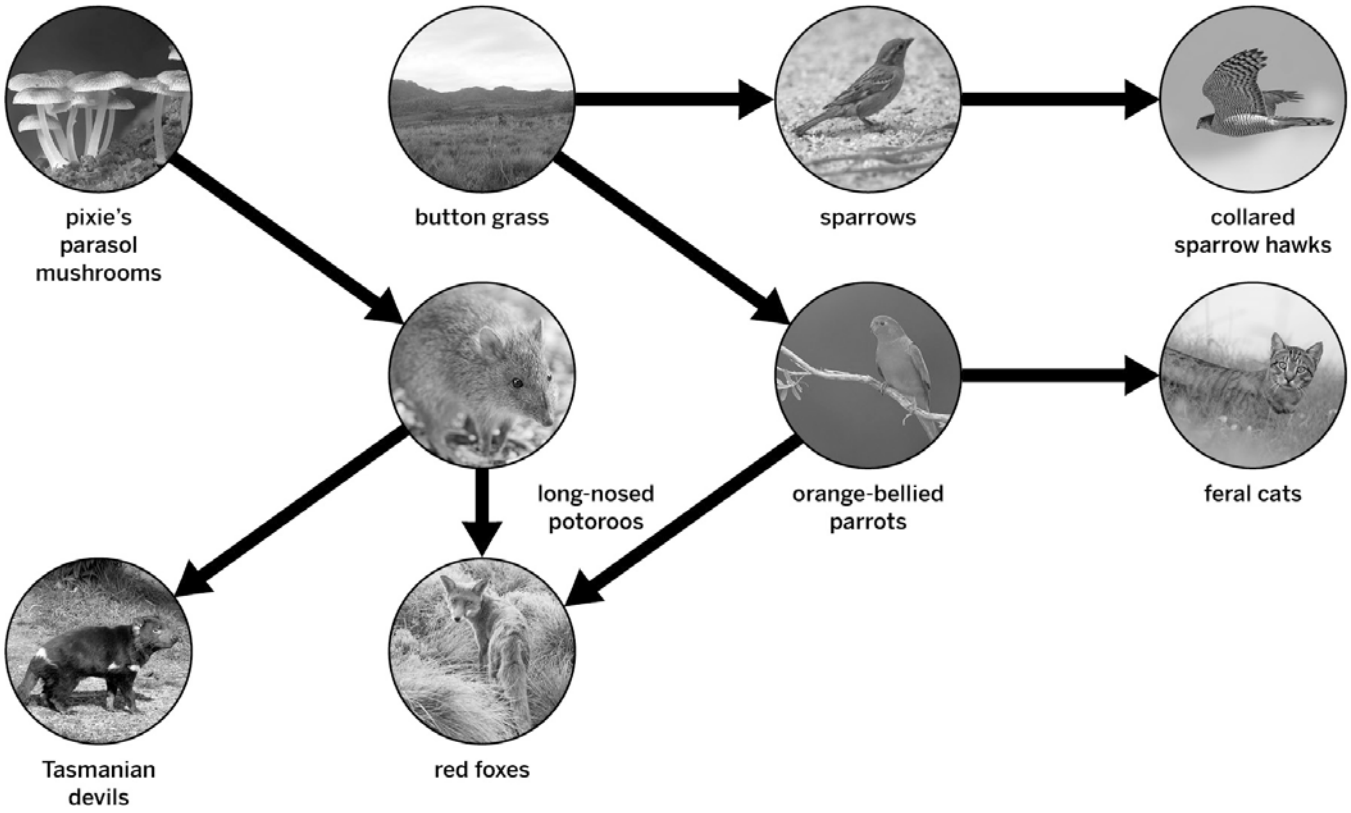
- competition
- consumer population
- ecosystem
- energy
- energy storage molecule
- indirect effect
- population
- reproduction
- resource population
- sample
- stability

Name: _____ Date: _____

Warm-Up

Use the food web to answer the question below.

Island Ecosystem Food Web



How might an increase to the size of the sparrow population affect the orange-bellied parrot population?

_____

_____

_____

_____

_____

_____

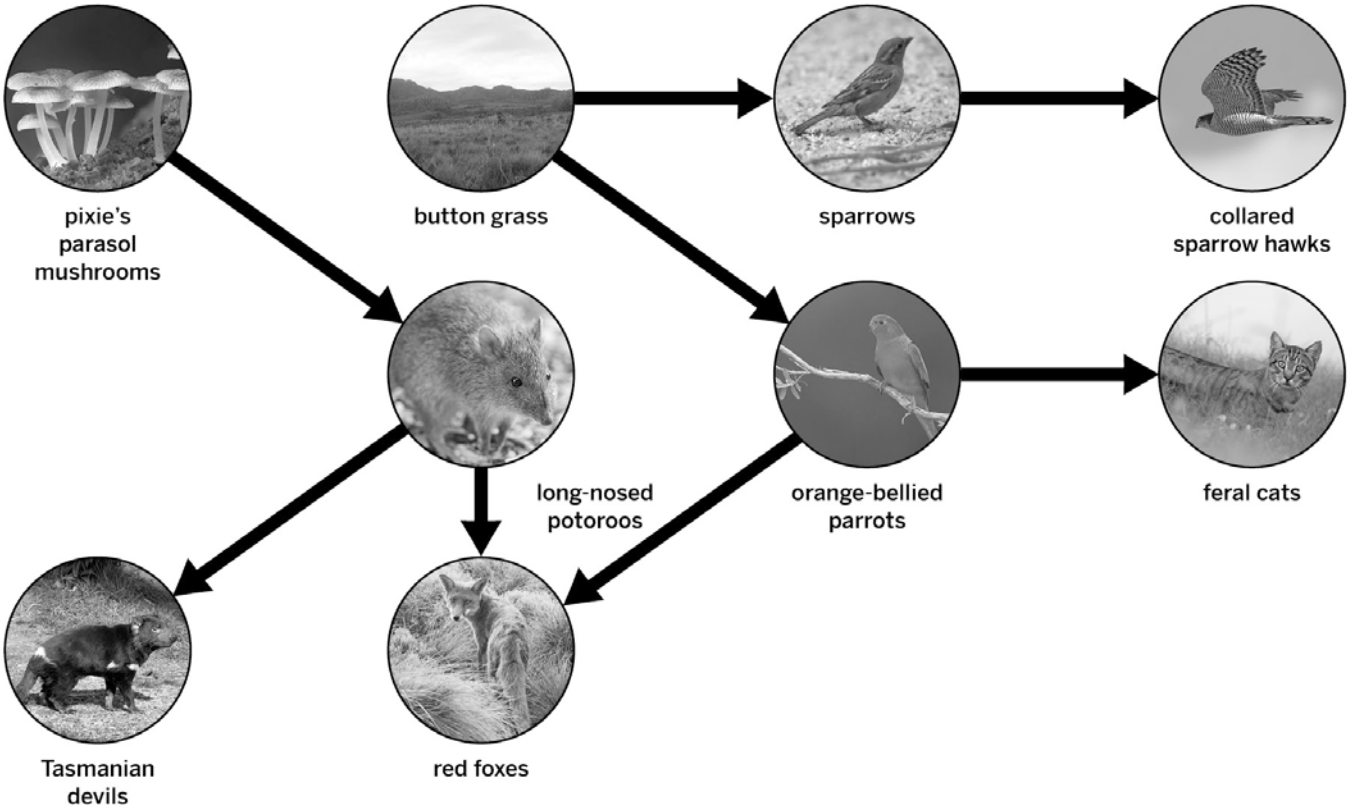
Name: _____ Date: _____

Analyzing the Food Web

Use the evidence from the previous lesson to annotate the food web.

- Write "increase," "decrease," or "stable" near the population circles to indicate what happened to each population over time.
- Add annotations to help you remember how strong the evidence is.
- If you have no evidence about a population, you can write "no evidence."
- When you are finished, compare your annotations with a partner.

Island Ecosystem Food Web



Name: _____ Date: _____

Evidence Sorting

Part 1: Evaluating Evidence

With your partner, decide how the Evidence Cards go together with the claims. Follow the instructions below.

Science Seminar Question: *What is the main cause for the decrease in the size of the orange-bellied parrot population?*

The population decreased because . . .

Claim 1: births decreased.

Claim 2: deaths increased.

1. **Set one set of Evidence Cards aside.**
2. **Discuss each Evidence Card with your partner.** Use your annotated food web to figure out how changes to the other populations could affect the parrot population. This will help you determine which Evidence Card best supports the claims. Make sure to talk about disagreements.
3. **Sort each Evidence Card.** If the evidence supports Claim 1, place it on top of the sheet with that claim. If the evidence supports Claim 2, place it on top of the sheet with that claim.

Part 2: Evaluating New Evidence

With your partner, read and annotate the new evidence. When you are finished, sort the evidence under the claim you think it best supports.

