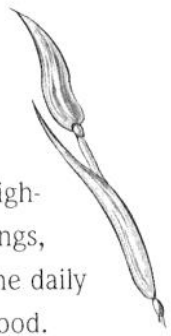
SCIENCE SEEKERS
Endangered Species

How do living things interact?

The Kelp Forest Ecosystem

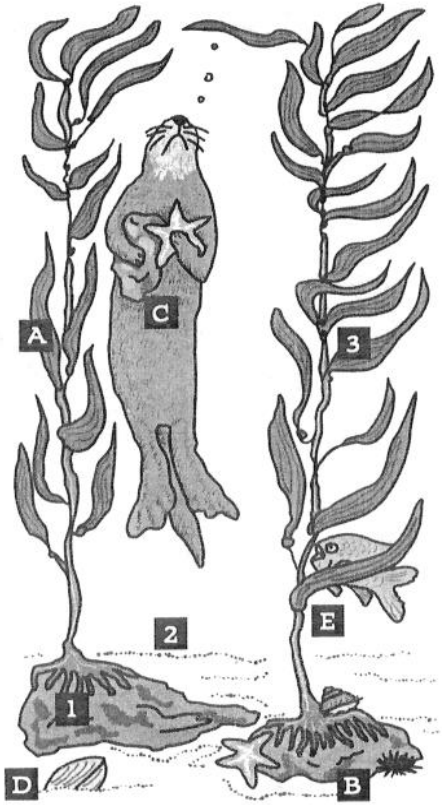
Where on Earth would you find a forest that can grow 18 inches taller every day? A forest like this exists near the city of Ocean Edge. But it's not on land, and it doesn't have any trees. This forest grows in cold ocean water, and it's made of monster-size seaweed called kelp.

Giant kelp can grow to be over 100 feet tall. Kelp plants anchor themselves to the rocky ocean floor and stretch up to the surface to absorb sunlight. Like a forest on land, the underwater kelp forest is home to hundreds of living things that find food and protection there. Snails and sea urchins snack on kelp leaves. Small fish hide from bigger fish among the stems. Sea otters roll themselves up in the tops of the kelp plants so they can sleep in the water without drifting away.

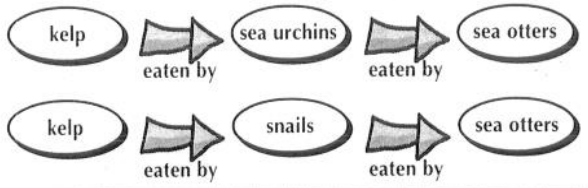


The kelp forest is an example of an **ecosystem** — a community of living things interacting with each other and with the physical environment in a certain area. An ecosystem is like a neighborhood — not just the streets, buildings, plants, animals, and people, but also the daily activity that happens in the neighborhood.

A city can contain many neighborhoods where different groups of people live and where different activities take place. Similarly, a large ecosystem like the ocean can contain many smaller ecosystems within it. Kelp forests, coral reefs, and tidepools are all small ecosystems that are part of the larger ocean ecosystem.



Kelp Forest Food Chains



The kelp forest habitat

A habitat is a specific place within an ecosystem where a living thing can find food, shelter, and other things it needs to survive. Giant kelp plants can only grow in a certain part of the ocean ecosystem. The habitat in which giant kelp grow best includes:

1. Rocks that provide places for kelp plants to anchor.
2. Cold ocean water (less than 70° F) that is clear enough for sunlight to reach plants.
3. Gentle currents that bring nutrients to the kelp plants, but aren't strong enough to break the plants loose from the bottom.

The kelp forest community

All the living things in an ecosystem make up a community. The kelp forest community includes giant kelp plants, sea urchins, sea otters, starfish, clams, octopuses, fish, seals, and hundreds of other plants and animals.

The kelp forest ecosystem

The interactions of a community of living things with each other and with the physical place in which they live makes up an ecosystem. Some of the interactions that take place in the kelp forest ecosystem are:

A. Giant kelp plants anchor to rocks and grow up to the ocean surface, providing food and shelter for other living things.

B. Sea urchins eat kelp plants.

C. Sea otters eat sea urchins, clams, starfish, octopuses, and many other creatures.

D. Clams hide in the sand.

E. Fish come to the kelp forest to hunt for food, and some lay eggs there.

SCIENCE SEEKERS
Endangered Species

How do living things interact?

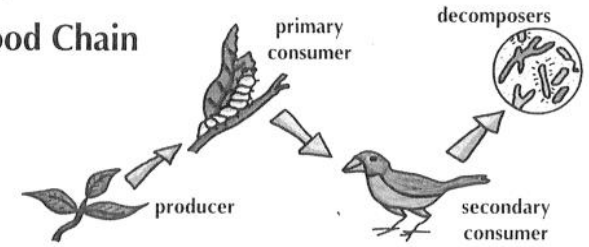
Investigation 1
Student B

Food Webs

When you ate breakfast this morning you were actually eating little pieces of energy from the sun. How? Starting with the sun, energy is passed from one living thing to another in a **food chain**.

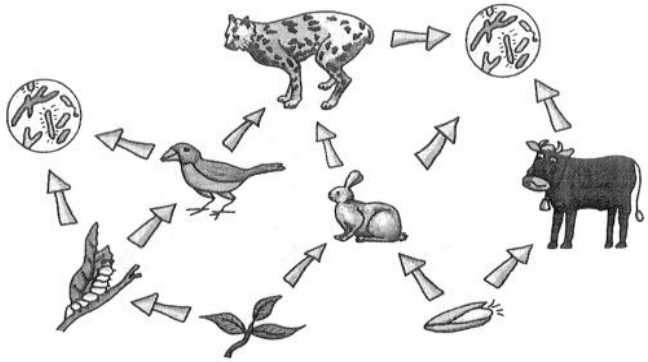
All food chains begin with plants. Since plants can use sunlight and nutrients from soil and water to produce their own food, they are called **producers**.

Food Chain



Primary consumers are the next link in a food chain. Primary consumers eat plants and use the food energy in the plants to fuel their bodies. Primary consumers are eaten by **secondary consumers**, (animals that eat meat). Sometimes, a secondary consumer will be eaten by a third, or **tertiary consumer** in the food chain. The final link in a food chain are **decomposers** like bacteria and worms. These tiny creatures break down the bodies

Food Web



of dead plants and animals, creating the nutrients in soil and water that start the cycle all over again by helping to feed plants. In an ecosystem like a pond or the ocean, many food chains connect and overlap, forming a **food web** through which energy flows through the ecosystem.

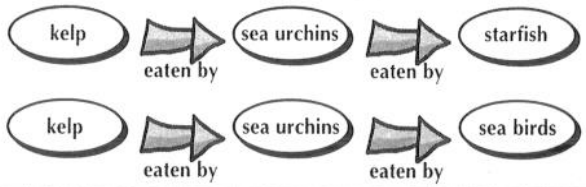
The sea otters that live off the coast of Ocean Edge live in an underwater forest made of giant seaweed called kelp. The sea otters eat, sleep, and hang out in the kelp forest, just like you do in your house. But you don't have to share your house with as many other living things as a sea otter does. There are hundreds of living things in the kelp forest.