Part 3: Reflecting on the Claims

At this point, which do you think is best supported by evidence?

Science Seminar Question: *What was the main cause of the decrease in the size of the orange-bellied parrot population?*

The population decreased because . . .

- ☐ **Claim 1:** births decreased.
- ☐ **Claim 2:** deaths increased.

What evidence supports your answer? (check all that apply)

- ☐ Evidence Card A
- ☐ Evidence Card B
- ☐ Evidence Card C
- ☐ Evidence Card D
- ☐ Evidence Card E
- ☐ Evidence Card F
- ☐ Evidence Card G
- ☐ Evidence Card H
- ☐ Evidence Card I

Name: _____ Date: _____

Lesson 4.3: The Science Seminar

What happened in the South Pacific Island Ecosystem that could have caused the decrease in the size of the orange-bellied parrot population? In the Science Seminar today, you and your classmates will discuss the evidence, listen to one another's ideas, and try to arrive at the best explanation for why this population size changed. After hearing from your classmates and participating in the Science Seminar, you will be ready to write a convincing scientific argument.

Unit Question

- Why do populations change size in an ecosystem?

Chapter 4 Question

- What was the main cause of the decrease in the size of the orange-bellied parrot population?

Key Concepts

- Within a population organisms are always being born and dying.
- A system can be stable even as things are being added to and removed from it. If the amounts being added and being removed are not equal, then the system will change.
- If the number of births and deaths in a given time are equal, then the population size will be stable.
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- The larger the resource population, the more energy storage molecules are available for its consumer populations.
- The larger the consumer population, the more energy storage molecules it will need. Therefore, it will eat more, causing more deaths in the resource population.
- Two populations can compete for the same resource population. A change to one of these populations affects the size of the other.
- The size of a population can be affected by any population that is connected to it in a food web, even if they are not directly connected.

Name: _____ Date: _____

Lesson 4.3: The Science Seminar (continued)

Vocabulary

- competition
- consumer population
- ecosystem
- energy
- energy storage molecule
- indirect effect
- population
- reproduction
- resource population
- sample
- stability

Name: _____ Date: _____

Warm-Up

Revisiting the Evidence

Take out your Evidence Cards from the last lesson. Look back at the Evidence Cards and review your annotations. Then, use the Evidence Cards to answer the questions below.

Question: *What was the main cause of the decrease in the size of the orange-bellied parrot population?*

The population decreased because . . .

Claim 1: births decreased.

Claim 2: deaths increased.

Which claim do you think is best supported? (check one)

- ☐ Claim 1
- ☐ Claim 2

What piece of evidence best supports your claim? (check one)

- ☐ Evidence Card A
- ☐ Evidence Card B
- ☐ Evidence Card C
- ☐ Evidence Card D
- ☐ Evidence Card E
- ☐ Evidence Card F
- ☐ Evidence Card G
- ☐ Evidence Card H
- ☐ Evidence Card I

How does the evidence you chose support your claim?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Preparing for the Science Seminar

Preparing Your Science Seminar Argument

1. Take turns with your partner sharing which claim you think is best supported.
2. Choose one or two of the best pieces of evidence and discuss why they support your claim.
3. Use your Warm-Up responses and the Argumentation Sentence Starters to help you share ideas.
4. Refer to your Evidence Cards as needed. You can also refer to the Evidence Cards below.

Science Seminar Question: *What was the main cause of the decrease in the size of the orange-bellied parrot population?*

The population decreased because . . .

Claim 1: births decreased.

Claim 2: deaths increased.

Argumentation Sentence Starters

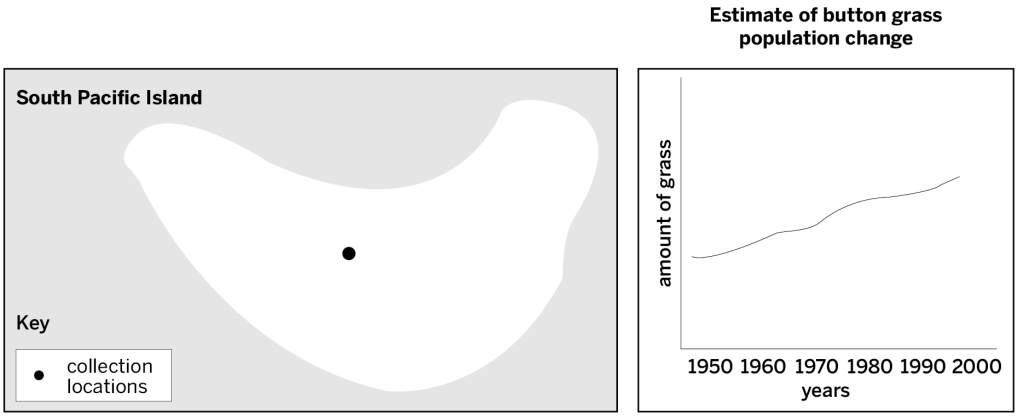
Describing evidence:	**Explaining how the evidence supports the claim:**
The evidence that supports my claim is . . .	If ___, then . . .
My first piece of evidence is . . .	This change caused . . .
Another piece of evidence is . . .	This is important because . . .
This evidence shows that . . .	Since, . . .
	Based on the evidence, I conclude that . . .
	This claim is stronger because . . .

Name: _____ Date: _____

Preparing for the Science Seminar (continued)

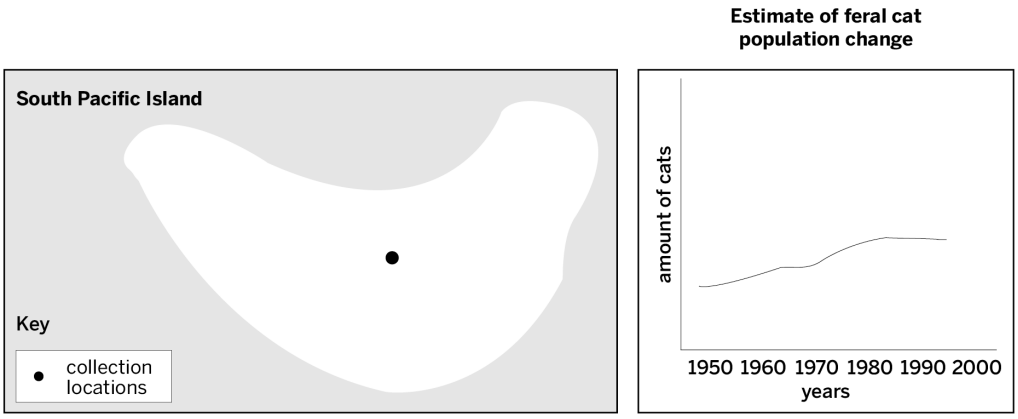
Evidence Card A: Button Grass

- Every year for the past 50 years, ecologists have been counting the number of button grass plants near the center of the island.
- They concluded that the population increased over 50 years.



Evidence Card B: Feral Cats

- Every year for the past 50 years, ecologists have been counting the number of feral cats near the center of the island.
- They concluded that the population increased over 50 years.

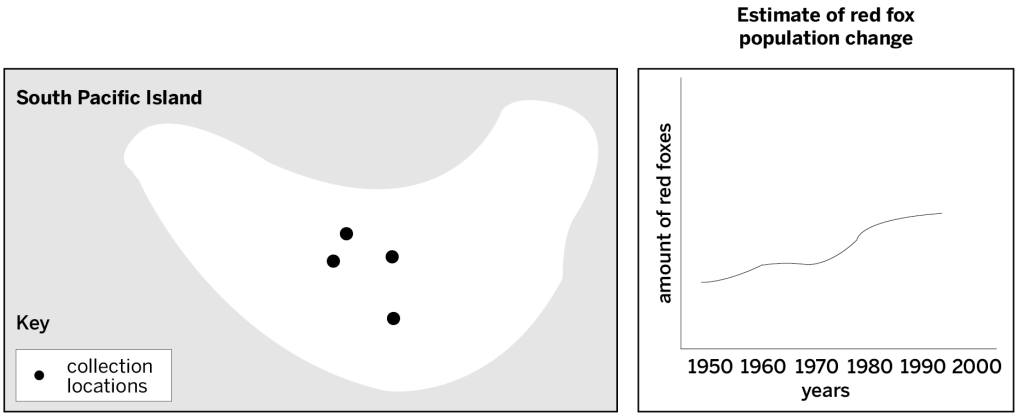


Name: _____ Date: _____

Preparing for the Science Seminar (continued)

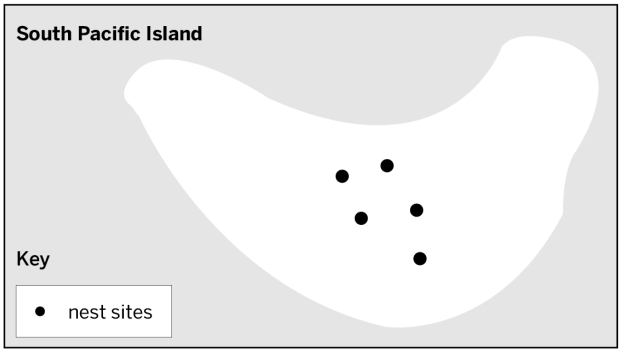
Evidence Card C: Red Foxes

- Every year for the past 50 years, ecologists have been counting the number of red foxes at four locations near the center of the island.
- They concluded that the population increased over 50 years.



Evidence Card D: Sparrows

- Sparrows build their nests all over the island.
- Every year for the past 50 years, ecologists have counted the number of eggs in sparrow nests at five sites in the middle of the island.
- They concluded that the number of sparrow births has increased over 50 years.

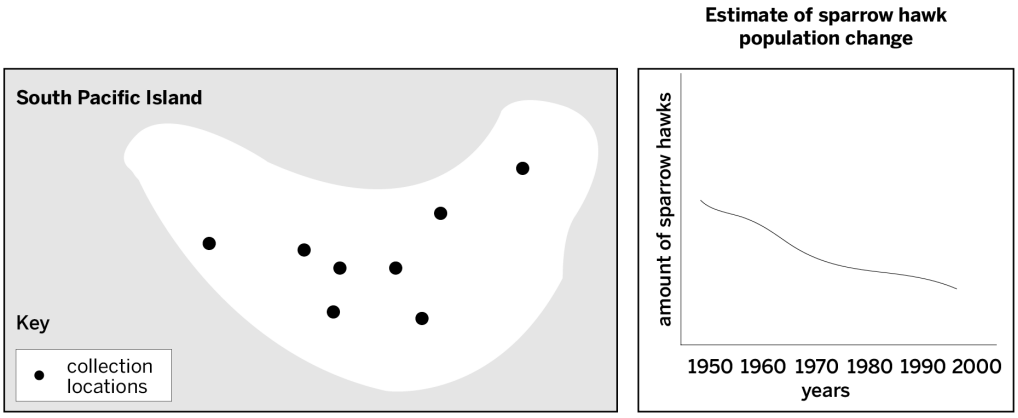


Name: _____ Date: _____

Preparing for the Science Seminar (continued)

Evidence Card E: Sparrow Hawks

- Every year for the past 50 years, scientists collected sparrow hawk population data in eight different locations throughout the island.
- They concluded that the population decreased over 50 years.



Evidence Card F: Tasmanian Devils

- Every year for the past 50 years, scientists collected Tasmanian devil population data in 10 different locations throughout the island.
- They concluded that the population decreased over 50 years.

Name: _____ Date: _____

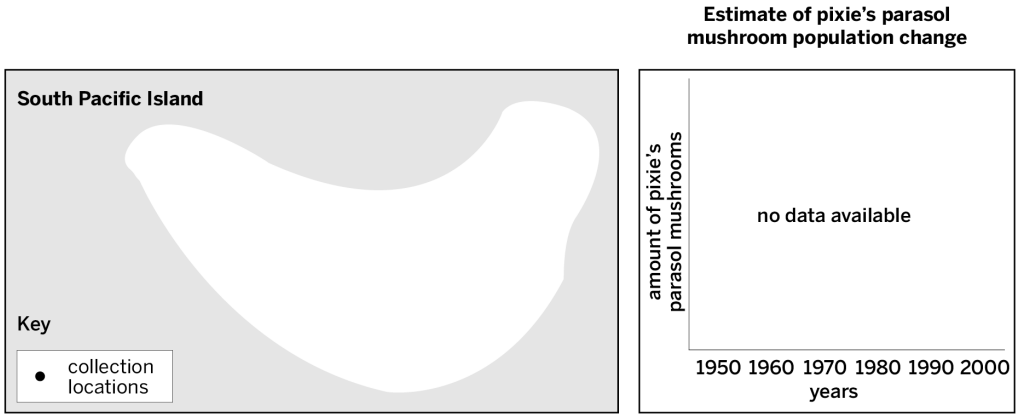
Preparing for the Science Seminar (continued)

Evidence Card G: Long-Nosed Potoroos

- Scientists do not have evidence about the population size.

Evidence Card H: Pixie's Parasol Mushrooms

- Scientists do not have evidence about the population size.

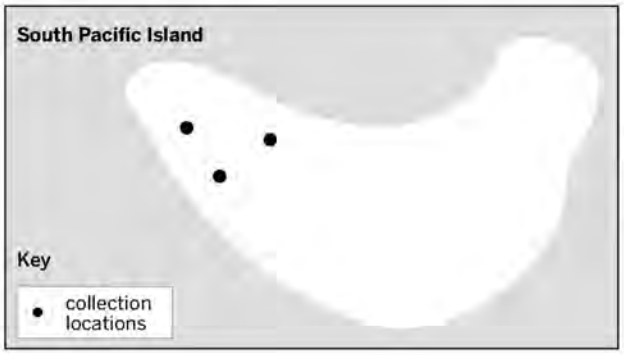


Name: _____ Date: _____

Preparing for the Science Seminar (continued)

Evidence Card I: Orange-Bellied Parrot

- Orange-bellied parrots have a layer of fat on their bodies. This is where they store most of their energy storage molecules.
- Over 50 years, scientists analyzed the fat of the parrots that were collected at three locations near the west coast of the island.
- Scientists concluded that the fat on their bodies has decreased over 50 years.



Name: _____ Date: _____

Participating in the Seminar

Question: *What was the main cause of the decrease in the size of the orange-bellied parrot population?*

The population decreased because . . .

Claim 1: births decreased.

Claim 2: deaths increased.

Science Seminar Observations

Write a check mark in the right-hand column every time you hear one of your peers say or do something listed in the left-hand column. If you hear an interesting idea, write it in the last row of the table.

Observations during the seminar	Check marks
I heard a student use evidence to support a claim.	
I heard a student respectfully disagree with someone else's thinking.	
I heard a student explain how her evidence is connected to her claim.	
I heard a student evaluate the quality of evidence.	
I heard an idea that makes me better understand one of the claims. That idea is:	

Name: _____ Date: _____

Homework: Writing a Scientific Argument

Write your scientific argument about what caused the size of the orange-bellied parrot population to decrease. As you write, remember to:

1. Clearly state your claim. You may choose to use one of the two claims below, or you can create your own.
2. Use your strongest evidence from the Island Ecosystem Food Web or the Evidence Cards to support your claim.
3. Use the Argumentation Sentence Starters and the Word Bank below to help you explain your thinking.

Science Seminar Question: *What was the main cause of the decrease in the size of the orange-bellied parrot population?*

The population decreased because . . .

Claim 1: births decreased.

Claim 2: deaths increased.

Argumentation Sentence Starters

Describing evidence:	**Explaining how the evidence supports the claim:**
The evidence that supports my claim is . . .	If ___, then . . .
My first piece of evidence is . . .	This change caused . . .
Another piece of evidence is . . .	This is important because . . .
This evidence shows that . . .	Since, . . .
	Based on the evidence, I conclude that . . .
	This claim is stronger because . . .

Word Bank

consumer population	indirect effect	ecosystem	population
resource population	energy storage molecule	competition	reproduction

Name: _____ Date: _____

Homework: Writing a Scientific Argument (continued)

Name: _____ Date: _____

Homework: Writing a Scientific Argument (continued)

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

1. I understand that samples that represent as much of the whole population as possible provide stronger evidence. (check one)

   ☐ yes

   ☐ not yet

2. What are the most important things you have learned in this unit about how population sizes change in an ecosystem?

_____

_____

_____

_____

_____

_____

3. What questions do you still have?

_____

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Populations and Resources Glossary

change: when something becomes different over time

cambio: cuando algo se vuelve diferente con el tiempo

competition: when two or more populations use the same resource, such as the same food source

competencia: cuando dos o más poblaciones usan el mismo recurso, por ejemplo, la misma fuente de alimento

consumer population: a population that eats organisms from another population

población de consumidores: una población que come organismos de otra población

ecologist: a scientist who studies the interactions of organisms with each other and their environment

ecologista: un/a científico/a que estudia las interacciones de los organismos entre sí y con su ambiente

ecosystem: all the living and nonliving things interacting in a particular area

ecosistema: todos los seres vivientes y no vivientes que interactúan en un área específica

energy: the ability to make things move or change

energía: la capacidad de hacer que las cosas se muevan o cambien

energy storage molecule: a molecule that organisms can use to release the energy they need to survive

molécula de almacenamiento de energía: una molécula que los organismos pueden usar para liberar la energía que necesitan para sobrevivir

food web: a model that shows what eats what in an ecosystem

red alimentaria: un modelo que muestra qué come qué en un ecosistema

glucose: a molecule that organisms can use to release energy, and that is made of carbon, hydrogen, and oxygen atoms

glucosa: una molécula que los organismos pueden usar para liberar energía y que está hecha de átomos de carbono, hidrógeno y oxígeno

indirect effect: the result of one cause leading to an effect that causes one or more other effects

efecto indirecto: el resultado de una causa que provoca un efecto que provoca uno o más otros efectos

molecule: a group of atoms joined together in a particular way

molécula: un grupo de átomos unidos de una manera particular

organisms: living things, such as plants, animals, and bacteria
organismos: seres vivientes, como plantas, animales y bacterias

population: a group of the same type of organism living in the same area
población: un grupo del mismo tipo de organismo que vive en la misma área

reproduction: the process of creating offspring
reproducción: el proceso de generar descendencia

resource population: a population that is eaten by organisms from another population
población recurso: una población de la cual comen los organismos de otra población

sample: a small part that is meant to show what the whole is like
muestra: una pequeña parte que sirve para mostrar cómo es el todo

stability: when something stays mostly the same over time
estabilidad: cuando algo permanece más o menos igual a lo largo del tiempo

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Populations and Resources:

Too Many Moon Jellies

Article Compilation

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The Arctic Ocean may be very cold, but it's filled with lots of different organisms.