In the kelp forest food web, the producers are kelp plants and microscopic plants that float around in ocean water called **phytoplankton** (FI-toe-plank-tun). Sea urchins, snails, and abalone (AB-a-loh-nee) are all primary consumers that eat kelp. Mussels, shrimp, and many other primary consumers eat phytoplankton. Secondary consumers like sea otters, seals, fish, and birds hunt in the kelp forest. Sea otters hunt and eat over 40 different types of food there, including octopuses, abalones, sea urchins, snails, crabs, clams, and mussels. Humans are also a consumer in the kelp forest food web. If you've ever bought ice cream at the store, you've probably eaten kelp!

phytoplankton

People harvest kelp plants and use substances in the kelp to make ice cream creamier. We also eat a lot of the same things sea otters eat, including clams, snails, lobsters, crabs, and sea urchins.

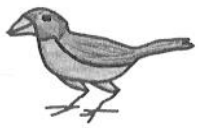
Kelp Forest Food Chains



How do living things interact?

Keystone Species

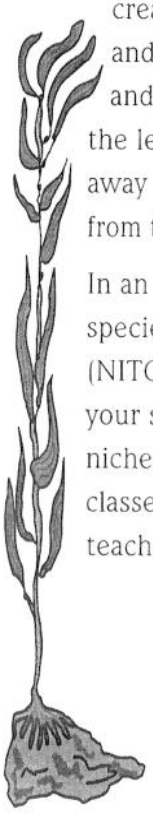
From the yellow-bellied sapsucker to the Comoro flap-nosed chameleon, we share the planet with a lot of strange creatures. So far, biologists know of about 2 million different kinds of living things in the world, and there are millions more out there that humans don't know about yet. To keep track of all of us, biologists divide living things into groups. Each different kind of plant or animal belongs to its own group or **species** (SPEE-shees). Often, you can tell different species apart just by looking at them. Human beings all belong to one species. Even though humans all look a little bit different from each other, we share some basic characteristics that put us all in the same group and make us different from other living things.



No one would look at a bird and think it belonged to the same species as human beings.

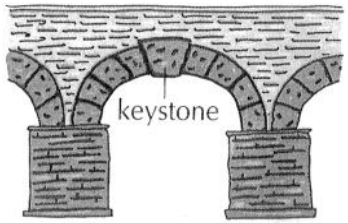
But sometimes, organisms that belong to different species can look very similar. For example, a southern sea otter looks a lot like a river otter, but each belongs to a different species. River otters must drink and wash their fur with fresh water, while sea otters spend all their time in the ocean and drink salt water. Because they belong to different species, a southern sea otter couldn't mate with a river otter, just like a cow couldn't mate with a horse.

The southern sea otters that live off the coast of Ocean Edge share their space with many other species of living creatures. Giant seaweed called kelp stretches from the ocean floor to the surface, creating an underwater forest that provides food and shelter for many forms of life. Fish swim in and out of the kelp stems, and snails crawl along the leaves. Sea urchins, starfish, and crabs hide away under rocks. Sea otters and birds dive down from the surface looking for food in the forest below.

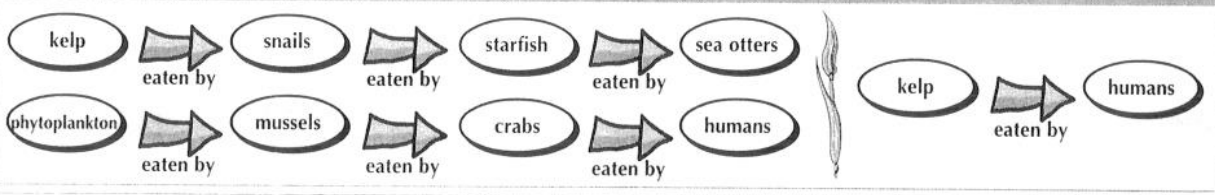


In an ecosystem like the kelp forest, each species has its own special role, or **niche** (NITCH) in the environment. Think about the way your school works. Everyone in the school has a niche, or role. Your role as a student is to go to classes and do homework. The science teachers teach science. Bus drivers bring students to and from school. In the kelp forest, each species' niche is based on the way it uses natural resources to survive, and how it affects the other living creatures around it. Sea otters have an important niche because they eat sea urchins. Sea urchins spend their days munching on seaweed. An army of sea urchins could quickly eat up a kelp forest, leaving no homes or food for the hundreds of other creatures that live there. Sea otters limit the number of sea urchins in the kelp forest by eating them, indirectly helping all the other living things in the kelp forest. Because of this, the sea otter is considered a **keystone species** in the kelp forest. The term *keystone* comes from a type of bridge in which the center stone (keystone) holds all the other stones in place. Without a keystone, the bridge would fall apart, just like without the sea otter, the kelp forest would disappear.

sea urchin



Kelp Forest Food Chains



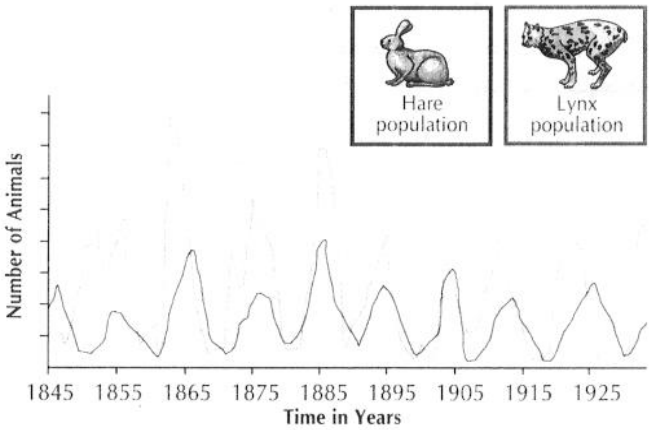
How do living things interact?

Eat or Be Eaten

Imagine eating at a restaurant where, if you wanted a steak, you had to go out back and chase down a cow yourself. You might quickly decide that it would be easier to be a vegetarian! In the wild, animals have to spend a lot of time and energy hunting for food, and also trying not to be eaten by something else.

Sea otters have to eat about a third of their body weight in food each day to stay healthy. It takes a lot of energy to stay warm in chilly ocean waters, and to dive over and over again to find food at the bottom of the ocean. Because they have to eat so much, sea otters spend about half of their time thinking about, looking for, and eating food.

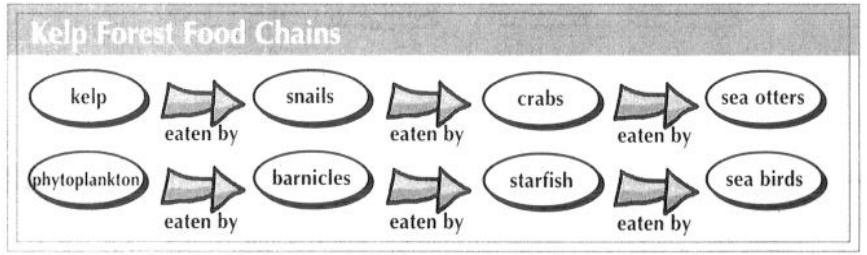
Sea otters are **predators**, which means they must hunt and eat other animals to survive. The animals they hunt, such as sea urchins, starfish, and octopuses, are their **prey**.



In a healthy environment, predators and prey keep each other's **populations** (or numbers) balanced. A simple example is the relationship between snowshoe hares (prey) and lynxes (predators) that live in the freezing Canadian Arctic. The graph shows the change in their populations over time.