The Arctic Ecosystem

Chapter 1: Life in the Arctic

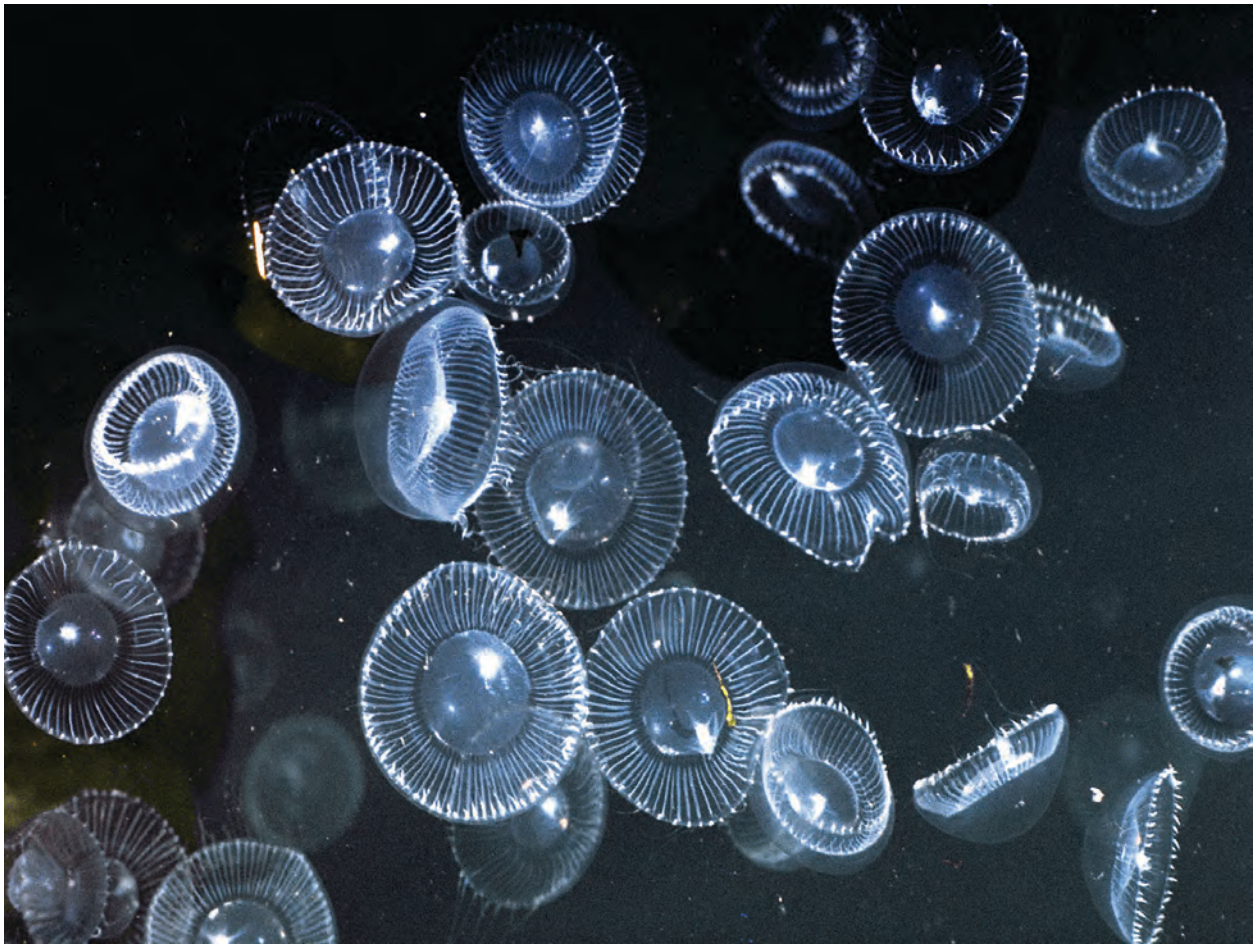
At first glance, the Arctic Ocean might not look like a great place to live. After all, it's cold there! However, despite its year-round cold climate, the Arctic is full of life. The chilly Arctic waters are home to many different populations of organisms, from tiny algae to giant whales. To learn more about the populations that can make up an Arctic ecosystem like the Gulf of Alaska, read one or more of the chapters that follow.

Chapter 2: Moon Jellies

Moon jellies got their name because of their pale, round bodies, which look like the full moon. Unlike many types of jellies, moon jellies do not have long tentacles for catching food. Instead, they trap zooplankton (ZOH-plank-tun)—tiny animals floating in the water—on the sticky undersides of their bell-shaped bodies. These jellies do sting the zooplankton they catch, but they need only a mild sting because the zooplankton are so small. The sting of a moon jelly is harmless to humans.

Moon jellies can move themselves through the water by squeezing their bodies in and out, but they are not strong swimmers. Most of the time, they let water currents move them from place to place. These jellies are seldom seen alone: they usually appear in huge groups of hundreds or even millions of jellies. Gathering in groups may provide some protection from predators such as sea turtles.

Another reason that moon jellies gather in large groups is their method of reproduction. Jellies never actually pair up and mate—instead, males send out sperm, letting water currents carry the sperm to nearby females. The females produce dozens of eggs, protecting the eggs with their bodies as they develop.



Moon jellies can appear in groups of hundreds or even millions at once!

Chapter 3: Walleye Pollock

People eat a lot of walleye pollock. If you have ever eaten a fish stick or a fish sandwich from a fast food place, you've probably eaten walleye pollock yourself. This type of fish is valuable to humans as a commercial fishing catch. Scientists and fishermen keep careful track of the pollock population to make sure it doesn't get too small.

Walleye pollock are silvery in color, with speckles that help them blend in with the sandy bottom of the ocean. They grow to about half a meter (one to two feet) in length and weigh up to 1 kilogram (2 pounds). Part of the pollock diet is made up of zooplankton (ZOH-plank-tun)—tiny animals floating in the water. For protection from predators, large numbers of pollock swim together in dense schools. Predators that eat pollock include larger fish and sea lions.

Walleye pollock gather in large groups to reproduce, which makes them more likely to reproduce successfully.

Pollock gather in very large groups for the purpose of reproduction. Each female sends thousands of eggs out into the water, and the males send out lots of sperm at the same time. Carried by the water, the sperm and eggs meet and the eggs are fertilized. The larger the female, the more eggs she will produce—up to one million!

Walleye pollock is a popular fish for humans to eat.

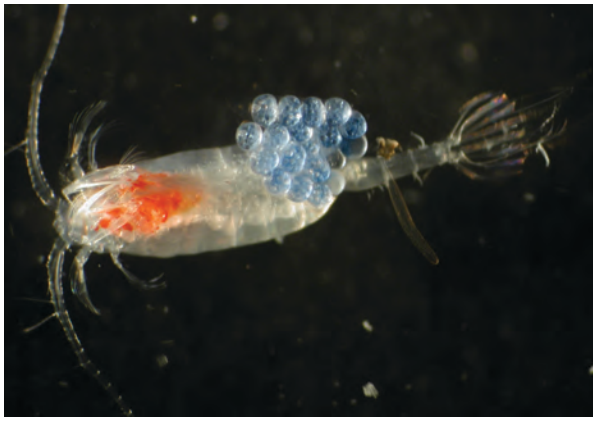
Any animal that is tiny and drifts through the water is considered zooplankton.