When the population of hares goes up, the lynx population does too because there is more food available. But with so many hungry lynxes around, the population of hares begins to go down. Then the lynxes can't find enough food and the population drops as they begin to starve. This allows the population of hares to increase again, and the cycle continues.

When there is no balance between predators and prey, the whole environment can be affected. In the 1800s, immigrants brought a few rabbits from England to Australia where wild rabbits had never existed. In just a few years the rabbit population increased quickly and by 1900 scientists estimated there were millions of rabbits all over Australia. Since the rabbits had no natural predators, and there was plenty of food, there was nothing to stop their population from growing. Before long, the rabbits were eating so much food that some native Australian animals were dying because they couldn't find enough to eat. Today, rabbits are still a major problem in Australia.



SCIENCE SEEKERS

Endangered Species

How do living things interact?

Investigation 1
Science Lab

What You Need

- 4 vials with caps
- masking tape
- pipette
- algae
- paper cup of water that sat overnight
- 4 snails
- plastic spoon
- bromothymol blue

Caution

Do not touch or taste the bromothymol blue. Wash your hands after handling the living organisms.

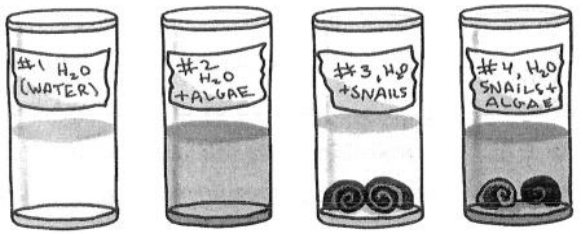
Interactions in a Pond Ecosystem

Kelp is a type of giant seaweed and belongs to a family of plants called algae, which usually grow in water. Some algae plants are too small to see, while others, like kelp, can grow to be over 100 feet tall. Just as giant kelp is a producer in the kelp forest food web, smaller algae plants are producers in other ecosystems like lakes and ponds.

Algae not only provide food for other living things in the ecosystem, they also provide oxygen. During photosynthesis, algae plants absorb carbon dioxide from the water, and release oxygen gas. The oxygen that algae produce gets used by other living things. Animals like fish and snails absorb oxygen from the water and release carbon dioxide, the same way humans breathe air to get oxygen and then exhale carbon dioxide. The algae plants themselves also absorb some oxygen, and produce a small amount of carbon dioxide. In this Science Lab, you'll observe snails and algae and investigate changes in the amount of carbon dioxide in the water to see how these living things interact.

What To Do

1. First, set up four different environments in the vials. Use masking tape to label the vials.
   Vial 1 – Water
   Vial 2 – Water & Algae
   Vial 3 – Water & Snails
   Vial 4 – Water, Snails, & Algae



2. Using a pipette, add 5 mL of water that has been standing overnight to vials 1 and 3. Vial 1 will serve as a control.
3. From the aquarium your teacher has set up, add 5 mL of water that contains algae to vials 2 and 4.
4. Using a plastic spoon, remove two snails from the classroom holding tank. Drain off any extra water. Add the snails to vial 3. Add another two snails to vial 4. Make sure the snails go all the way down into the water.
5. Bromothymol blue is an indicator that is blue when the amount of carbon dioxide (CO_2) in water is low and becomes more and more yellow as the amount of carbon dioxide increases. To find out the relative amounts of carbon dioxide in each environment, add 10 drops of bromothymol blue to each vial. Put the caps on the vials. Gently swirl each vial to mix the indicator with the water.
6. Observe the color of the water in each vial. Record your observations in the "Snail – Algae Interactions Observations" chart.
7. Allow all 4 vials to sit in direct sunlight for about an hour, or overnight. Then observe the color of the water in each vial again. Record your observations in the chart.

How do living things interact?

Snail – Algae Interactions Observations				
	Vial 1 *Water*	**Vial 2** *Water & Algae*	**Vial 3** *Water & Snails*	**Vial 4** *Water, Snails, & Algae*
Color at start				
Color after 1 hour (or overnight)				

What It Means

1. What was the order of the vials from the most yellow to the darkest blue? Based on this, order the vials from the greatest amount of carbon dioxide to the least amount of carbon dioxide.

Vial # _____ (most CO_2)

Vial # _____

Vial # _____

Vial # _____ (least CO_2)

2. Read the introduction to this lab again. For vials 2, 3, and 4, explain how carbon dioxide was being used and how it was being produced. What interactions among organisms took place?

3. Snails eat algae and also need the oxygen that algae produce. Based on this, predict what would happen if you added a lot more snails to vial 4.

Advising the Team

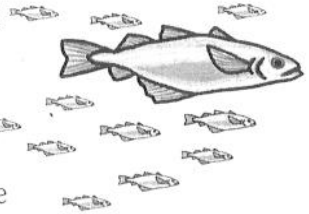
Based on your observations of snails and algae, and the information you've learned during Investigation 1, what does it mean for an ecosystem to be "balanced"? What can happen if an ecosystem is not in balance?

How does a species survive?

Birth Rate

For a living thing to survive, it must work hard to find enough food, water, and other things it needs within its ecosystem. But for a whole species to survive, each individual must also reproduce, adding more members to the group. This creates a new generation that will live on after the parents' generation dies.

Some species produce many young at once. For example, a female codfish can lay over a million eggs at one time. After she does, her job as a mother is done. She swims away and never sees her babies again. A large number of the eggs and young fish are eaten by predators. But with a million chances, the odds are good that at least a few of the babies will survive.



Other species, including sea otters, have only one baby at a time and protect it until the baby is old enough to protect itself. If enough babies grow up to have babies of their own, then the species will survive.

The percentage of pups born in a sea otter population in a year is called the **birth rate**. For example, if a population of 100 sea otters has 25 pups, then the birth rate is 25%. One quarter of the sea otters gave birth to one pup while others (such as males, or young juvenile otters) didn't have any. By calculating the birth rate of a population you can easily compare one population to another.

For example, let's say there are two basketball teams. One team has won 12 games, and the other has won 16 games. Which team has a better record? You can't answer until you know how many games each team has played. But if you know that one team has won 12 out of 14 games (or 86%), and the other team has won 16 out of 26 games (or 55%), then you can easily compare the two teams even though they have played a different number of games. Similarly, calculating a birth rate lets you compare the number of births in two populations of different sizes.

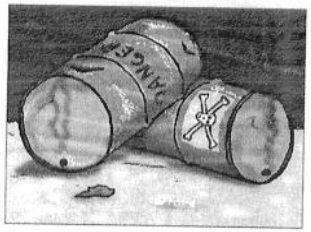
Stable population birth rate

Total number of pups = 23

Total juvenile, sub-adult, and adult otters = 105

$$\frac{\boxed{23}\ \text{(total pups)}}{\boxed{105}\ \text{(sea otters)}} = \boxed{.22}\ \text{pups per sea otter} \times 100 = \boxed{22}\ \% \ \text{normal birth rate}$$

In Ocean Edge, scientists are concerned that contamination of the harbor by a chemical called PCB has harmed the male otters' reproductive systems. If Ocean Edge sea otters aren't able to reproduce, they would have a lower birth rate than a normal group of sea otters. This would cause the Ocean Edge population to decline, because the number of sea otters born each year would be less than the number that die each year. Work with student D to calculate the Ocean Edge birth rate. Then compare it to the birth rate of a stable sea otter population. Record this information on your group's Investigation Log. If the Ocean Edge birth rate is lower than normal, it may be one clue that reproductive failure is causing the population to decline.



Ocean Edge population birth rate

Total number of pups = _____

Total juvenile, sub-adult, and adult otters = _____

$$\frac{\boxed{\ }\ \text{(total pups)}}{\boxed{\ }\ \text{(sea otters)}} = \boxed{\ }\ \text{pups per sea otter} \times 100 = \boxed{\ }\ \% \ \text{Ocean Edge birth rate}$$

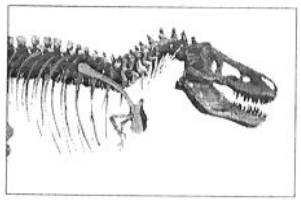
SCIENCE SEEKERS
Endangered Species

How does a species survive?

Investigation 2
Student B

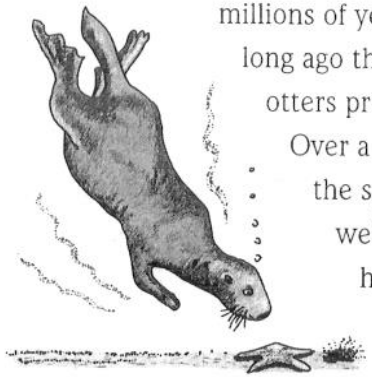
Adapting to Change

Have you ever seen a *Tyrannosaurus Rex*? You may have seen a fossil at a museum or a drawing in a book, but no one has ever seen one alive. That's because the *Tyrannosaurus Rex*, once the world's most savage hunter, is now gone. Luckily for us, its species died out a long time before humans ever showed up on Earth. In fact, scientists estimate that up to 98 percent of all the species that ever lived on Earth have died out or become **extinct**. And it's still happening. Animals and plants that are in danger of soon becoming extinct are called **endangered**.



Why do so many species become extinct? Our planet is constantly changing. Over long periods of time the atmosphere heats up and cools down. Swamps become deserts and oceans become forests. In order to survive, a species must be able to adapt, or change, in response to changes in the environment.

Adaptations are behaviors or physical characteristics that help living things survive in a particular habitat. Physical adaptations develop over many millions of years. For example, long ago the ancestor to sea otters probably lived on land. Over a long period of time, the species developed webbed back feet, which help sea otters dive underwater to find food. They also developed thick fur to help keep them warm in cold water. Today, sea otters hunt, eat, and even sleep in the water.



A behavioral adaptation that helps the sea otter species survive is its ability to use tools. Sea otters love to eat clams, mussels, and scallops. But their teeth aren't strong enough to crack the shells. So sea otters use a tool — a rock — to open the shells. While floating on its back a sea otter rests a rock on its belly. Then, it holds its dinner in its paws and pounds it on the rock until the shell breaks open.

When environmental changes happen slowly over thousands of years, species have a long time to adapt to changes. But today, people are rapidly changing environments before species have a chance to adapt, causing many species to become prematurely endangered or extinct. For example, giant panda bears in China eat only one thing — bamboo. They even have a special physical adaptation — a sixth finger that helps them strip bamboo leaves from the stems. In the past 100 years, farmers have cleared bamboo plants from much of the land, leaving the pandas with very little food. If the bamboo had disappeared over thousands of years, the panda species might have been able to adapt to eating something else. But because the bamboo has disappeared from the ecosystem so quickly, many pandas have died of starvation. Today, there are only about 700 panda bears left in the world.

We know that extinctions of species have been happening throughout the history of Earth. But in recent years human actions have directly or indirectly caused the extinction of many other species. We are rapidly changing the ecosystems around us without knowing what the consequences are. Extinctions are one clue that we're changing our environment in ways that aren't healthy for other living things.

SCIENCE SEEKERS
Endangered Species

How does a species survive?

Population Growth

If you always put more money into your bank account than you take out, then your bank account will grow over time. But if you take out more than you put in, after a while you'll be broke. Population growth works in the same way. Populations can change in size when members are added to the group, or when members leave the group. For example, if you were studying a population of birds living in a maple tree, the population would increase when new birds build nests in the tree, and when chicks are hatched. The population would decrease if any of the birds died, or moved to another tree.

Observations of the sea otters in Ocean Edge have shown that **migration** (traveling between groups) has not happened, probably because Ocean Edge is over 200 miles from any other sea otter population. When sea otters are born, or when they die, it changes the total number of otters in the group. If there are more births than deaths each year, then the population increases; if there are more deaths than births each year, then the population decreases. If the number of births and deaths remain about the same, the population neither increases nor decreases.

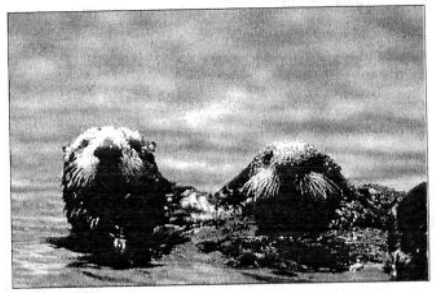
births > deaths = population increase

deaths > births = population decrease

births = deaths = stable population

Scientists have carefully counted and monitored the sea otters in Ocean Edge over the past year. Use your group's Investigation Log to calculate the number of deaths in each sea otter age group, and for the whole population. Record these numbers in the Population Model Data table.

The numbers you calculate will be entered into a computer model being developed at the Center for Science Seekers. The Center will compute the death rate for each age group. By analyzing the death rates in each age group, the population model will show if a high number of deaths in one of the age groups is causing the whole population to decline. Since sea otters of different ages die for different reasons, knowing which age group is dying at a higher rate than normal could help explain why the whole population is declining.



When your calculations are complete, copy the data in the table onto your group's Investigation Log. Be ready to send this data to the Center for analysis.

Population Model Data

Age Group	Number of deaths	Total Number in age group
Pups (0–6 months)		
Juveniles (6 months–1 year)		
Sub-adults (1–3 years)		
Adults (3 years and older)		
Total Population		

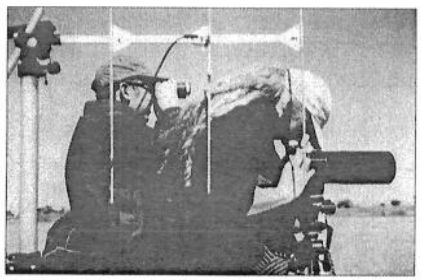
SCIENCE SEEKERS
Endangered Species

How does a species survive?

Investigation 2
Student D

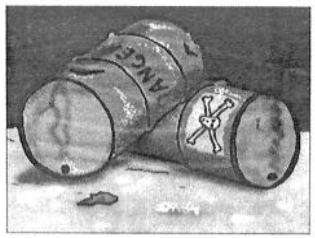
Life Cycles

Like all living things, sea otters go through several stages of development as they grow from birth through childhood and into adulthood. Scientists learn about sea otters at all of these stages by



attaching radio tags to the flippers of individual sea otters. Over several years, they observe these sea otters to learn how often they have pups, how much they eat, how long they live, and more.

A healthy sea otter can live up to about 18 years. But not all sea otters survive that long. Sea otters are threatened by many things in their environment — diseases, parasites, pollution, contaminants, limited food supplies, shark attacks, and more. At each stage of its life cycle a sea otter's behavior is different, and its survival can be threatened by different things in the environment.



To monitor the Ocean Edge sea otter population, scientists have taken a yearly census, or count, of the number of sea otters in the population. Share the data in the table with students A and C to help calculate the birth and death rates of the sea otter population in Ocean Edge.