Chapter 4: Zooplankton

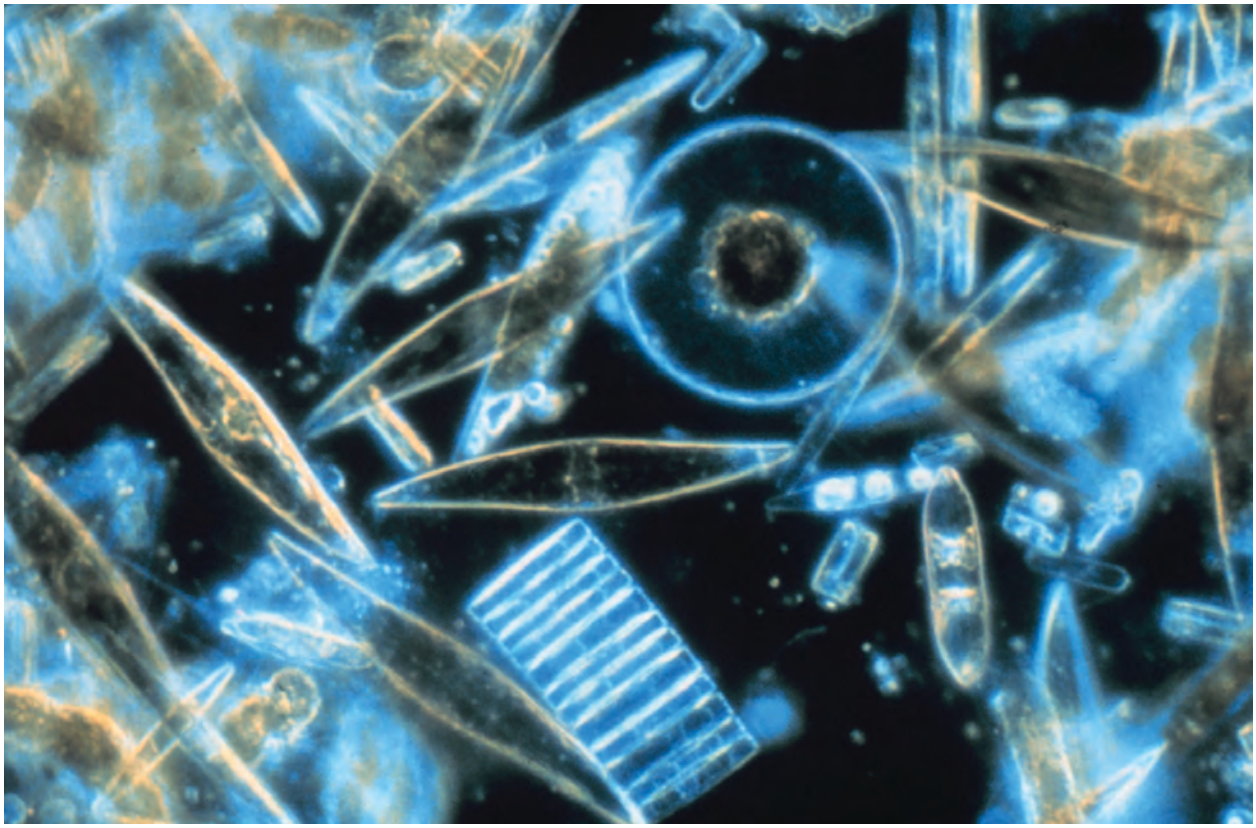
Zooplankton (ZOH-plank-tun) are tiny animals that drift through the water, moved from place to place by currents. There are many different kinds of zooplankton, and most are too small to be seen. Some zooplankton eventually grow and change into fish, crabs, sea stars, and other larger animals. However, many zooplankton remain tiny for their whole lives—for example, copepods. These tiny animals have hard outer coverings, legs with joints, and long antennae.

Different types of zooplankton have different ways to keep themselves from sinking to the bottom, such as gas-filled floats in their bodies and flat body shapes that act like tiny parachutes. Many zooplankton are clear, so that they are harder for fish and other predators to see. Zooplankton eat tiny algae that drift through the water. Another source of food for zooplankton is other zooplankton.

Because there are so many different types of zooplankton, they have many different methods of reproduction. Some mate and lay eggs, while others simply divide themselves in half.



Some types of zooplankton lay eggs, like this copepod. In this photo, its eggs are light blue.



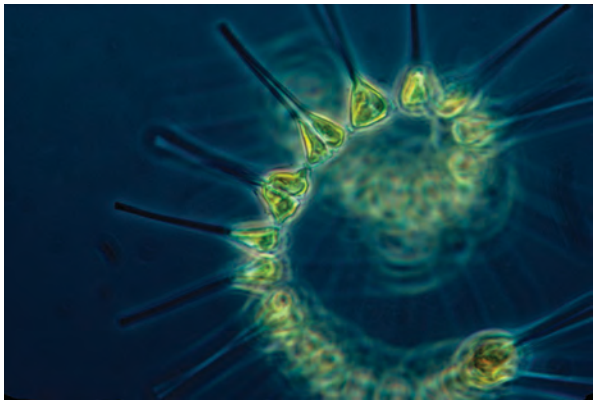
All of these shapes are different types of algae!

Chapter 5: Algae

Algae (AL-gee) are plant-like organisms. Some types of algae are huge, such as giant kelp. However, some of the most important types of algae are tiny—many are so small they can only be seen through a microscope. Tiny algae drift near the surface of the water, where there is plenty of sunlight. Like plants, algae produce their own food through the process of photosynthesis—using energy from sunlight, algae make glucose out of carbon dioxide and water. As they do this, they also produce oxygen. In fact, about half the oxygen we breathe is produced by algae in the ocean.

There are thousands of types of algae, many of them very different from one another. Some have beautiful clear glass-like shells; others have whip-like tails that they use to swim through the water. Some algae even glow in the dark, producing a blue-green light.

Different types of algae have different methods of reproduction, in some cases simply dividing themselves in half.



Some types of algae, like this one, glow in the dark.

Chapter 6: Leatherback Sea Turtles

Leatherback sea turtles are the largest sea turtles on Earth. They have tough, leathery skin on their backs instead of shells.

The leatherback sea turtle is larger than any other kind of sea turtle on Earth, growing up to 2 meters (6.5 feet) long. It is different from other sea turtles in another way as well: instead of a hard outer shell, the leatherback has tough, leathery skin covering its back.

Leatherback sea turtles specialize in eating jellies. Instead of teeth or hard jaws, they have backward-pointing spines in their throats to help trap the jellies they swallow. Scientists have estimated that one adult leatherback eats more than 2,000 pounds of jellies every year!

Leatherback sea turtles have spines in their mouths to keep the jellyfish they swallow from escaping.

Despite their soft bodies, adult leatherbacks are so big and fast that they have few predators. Only large sharks and orca whales attack and eat adult leatherbacks at sea. However, leatherback eggs and newly-hatched leatherbacks are often eaten by birds and other small predators. Humans also collect leatherback eggs to eat, although egg collecting is against the law in many places.

Leatherback sea turtles lay large batches of eggs in the sand.

Leatherbacks swim far and wide across the ocean, ranging farther north than any other sea turtles. To reproduce, leatherbacks swim hundreds of miles to gather near tropical beaches. After mating, a female drags herself up onto the beach, digs a hole in the sand, and lays about 100 eggs inside. Then she buries the eggs and returns to the water. When the tiny young turtles hatch a few weeks later, they dig their way out and race to the water, already completely independent.

Orcas are also known as "killer whales" because they are fierce predators.

Chapter 7: Orca Whales

Orca whales are also known as "killer whales" because they are such fierce predators. These toothed whales hunt in packs like wolves, but they are much bigger than wolves! Orcas can grow more than 7.5 meters (25 feet) long and weigh more than 5,900 kilograms (13,000 pounds). An orca has a tall fin sticking up from its back, as high as 2 m (6 ft) in some cases.

Most orcas live in family groups called pods. A pod of orca whales is usually made up of a mother and her offspring, both male and female. Pods of orca whales work together to hunt, chasing their prey from all sides. Some pods of orcas specialize in hunting large fish, but other pods specialize in hunting seals, whales, and other large marine animals, including sea turtles. Humans are the only animals that hunt and kill orcas.

Orcas live a long time—possibly more than 80 years in some cases—and they don't reproduce very often. Females give birth to one calf (baby whale) at a time, waiting several years between births. Orcas give birth in the water, and their calves are able to swim immediately. Like other whales (and humans), orcas are mammals, and the calves drink milk from their mothers.

Orcas hunt in packs, working together to hunt large marine animals.

Chapter 8: Green Sea Urchins

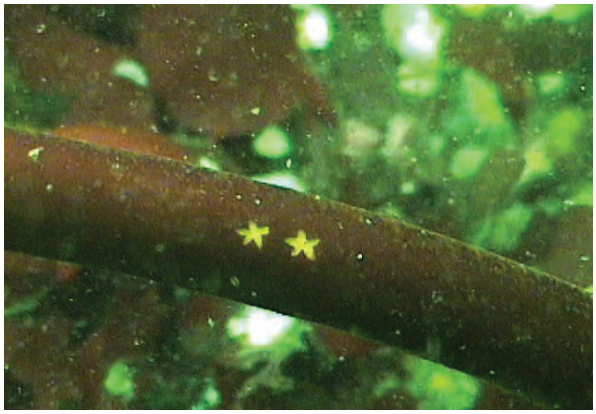
Green sea urchins are small, round animals covered with spines and tube feet that stick out in all directions. The tube feet have suction cups on the ends and are good for clinging to rocks and seaweed. Urchins also use their feet to sense the world around them—they have no eyes, but they can sense light and dark with their feet!