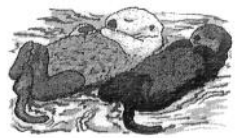
Pups

Age: 0–6 months

Status: A newborn sea otter is helpless, and must be fed andwashed by its mother. At first, the pup sleeps most of the time. After about 1 month, the pup begins learning how to swim, but its baby fur is so fluffy that it can't dive underwater with its mother.

Threats: Because mother sea otters must leave their pups floating on the surface when they dive underwater for food, pups often drift away and get lost. Without a mother to feed it and groom its fur, a baby sea otter will die from starvation or from exposure to cold ocean water.

Sub-adults



Age: 1–3 years

Status: Sub-adults are completely independent and may roam far from the place where they were born in search of food.

Threats: Because sub-adult sea otters often swim so far from shore, they sometimes become entangled in fishing nets where they can drown.

Sea Otter Census	
Age Group	**Total otters in age group**
Pups (0–6 months)	55
Juveniles (6 months–1 year)	38
Sub-adults (1–3 years)	86
Adults (3 years and older)	121

Juveniles

Age: 6 months–1 year

Status: Juvenile sea otters are no longer dependent on their mothers for food. Young sea otters are curious about the world and learn a lot of survival skills they'll need later by playing with other young otters.

Threats: Most juvenile sea otters are not very good hunters yet. In areas where food is hard to find, juveniles may not be able to get enough to eat and could starve.

Adults

Age: 3 years and older

Status: Full-grown adult males are 3-4 feet long and can weigh 50-70 pounds. Females are a little smaller, and weigh about 45-60 pounds. At 3 years, a female otter is ready to begin a family of her own.

Threats: Adult sea otters are sometimes attacked by sharks. Scientists think the sharks mistake adult sea otters for their usual prey, seals.

SCIENCE SEEKERS

Endangered Species

How does a species survive?

Investigation 4

Science Lab

What You Need

2 vials with caps

1 package of yeast

1 measuring scoop

masking tape

sugar

methylene blue

warm tap water

ice water or a freezer

boiling water

Caution

Do not touch or taste the methylene blue.

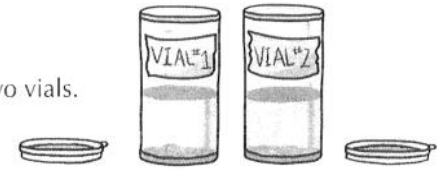
Effects of Environmental Changes on a Yeast Population

An **ecosystem** is a community of living things interacting with each other and with the physical environment. For a species to survive, each individual must be able to find enough food, water, shelter, and other things it needs within its ecosystem. This is true whether the organism is an animal like a sea otter, or a tiny microscopic yeast.

Yeast are fungi that have a dormant (or resting) stage. When you buy yeast at the store, the yeast are in this dormant stage. But when dormant yeast are placed in an environment with ideal conditions of food, temperature, and water, they begin to grow and reproduce. The yeast get the energy they need to grow by breaking down sugars and other carbohydrates. During this process, known as **respiration**, oxygen is removed from the environment and converted to carbon dioxide. By monitoring the level of oxygen in the environment, it is possible to determine whether or not a yeast population is growing. A low oxygen level means that respiration is taking place and the yeast are growing. A high oxygen level means that respiration is not taking place.

Like all living things, yeast grow best within a certain temperature range. In this Science Lab, you will observe how changes in the environment can make yeast grow, or stop growing.

What To Do



1. Use masking tape to label two vials.
   Vial # 1
   Vial # 2
2. Use a measuring scoop to add ¼ teaspoon yeast to each vial. Then add 1 tablespoon of warm water to each vial. The water should feel warm to the touch, but not so hot that you can't keep your finger in it for a few minutes.
3. Methylene blue is an indicator that is blue in the presence of oxygen. When there is no oxygen present, methylene blue becomes colorless. Add 1 drop of methylene blue to each vial. Replace the caps and shake the vials to mix the yeast and water. Observe the color of the mixture in each one. Record your observations in the "Stage 1" column of the Yeast Population Observations chart.
4. Add ¼ teaspoon of sugar to each vial. Replace the caps and shake the vials. Let the vials sit for 5 minutes. Observe and record the color of the mixtures and any other changes you see.
5. Place vial 1 in the freezer for about 20 minutes. While you wait, continue with step 6.
6. Add 1 tablespoon of boiling water to vial 2. Let it sit for 5 minutes. Then observe and record the color of the mixture and any other changes in the appropriate column of the chart.
7. After 20 minutes, remove vial 1 from the freezer. Observe the color of the mixture and any other changes that may have occurred, and record your observations in the chart.
8. Allow both vials to sit at room temperature for about 20 minutes. Observe the color of the yeast mixture and any other changes, and record your observations in the chart.

How does a species survive?

Yeast Population Observations					
	Stage 1 *Yeast and warm water*	**Stage 2** *Yeast, water, and sugar*	**Stage 3** *After 20 min. in freezer*	**Stage 3** *After adding boiling water*	**Stage 4** *After 20 min. at room temperature*
Vial 1 Color changes					
Vial 2 Color changes					

What It Means

1. How did each of the following factors affect the yeast population:

Sugar: _____

_____

Cold temperature, followed by return to room temperature:

_____

_____

Boiling water: _____

_____

2. How was the growth of the yeast affected by sugar, and by temperature changes?

_____

_____

_____

Advising the Team

Like yeast, all living things must live in an ecosystem where they can find food, ideal temperatures, and much more. What are some of the things sea otters need to survive that are provided by the kelp forest? What is one environmental change that you think could cause the sea otter population to increase? Why? What is one change that could cause the population to decrease? Why?

_____

_____

_____

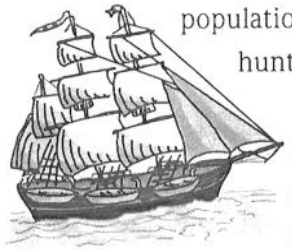
_____

_____

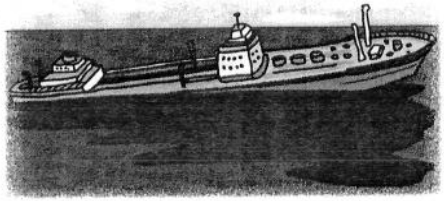
What threatens a species?

Human Activity

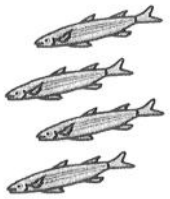
When European explorers first sailed the Pacific Ocean, there were about 300,000 sea otters bobbing up and down in the water along the coast of North America. It didn't take the explorers long to realize that the sea otters' warm, soft fur would be very valuable back home. Soon, traders were bringing thousands of sea otter furs back to Europe with each trip. The hunters were killing the adult sea otters faster than pups could be born, causing the population to decrease. Even though hunting sea otters was banned in 1911, the population never recovered and there are still only a few thousand southern sea otters left today.



Many other species are endangered today because of hunting that happened in the past. Humans have hunted whales for their blubber, elephants for their ivory, and tigers for their fur. Today, there are very few of these animals left in the world. But hunting isn't the only way that humans affect other species. The things we do to make our lives more comfortable indirectly affect every other species on the planet. Many of our industries create pollution that can harm other species. For example, oil pollution is deadly to sea otters because oily fur can't keep them warm enough in chilly ocean water. One major oil spill off the coast of California could wipe out the entire southern sea otter population in the United States.