Green sea urchins mainly eat a type of seaweed called kelp. A sea urchin has five teeth in the center of its underside, and it leaves star-shaped marks when it takes a bite out of a piece of kelp. Gulls, crabs, and several other predators eat green sea urchins, despite their sharp spines. In addition, people catch green sea urchins to eat. Eating sea urchins is especially popular in Japan.

Male and female sea urchins don't get together for reproduction. Instead, all the green sea urchins in an area release eggs and sperm into the water at once. They rely on water currents to bring their sperm and eggs together and produce young. Young sea urchins can swim, and they drift with the tiny plankton until they grow into adult sea urchins.

Green sea urchins are covered with sharp spines.

Green sea urchins have star-shaped mouths.



A sea urchin left these two star-shaped bite marks on a thick strand of kelp it was eating.

Chapter 9: Kelp

There are many types of kelp, including giant kelp—the largest algae on Earth. Giant kelp can grow up to 45 meters (150 feet) long!

Kelp is a kind of algae (AL-gee). Like plants, kelp and other algae produce their own food through the process of photosynthesis. Using energy from sunlight, kelp makes glucose out of carbon dioxide and water. As it does this, it also produces oxygen.

Clinging to a rock with a part called a holdfast, kelp grows up toward the sunshine at the water's surface. Pockets filled with air keep the kelp floating upward. Kelp grows very quickly—up to two feet per day—and it can form huge underwater forests where ocean animals hide. Many of these animals eat kelp, including sea urchins, snails, and some fish. In addition, many humans gather and eat kelp.

To reproduce, kelp sends out male and female spores. Carried by water currents, these spores meet to form new kelp organisms that cling to rocks and begin growing upward.

Giant kelp can form large underwater forests.

Little floating bulbs help kelp leaves float toward the surface of the water, where they can get sunlight for photosynthesis.

Wetlands filter water because the plants that grow in wetlands act like a strainer.

How Ecosystems Clean Earth's Water

Ecosystems are finely tuned systems in which organisms and the nonliving things around them interact. They can also be useful to humans: ecosystems provide food for us to eat, help keep our air and water clean, move nutrients and other things organisms need to places where they're needed, and more. These processes happen most efficiently when ecosystems are healthy and balanced. One sign of a healthy ecosystem is its biodiversity. Biodiversity is a word that ecologists use to describe how much variety there is in an ecosystem: in other words, how many different species are part of the ecosystem. Biodiversity is important because the more diversity there is in an ecosystem, the stronger the system is, and the less likely it is to break down.

Healthy ecosystems provide many services to humans, including water filtering—cleaning water by removing substances that may be harmful. Read on to learn about some ecosystems that help filter water.

Wetlands are ecosystems that exist in some areas where where land and water meet. These ecosystems are often grassy or covered with other low plants, and can be underwater all or part of the time. Wetlands filter water by acting like a strainer: as water flows through the wetlands, substances in the water get stuck on the plants and absorbed by their roots. If the substances are harmful to people, the plants can sometimes turn them into less harmful or totally harmless substances. By slowing down the flow of water, wetlands can also absorb some of these substances into the soil, where bacteria can change the harmful substances into other, less harmful substances.

The ocean is Earth's largest ecosystem, and it filters a lot of water! Ocean water is filtered in many ways, including by oysters and other animals that live in the ocean. Oysters suck water in and use the microscopic organisms they find there for food. Then they spit clean water back out. One oyster can filter about 180 liters (47 gallons) of ocean water every day! In shallow water, this filtering helps grasses and plants growing nearby on the ocean floor. The water cleaned by the oysters is clearer and lets more sunlight get to the plants, allowing them to perform more photosynthesis.

Water in the ocean is filtered through animals that live there.

The trees in forest ecosystems help filter water through their roots.

Not all filtering of water takes place in underwater ecosystems—water filtering can also take place on land! Forests filter water whenever rain falls: trees and other plants shield the ground from the force of falling raindrops and keep soil in place, so both the water and the soil are less likely to wash away. The layer of dead leaves on top of the soil helps filter the water as it soaks into the ground. Tree roots also provide space in the soil for water to soak in, allowing it to be cleaned by bacteria as it passes through the soil. In the forest, water can either stay in the ground as groundwater or find its way into rivers and streams—and it's well filtered by the time it gets to them.

Filtering water is just one of many services provided by ecosystems. Since they provide things we need, it's a good idea for humans to make sure the ecosystems around us are healthy, with plenty of biodiversity.

Male elk fight one another for the chance to reproduce with female elk. Fighting takes lots of energy.

Reproduction and Energy

Chapter 1
Reproduction Requires Energy

Reproduction is a lot of work. Some organisms travel thousands of miles to find a mate, the right place to lay eggs, or the right spot to give birth. They might work hard to attract mates using songs, movements, and other displays. Other organisms might fight fierce battles to win their mates and the chance to reproduce. Often this is just the beginning of the job: Many organisms work hard to protect their eggs, find food for their young, and do everything else that may be required for successful reproduction.

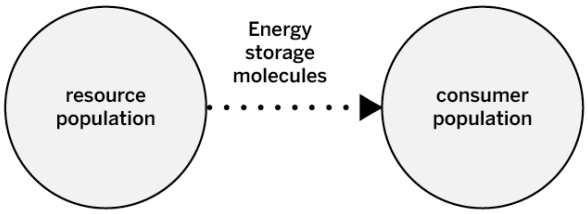
No matter what an organism goes through to reproduce, the process requires lots of energy. In fact, for many organisms, reproduction requires more energy than anything else in their lives. Some don't even survive—reproduction requires so much energy that these organisms reproduce and then die. Whether reproduction is relatively easy or extremely difficult, every organism needs energy in order to reproduce. Without energy, there can be no reproduction.

Organisms get the energy they need from energy storage molecules such as glucose, starch, and fat. These molecules store energy that can be released in the bodies of organisms when they need it. Plants and other producers

can make their own energy storage molecules through photosynthesis, but other organisms can't do that—to get energy storage molecules, they need to eat food.

What is food, really? Food is the body parts of organisms that contain molecules, such as energy storage molecules, that other organisms need. "Consumer population" is the term ecologists use to talk about a population that eats other organisms for food. Ecologists call a population that is eaten for food a "resource population." Every consumer population gets its energy storage molecules from a resource population.

To learn about some specific populations and how they get the enormous number of energy storage molecules they need to release energy for reproduction, read one or more of the chapters that follow.



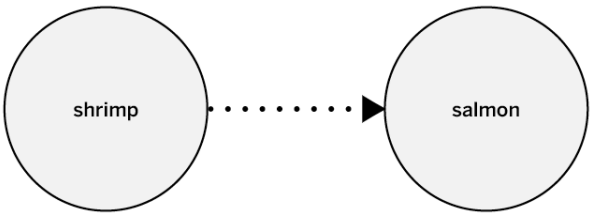
Consumer populations eat resource populations to get the energy they need to reproduce.

To reproduce, these salmon are swimming upstream from the ocean, through rivers, back to the stream where they first hatched.

Chapter 2
Sockeye Salmon: Dying to Reproduce

The sockeye salmon of the Snake River in Idaho literally work themselves to death in order to reproduce! For these salmon, reproduction requires so much energy that they die in the process. However, if they are lucky, they will each leave thousands of offspring behind.

These Sockeye salmon begin their lives in the fast-flowing Snake River in the mountains of Idaho. While they are young, the salmon follow the Snake and Columbia rivers all the way to the Pacific Ocean, where they spend most of their lives. In the ocean, they eat shrimp, squid, eels, and other fish to get energy storage molecules. They eat as much of these resource populations as they can—they need to eat enough to fuel a journey back to the area of the Snake River where they hatched. This is where they will reproduce.



Shrimp are one resource population for sockeye salmon. Sockeye salmon get some of their energy storage molecules by eating shrimp.

Returning to the place where they were hatched is an energy-intensive journey of hundreds of miles! Using scent to find their way, the salmon follow the Columbia River and then the Snake River back to the place where they hatched. They swim up the river, struggling against the current. In some places, waterfalls block their way. The salmon jump as high as 3.5 meters (12 feet) in the air to get up and over these waterfalls, using huge amounts of energy. Finally, they find the right place to reproduce.