Often, humans harm other species without meaning to. When we chop down forests for wood to build houses and make paper, or pave fields for houses, roads, and parking lots, many living things have to find new homes. When we take fish from the oceans to sell around the world, whales, sharks and many other ocean animals have to find something else to eat. In Ocean Edge, fishermen have recently reported finding sea otters in their nets. While diving for food, the sea otters became tangled up in the fishing nets and drowned, unable to reach the surface for air. This has mostly affected sub-adult sea otters because they usually hunt for food further offshore than other age groups. When sub-adults die, it affects the long-term growth of the sea otter population. Not only do the sub-adults themselves die, but in future years there are fewer adult sea otters to give birth to pups.



Using the data on your group's Investigation Log, fill in the table below to show how the sea otters in each age group are affected by different types of human activity near Ocean Edge. Then work with your teammates to analyze all the causes of death to determine why the Ocean Edge population is declining.

Sea Otter Deaths Caused by Human Activity

Cause of Death	Pups	Juveniles	Sub-adults	Adults
Drowned in fishing net				
Hit by boat				
Oil coated fur				

SCIENCE SEEKERS
Endangered Species

What threatens a species?

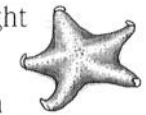
Investigation 3
Student B

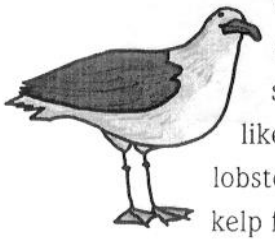
Competition for Food

When the number of births in a population is greater than the number of deaths, the size of the population increases over time. But populations can't keep getting bigger and bigger forever. If they did, the world would be a pretty crowded place. At some point, **limiting factors** in the environment stop a population from increasing. Limiting factors include food, space, weather, and predators. For example, the number of corn plants growing in a field is limited by the amount of space in the field. Each corn plant needs enough space for its roots to grow, and for its leaves to stretch out so the plant can receive sunlight. Other limiting factors for corn plants might be the amount of water and sunlight available, the weather, the amount of nutrients in the soil, and the number of insects eating the plants.

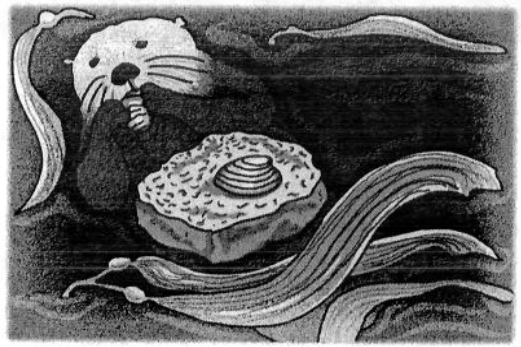
Living things that share space in an ecosystem have to compete for a limited supply of food. Imagine standing in line to buy lunch in your school's cafeteria. As you get closer to the front, you see that the pizza — your favorite — is running out. Just as you reach the front of the line, the last slice of pizza is given away to the person ahead of you. You've just been a victim of **competition**. A limited supply of food (pizza) ran out before you could get any. Instead of a delicious slice of hot, cheesy pizza, you're stuck eating a soggy peanut butter and jelly sandwich.

Sea otters have a big appetite. Each adult sea otter has to eat almost a third of its body weight (10-20 pounds) in food each day to survive. Sea otters have to compete with each other, and with other species for food. A sea urchin that might have been a sea otter's lunch also looks like a tasty treat to a starfish or a bird. Humans also compete with sea otters for food. Some of the sea otters' favorite snacks, like sea urchins, clams, and lobsters, are harvested from the kelp forest by humans.





When there isn't enough food to go around, the best hunters will be the first to find food. Young juvenile sea otters who aren't good hunters yet have to spend a lot more time and energy to find even a little food. Or they might not be able to find any food at all. After a while, these young animals may die of starvation. A limited food supply also affects pups who are still being fed by their mothers. Mother sea otters have a tough job, because they have to find enough food for themselves, and for their babies. If a mother can't find enough food, her pup may die of starvation.



Using the data on your group's Investigation Log, fill in the table below to show which sea otter age groups are likely to die of starvation. Then work with your teammates to analyze all the causes of death to determine why the Ocean Edge population is declining.

Sea Otter Deaths Caused by Starvation

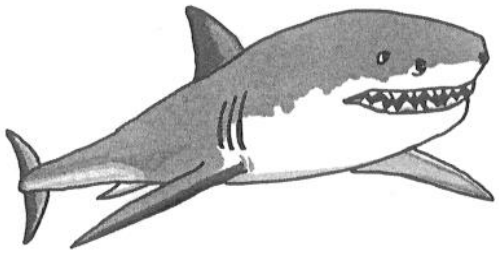
Cause of Death	Pups	Juveniles	Sub-adults	Adults
Starvation				

What threatens a species?

Predators

In the kelp forest ecosystem, the sea otter is one of the highest consumers in the food web. Like humans, sea otters have few natural predators. Occasionally a sea otter pup left alone on the surface is caught and eaten by an eagle, but this is very rare.

However, there is one enemy that kills sea otters: great white sharks. Sharks normally eat seals, but when a hungry shark spies something floating on the surface, it sometimes bites first and asks questions later. Each year, sea otters are found washed up on the beach, killed by shark bites. Scientists believe that large sub-adult and adult sea otters get attacked because they look a little bit like seals. Once the shark realizes it has made a mistake, it swims off in search of a tastier treat.



Shark Attack Data	
Pups	
Juveniles	
Sub-adults	
Adults	
Total shark attack deaths	
Total deaths in population	

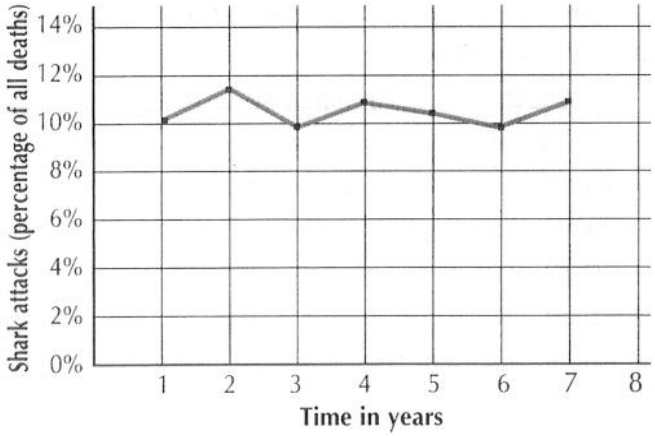
Using the data on your group's Investigation Log, fill in the table to show how many shark attacks were recorded last year. Then do the following:

1. Calculate the percentage of sea otters killed by sharks this year. To do this, divide the total number of otters that died from shark bites by the total number of deaths in the whole population (check your group's Investigation Log for this information).

$$\frac{\square \text{ (total shark attack deaths)}}{\square \text{ (total deaths)}} = \square \times 100 = \square\,\% \text{ (percentage of deaths caused by shark attacks)}$$

2. The chart below shows data on shark attacks over the last 8 years. Plot this year's percentage of sea otters killed by sharks on the chart. Look for a pattern in the chart. In the last 8 years, has the rate of shark attacks gone up, down, or has it stayed about the same?

3. Based on your conclusion, do you think increased shark attacks could be causing the Ocean Edge population to decline? Record your observations on your group's Investigation Log.



SCIENCE SEEKERS
Endangered Species

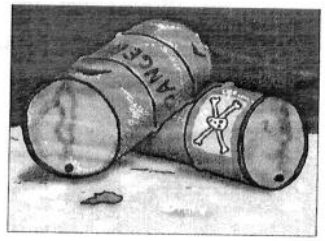
What threatens a species?

Investigation 3
Student D

Monitoring Endangered Species

Have you ever looked at your cat or dog sleeping in the sun and thought that it would be much easier to be an animal than a human being? Most cats and dogs are lucky — they live in warm houses where they get plenty of food and rest. Being a wild sea otter isn't quite so easy. Sea otters must work hard all the time just to stay alive. It takes a lot of energy to stay warm in cold ocean water, to dive 30 feet or more beneath the surface looking for food, and to stay afloat in stormy weather. A sea otter who can't do these things will soon die. For example, pups must rely on their mothers to find food for them and to groom their fur so they stay warm. If pups are separated from their mothers, they soon die of starvation or because they can't keep warm in the chilly ocean water.

Sea otters also face parasites and diseases that can cause sickness and death. When scientists examined the bodies of some sea otters in Ocean Edge, they found that many of the pups and juveniles had died from stomach parasites. Several sub-adult and adult sea otters died from a disease that causes their brains to swell. And a few sea otters died from infected wounds, or other bacterial infections like pneumonia.



Like all living things, sea otters' bodies have an immune system that helps them fight off infections. Although it's normal for some sea otters to die from disease, it's possible that pollution in the water near Ocean Edge weakend the sea otters' immune systems so much that they were unable to survive infections.

When humans make changes to the environment around us, we can't always predict what the consequences will be. Will pollution we put into the water and air kill other living things, or will they be able to survive? If we drain a wetland area to build new houses, will the animals there be able to find a new place to live? Scientists spend a lot of time monitoring endangered species to try to find out what is causing their populations to decline and how ecosystems are being affected by our actions. If we find evidence that other species are becoming extinct as a result of our actions, then we can try to protect them. Protecting other species is important because when a species becomes endangered or extinct, the entire ecosystem can become unbalanced. This affects many other species, including humans. For example, bees help many plants reproduce by carrying pollen from one plant to another. If bees became extinct, these plants would not be able to reproduce and could become extinct as well. Then, people and animals that rely on these plants for food could starve.

Using the data on your group's Investigation Log, fill in the table. Then work with your teammates to analyze all the causes of death to determine why the Ocean Edge population is declining.

Deaths by Disease & Natural Causes

Cause of Death	Pups	Juveniles	Sub-adults	Adults
Disease				
Lost/abandoned pups				
Infected wounds				
Old age				

SCIENCE SEEKERS

Endangered Species

What threatens a species?

Investigation 3
Science Lab

What You Need

1 game board

1 set of game cards (Spring, Summer, Fall, Winter, and Birth cards)

4 game pieces with bases (1 for each player)

1 die

Game Setup

- If you are using the game for the first time, copy and cut apart the cards. Sort them into five piles: Winter cards, Spring cards, Summer cards, Fall cards, and Birth cards.
- Shuffle each set of cards. Place each set face down in the designated spot on the board.
- Each player should choose a playing piece and fit it into a colored base.

A Year in Otter Cove

A sea otter population is affected by many factors in the environment. Winter storms, food supply, human intervention, predators, and various other threats can all affect the number of births and deaths in the population. In addition, sea otters can migrate from one group to another. In this Science Lab, you'll play a board game to model how a sea otter population can change in size during the course of one year.

What To Do

Each player is keeping track of a separate population of sea otters. At the start of the game, each player has a population of 48 sea otters. This is recorded in the Score chart. The sea otters are divided into different age groups:

30 adults — 20 females and 10 males *(3 years and older)*
12 sub-adults *(1–3 years old)*
6 juveniles *(6 months–1 year old)*
0 pups *(newborn–6 months old)*

Rules

1. All players place their playing pieces on the space marked Start.
2. Each player rolls the die. The player with the highest number goes first.
3. Player 1 rolls the die and moves the corresponding number of spaces, starting with the corner space marked Fall and going clockwise around the board. Player 1 takes a card from the **Fall** pile and reads the card aloud. Each card describes an event that takes place and affects the player's population. If there is any change in population size, Player 1 records the change in his or her Score chart, along with the cause of the change. At the end of a turn, Player 1 returns the card to the bottom of the pile, unless the card instructs not to.
4. Play continues to the left. Each time a player lands on a space (including corner spaces) the player takes a card from the season represented by the side of the board on which he or she is traveling.
5. If a card tells a player to move forward, the player does not take another card after moving. If a card tells a player to take another turn, the player takes another complete turn, rolling the die, moving, and drawing another card.
6. When a player reaches or passes a corner space, the player should record changes to his or her population as written on the space. Any time a corner space is passed, the player should record these changes in his or her Score chart *before* drawing another card.

   Winter—the player takes a **Birth** card to determine how many pups are born to the population. The player records this change to the population in the Score chart and keeps the **Birth** card.

   Spring—all juveniles become sub-adults

   Summer—all pups become juveniles
7. Play ends when all players have gone around the board once and reach or pass the **Finish** space. This does not require an exact roll. When a player reaches the Finish space, 1/3 of the sub-adults become adults, divided evenly between males and females. (If necessary, round to the nearest whole number after dividing.) Players who finish early can still have sea otters migrate to or from their populations.

What It Means

1. Examine the changes in the size of your sea otter population over the course of one year.
   What was the total number of births?
   What was the total number of deaths?
   How many otters migrated to your population?
   How many otters migrated away from your population?
   Overall, did the number of otters go up, go down, or stay the same?

2. What do you think might happen to your population after two years? Three years? Five years? Explain your answer.

3. Compare the changes in your population to the other players in your group. Did one otter population grow much larger or much smaller than the others? If so, why?

4. What events most influenced the change in your population size?

What threatens a species?

Example:

Population Change	Reason for Change	Adults male	Adults female	Sub-adults	Juveniles	Pups	Total Population
	Population at start	10	20	12	6	0	48
-1 adult M	Starvation because of decline in sea urchins	9	20	12	6	0	47

Population Change	Reason for Change	Adults male	Adults female	Sub-adults	Juveniles	Pups	Total Population
	Population at start	10	20	12	6	0	48

Scoring

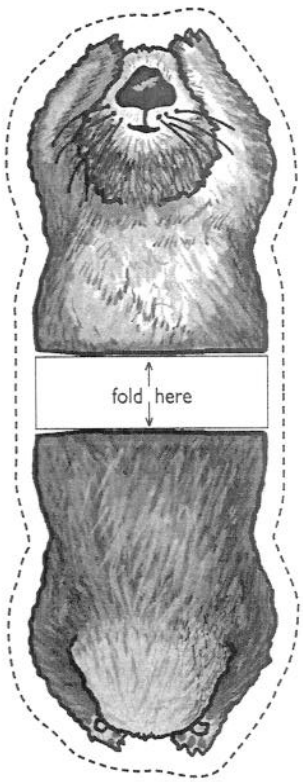
Record all changes to your sea otter population in the Score chart. When a card indicates that sea otters are added to or taken away from your population, record the information including the number of otters added or taken away, and the reason for the change.