Even after their long, hard journey, the work of reproduction is not over for sockeye salmon—they still have to battle one another for the chance to reproduce. Females fight each other to get the best nesting spots and males fight each other for access to females. All that fighting uses even more energy.

To reach the place where they will reproduce, salmon often have to jump high in the air to get over waterfalls that block their way.

These little orange balls are salmon eggs at the bottom of a stream.

The female salmon dig nests in the gravel at the bottom of the stream to lay their eggs in. Each female makes four or five nests and lays as many as 1,200 eggs in each one. Laying so many eggs also requires lots of energy. After the female lays her eggs, the male places his sperm over them, and the female buries the nest with more gravel. Once they have mated, the exhausted salmon guard the eggs for as long as they can before dying there in the stream.

During the entire process of reproduction, salmon need to release energy from energy storage molecules. They release energy from fat that they stored in their bodies during their time eating in the ocean.

Reproducing in harsh conditions as emperor penguins do requires large amounts of energy.

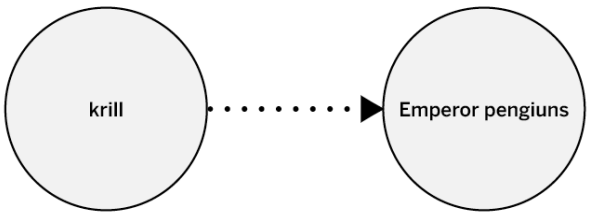
Chapter 3
Emperor Penguins: Reproducing in the Coldest Place on Earth

For the emperor penguin population near Ragnhild, Antarctica, reproduction requires an enormous amount of energy. They reproduce in one of the harshest environments on Earth: the thick shelf of ice that forms around Antarctica each winter. Just surviving in this environment takes lots of energy, and reproducing there takes even more. Temperatures often drop below –34 degrees Celsius (–30 degrees Fahrenheit), with strong winds and violent storms. In these harsh conditions, emperor penguins spend months working hard to raise just one chick at a time.

For this population of emperor penguins, the work of reproduction begins with a walk across miles of ice to reach their breeding grounds. Once there, the penguins pair up and mate, and each female lays a single egg on the ice. The male quickly and carefully rolls the egg onto the top of his feet, where he will keep it warm under a flap of skin. The male must keep the egg balanced on his feet until it hatches more than 2 months later. Through the freezing-cold Antarctic winter, male emperor penguins act like living heaters, using energy to warm the eggs with their body heat.

To keep their eggs and chicks off the cold ice, emperor penguins carry them on top of their feet.

Meanwhile, the female penguins must walk all the way back to the ocean to find food for themselves and for the chicks that will soon hatch. By this time in the winter, more ice has frozen and widened the ice shelf around Antarctica. Female penguins may have to walk across more than 50 miles of ice to reach the water! Walking so far in the freezing cold requires lots of energy. In the ocean, the female penguins catch and eat squid, small fish, and tiny ocean creatures called krill. These resource populations provide the energy storage molecules they and their offspring need to survive.



Antarctic krill are one resource population for emperor penguins. Emperor penguins get some of their energy storage molecules by eating krill.

Once full, the female penguins walk back to the breeding grounds, where their partners are warming their eggs. The chicks there have finally hatched and are ready to eat the food their mothers bring. The male and female penguins now take turns: one holds the chick on its feet to keep it warm while the other walks to the ocean to hunt. In the ocean, the penguins catch as much food as they possibly can. They need to catch enough for their own energy needs as well as extra food to feed their hungry chicks.

The penguin pair shares the work of raising the chick for several more weeks, until the chick can survive on its own. During this time, the penguins' bodies release energy from energy storage molecules—all the fat they built up while they were feeding in the ocean. Reproduction is hard work for the emperor penguins near Ragnhild, requiring more energy than any other part of their lives.

Emperor penguins have to travel miles across the ice to find food for themselves and their chicks.

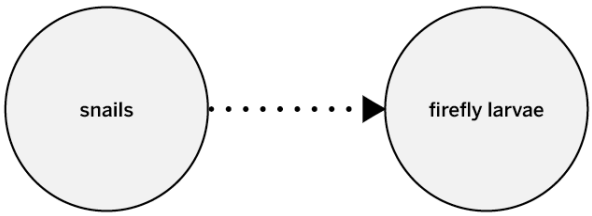
Fireflies are insects that light up to attract a mate.

Chapter 4
Fireflies: Reproducing Brilliantly

It's easy to see that fireflies use energy for reproduction: they actually light up to attract a mate! The glow of fireflies comes from a chemical reaction that happens inside their bodies. It takes energy for fireflies to turn the glow on and off. There are many types of fireflies living in colonies all over the world. One well-known population is a population of Blue Ghost fireflies living in Dupont State Forest in North Carolina.

Fireflies turn their glow on and off in patterns that other fireflies recognize. They find each other using light signals. Females usually sit on leaves and flash, while males flash as they fly around searching for females. Male Blue Ghost fireflies are known for using long, slow flashes as they fly. Of course, flying also requires energy. Male and female fireflies flash signals to each other as the male gets closer and closer to the female. Eventually, they mate. After mating, each female firefly lays about 100 eggs in the soil. It takes energy to produce so many eggs!

The firefly eggs hatch into wingless larvae that live in the soil. Fireflies spend most of their lives as larvae, eating insects, snails and slugs. These resource populations provide the firefly larvae with lots of energy storage molecules, which they store in their bodies in the form of fat. When they are ready, the larvae build mud chambers for themselves and hole up inside. In the chambers, the larvae transform into adults with wings, ready to fly away and mate.



Snails are one resource population for fireflies. While the fireflies are still wingless larvae, they eat snails and get some of their energy storage molecules that way.

The energy storage molecules that the fireflies store up as larvae come in handy when it's time for them to reproduce: after eating for most of their lives, the fireflies' bodies can release energy from the energy storage molecules they built up in their bodies during that time. In fact, adult Blue Ghost fireflies do nothing but mate and lay eggs, so all of their energy goes into reproduction.

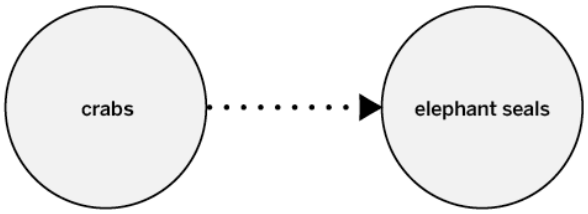
Blue Ghost firefly larvae do nothing but eat for most of their lives. When it's time to lay eggs as adult fireflies, they have plenty of fat they can use for energy.

Male elephant seals fight each other to control the best areas on the beach. The male who controls the beach can mate with the female seals who spend time there.

Chapter 5
Elephant Seals: Fighting to Reproduce

For male elephant seals, reproduction is an exhausting battle. These enormous animals fight over mating territories in long, noisy, bloody clashes. For male elephant seals, just winning the chance to reproduce takes enormous amounts of energy.

Elephant seals spend about ten months of the year in the open ocean, hunting and eating so they can store up enough energy storage molecules to keep them going during reproduction. Elephant seals eat many different types of fish, including rays and small sharks, as well as octopuses and crabs. These resource populations provide the energy storage molecules elephant seals need to reproduce.



Crabs are one resource population for elephant seals. Elephant seals get some of their energy storage molecules by eating crabs.

Even though elephant seals spend most of their time in the water, they reproduce on beaches. One population of elephant seals does all its reproduction work on a beach called Piedras Blancas, on the central coast of California. The males arrive at Piedras Blancas beach first and begin staking out territories—areas of the beach that belong to them. The very biggest

males, which may be 7 meters (20 feet) long and weigh more than 3,600 kg (8,000 pounds), take the best spots on the beach. Holding beach territory is important, because when females arrive, they will choose an area of the beach and eventually mate with the male who controls that territory. To keep his territory, a male has to fight off any other males who challenge him. The fights begin with threats: the males rear up and make roaring noises with their long, trunk-like snouts. If neither male backs down, they clash together, hitting each other on the neck and chest with sharp teeth. Males rarely die in these battles, but they often end up injured and bloody—and each fight requires lots of energy.

In order to mate with the females on his stretch of beach, a male has to defend his territory by winning fight after fight over the course of several months. All that effort takes energy—and the seal's body gets its energy from the energy storage molecules it stored up during its time eating in the ocean. These males may win the chance to reproduce with a dozen or more females, but there's a high energy cost for it. During the months a male spends mating and defending his beach, he may lose about one third of his body weight!

Reproduction requires energy for female elephant seals, too. The females produce rich milk for their babies. In order to produce plenty of milk, female elephant seals have to catch lots of fish and crabs to eat. Hunting and nursing a baby seal take lots of energy!

Jelly population explosions can happen all over the world. This photo shows lots of jellies in a shallow part of the ocean near Denmark.

Jelly Population Explosion: How Competition Can Affect Population Size

Jelly Population Explosions

In some ecosystems, the population of jellies has increased so much over a short period of time that people call it a population explosion. Ecologists, fishermen, and many other people around the world are concerned about jelly population explosions. In some places where jelly populations are getting bigger, the increase in population can affect human activities and the ecosystems we depend on: masses of jellies damage fishing nets, clog water pipes for power plants, and drive swimmers away from beaches. Scientists around the world are hard at work trying to understand why these population increases occur and how we can avoid causing them.

Moon jellies are one of the most common types of jelly living in the ecosystems of Northern and Southern Benguela.

Two Jelly Populations

To understand what can cause jelly populations to increase, a team of ecologists studied two ocean ecosystems near the southwestern coast of Africa—Northern Benguela and Southern Benguela. Northern Benguela is off the coast of Namibia, while Southern Benguela is off the coast of South Africa. A strong ocean current divides Northern Benguela from Southern Benguela. These two ecosystems are very similar: both include populations of jellies, zooplankton, and fish such as sardines and anchovies, as well as African penguins and Cape fur seals. Humans have fished in both of these ecosystems for a long time.

The team of ecologists studying the two jelly populations analyzed data that had been collected over the last 50 years by other scientists and by fishermen. Based on the samples of jellies counted in each region, they determined that the jelly population increased in Northern Benguela, but not in Southern Benguela. Today, the population of jellies in Northern Benguela is much larger than has ever been recorded there before. Yet in Southern Benguela, the jelly population has remained relatively stable.

Northern Benguela and Southern Benguela are two ocean ecosystems off the coast of Africa.

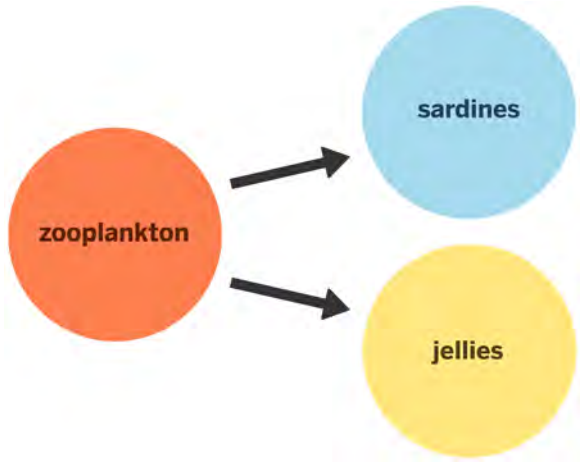
Fishing with a net like this red one can catch thousands of sardines and anchovies at a time. People catch these fish for food.

In comparing these two ocean ecosystems, the ecologists found an important difference: laws prevented people from catching too many fish in Southern Benguela. In the 1950s, commercial fisheries began to catch large numbers of sardines and anchovies from both Northern and Southern Benguela. However, starting in the 1970s, people passed laws that limited the number of sardines and other fish that could be caught each year in Southern Benguela, in an effort to protect the fish populations there. In contrast, there were no limits placed on fishing in Northern Benguela.

Without laws limiting the number of fish they could catch in Northern Benguela, people caught huge numbers of sardines and other fish there, causing the fish populations to decrease. By the early 2000s, the fish populations returned to near-normal levels in Southern Benguela, but had dropped to record low numbers in Northern Benguela.

Competition for Food

In this ecosystem, the jellies do not eat fish, and the fish do not eat jellies. So why did a decrease in the size of the fish populations in Northern Benguela affect the jelly population? Let's look at the sardine population as an example. Jellies and sardines eat the same food: zooplankton. The relationship between jellies and sardines is called competition because they are competing for the same resource population.



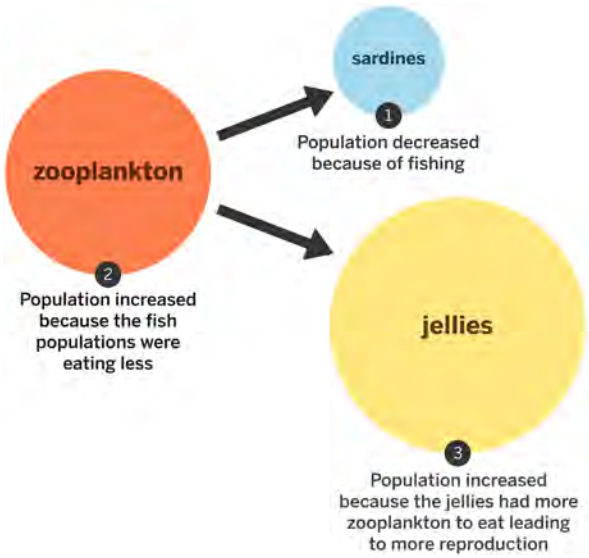
Jellies and sardines are not directly connected on the food web, but they both eat zooplankton. This relationship is called competition because both populations are competing for the same resource population.

When the sardine population decreased due to unlimited fishing in Northern Benguela, fewer sardines were around to eat zooplankton. With fewer zooplankton eaten by the sardines, the zooplankton population increased—leaving more zooplankton for the jellies to eat. Having a larger resource population made more energy storage molecules available to the jellies. This allowed them to reproduce more. More reproduction led to more births than deaths, so the jelly population increased. This is how the change in the sardine population was able to affect the jelly population, even though jellies are not directly connected to sardines on the food web. A change to the sardine population caused the zooplankton population to change, which caused the jelly population to change. This is an example of an indirect effect, the result of a chain of causes and effects, where one cause leads to an effect that then causes another effect.

In Southern Benguela, the jelly population did not increase. Because of limits on fishing, the fish population in Southern Benguela was relatively stable. This meant the fish consumed the same number of zooplankton as usual, leaving the same number of zooplankton for jellies and not causing any change to the jelly population. In a stable ecosystem, biodiversity—the number of different kinds of living things in the ecosystem—also stays the same. Biodiversity is a measurement of how healthy an ecosystem is. When an ecosystem becomes less biodiverse, it is because the ecosystem is so unstable that entire populations are dying out. In order to maintain healthy ecosystems, people need to come up with plans like Southern Benguela's fishing limits to help keep ecosystems stable and maintain their biodiversity.

Looking at lots of population data helped ecologists figure out what caused the jelly population increase in Northern Benguela. However, jelly populations are increasing in other ecosystems all over the globe. Since every ecosystem is unique, other jelly increases may have different causes.

After Overfishing in Northern Benguela



This diagram shows an indirect effect of overfishing in Northern Benguela: a jelly population increase.

This is a close-up of acacia ants crawling on the branches of a bullhorn acacia tree. The big, red objects on the right are thorns. The big thorns reminded people of the horns on a bull, so people gave the trees the name "bullhorn acacia."

The Ant and the Acacia

When we think about species in an ecosystem, we're often thinking in terms of food webs that show what eats what. In a food web, you can see relationships like predation (when one species eats another) and competition (when two species are both trying to get the same resource, such as food). In these relationships, it seems like what is good for one species is bad for the other. If a predator population increases, its prey population is likely to decrease. However, not all relationships in ecosystems are like this: in some cases, two species interact in ways that are good for both species. One example is the bullhorn acacia tree and the acacia ant.

Bullhorn acacia trees and acacia ants have a kind of relationship called mutualism that helps both species survive. All organisms need certain things to stay alive; things like food and a place to live. In some cases, organisms get what they need through mutualistic relationships with other species. Mutualism provides both species with something they need. Ecosystems are full of mutualistic relationships like the one between bullhorn acacia trees and acacia ants.

Bullhorn acacia trees are thorny trees that grow in Central America. With no damage to themselves, these trees provide everything

acacia ants need to survive: water, a complete diet, and shelter inside their big, hollow thorns—the ants can chew through a spot at the bottom of a thorn and move right in to raise their young.

At the same time, acacia ants act as bodyguards against other animals that might want to eat bullhorn acacia trees. If another animal tries to eat the tree they call home, the ants attack the animal and their bodies release a bad-smelling chemical. This relationship ensures that the ants have food and a place to live, and the acacia tree is protected from organisms that might destroy it.

Mutualism is helpful to both species—which means both species would be harmed if the population of one species decreased. Say the bullhorn acacia trees were wiped out by a tree disease. In that case, the acacia ants would have to find other sources of food and shelter, and there's no guarantee they'd find either one. The acacia ant population would decrease.

Just as acacia ants would be harmed if bullhorn acacia trees disappeared, the trees would be harmed if the ants disappeared. In that case, the acacias wouldn't be able to rely on the protection the ants provide. Animals might eat most of the leaves of the acacia trees, making it harder for the acacias to make food for themselves through photosynthesis. Without enough food, the acacias would have trouble reproducing and the population of acacia trees would shrink. Acacia ants need bullhorn acacia trees, and bullhorn acacia trees need acacia ants.

Populations and Resources:
Too Many Moon Jellies

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

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Published and Distributed by Amplify.
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ISBN 978-1-947002-96-8