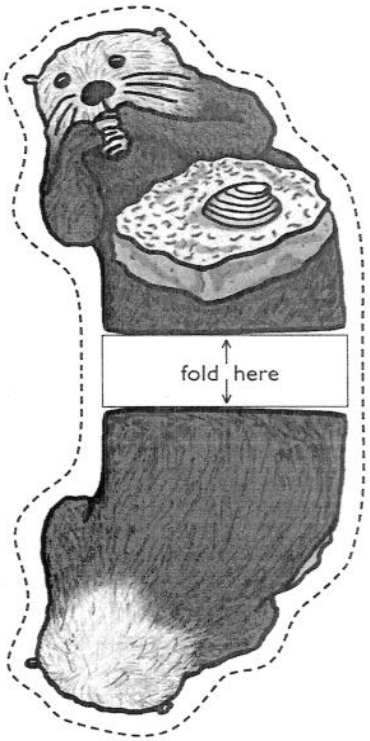
Scoring Notes

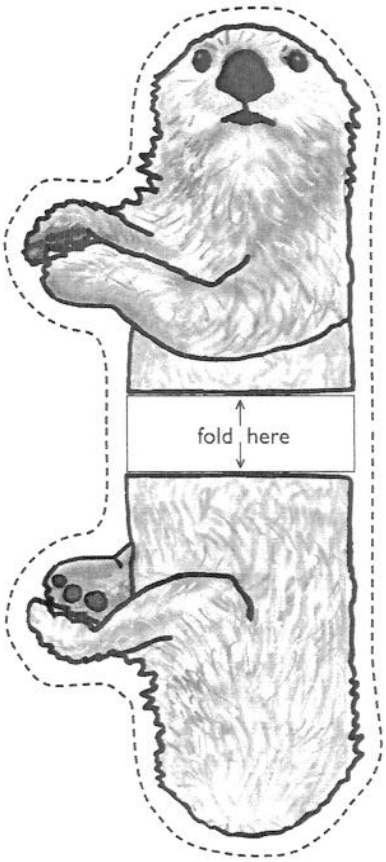
1. In the Population Change column, write down how many sea otters are added or removed, their age group, and whether they are male or female (for adults). Recalculate your population after each turn.
2. If a female sea otter dies during winter or spring, her pup may also die. If there is another female sea otter in your group who does not have a pup, then she will adopt the orphan pup. Otherwise, the pup dies.
3. If you draw a card that affects an age group in which you have no otters, then the card has no effect.
4. Migrating sea otters are passed to the your right or left, as indicated on the card. Both players must record the change in their Score charts. Migrations can affect your population even if it is not your turn, or if you have already finished going around the board.

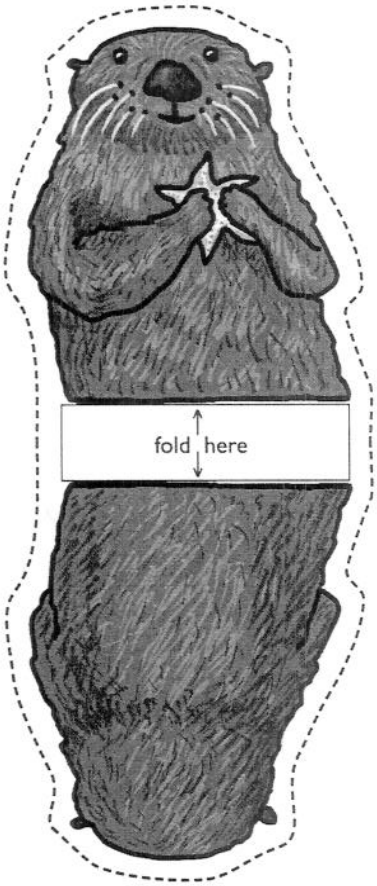
Game Pieces

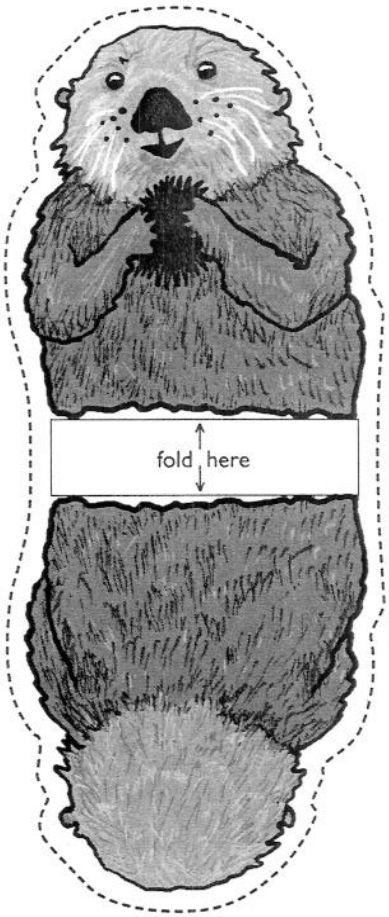
Reproduce one set of game pieces for each group of students. Use heavy paper (card stock). Students should cut out the game pieces along the dotted lines, fold where indicated, and use tape or glue to secure at the top.

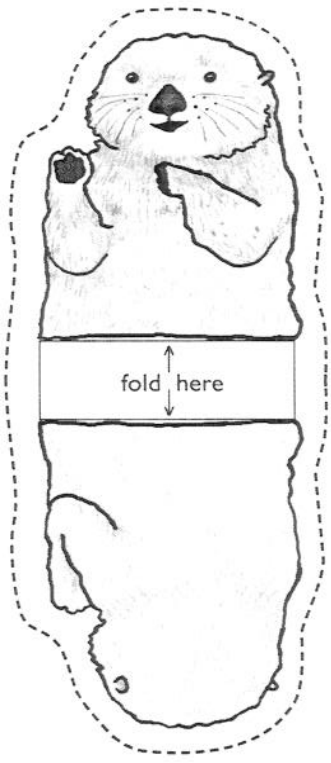












Fall Cards

An old male sea otter's teeth are worn down from crushing hard-shelled clams, mussels, and other mollusks. It can no longer feed and starves to death.

– 1 adult male

This card affects all players who are in Fall

An earthquake destroys some of the seashell beds around Otter Cove. Less food is available, and juveniles who are not yet good at hunting aren't able to find enough food. Two juveniles in each population die of starvation.

– 2 juveniles
(all players in Fall)

Do not replace this card in the Fall pile. Remove it from the game.

Two sub-adult sea otters who have swum far off from shore are caught in a fishing net and drown.

– 2 sub-adults

The sea otters' immune systems are weakened by pollution in the water, and three die of disease.

– 2 adult females

– 1 sub-adult

A small boat strikes a rock and motor oil leaks out into the water. The fur of an adult female becomes coated with oil when she swims past the area. Her fur can no longer trap enough air to keep her warm, and she dies.

– 1 adult female

Two males fight over territory. One is seriously injured and later dies.

– 1 adult male

Two sub-adults from a population farther up the coast migrate and join this population.

+ 2 sub-adults
(take from the player on your right)

One sub-adult and one adult male migrate down the coast and join another population.

– 1 sub-adult
(pass to the player on your left)

– 1 adult male
(pass to the player on your left)

Take another turn

Sea otters use their sensitive forepaws to find snails on the kelp stems and to turn over rocks to search for limpets and small crabs to eat.

Go forward two spaces

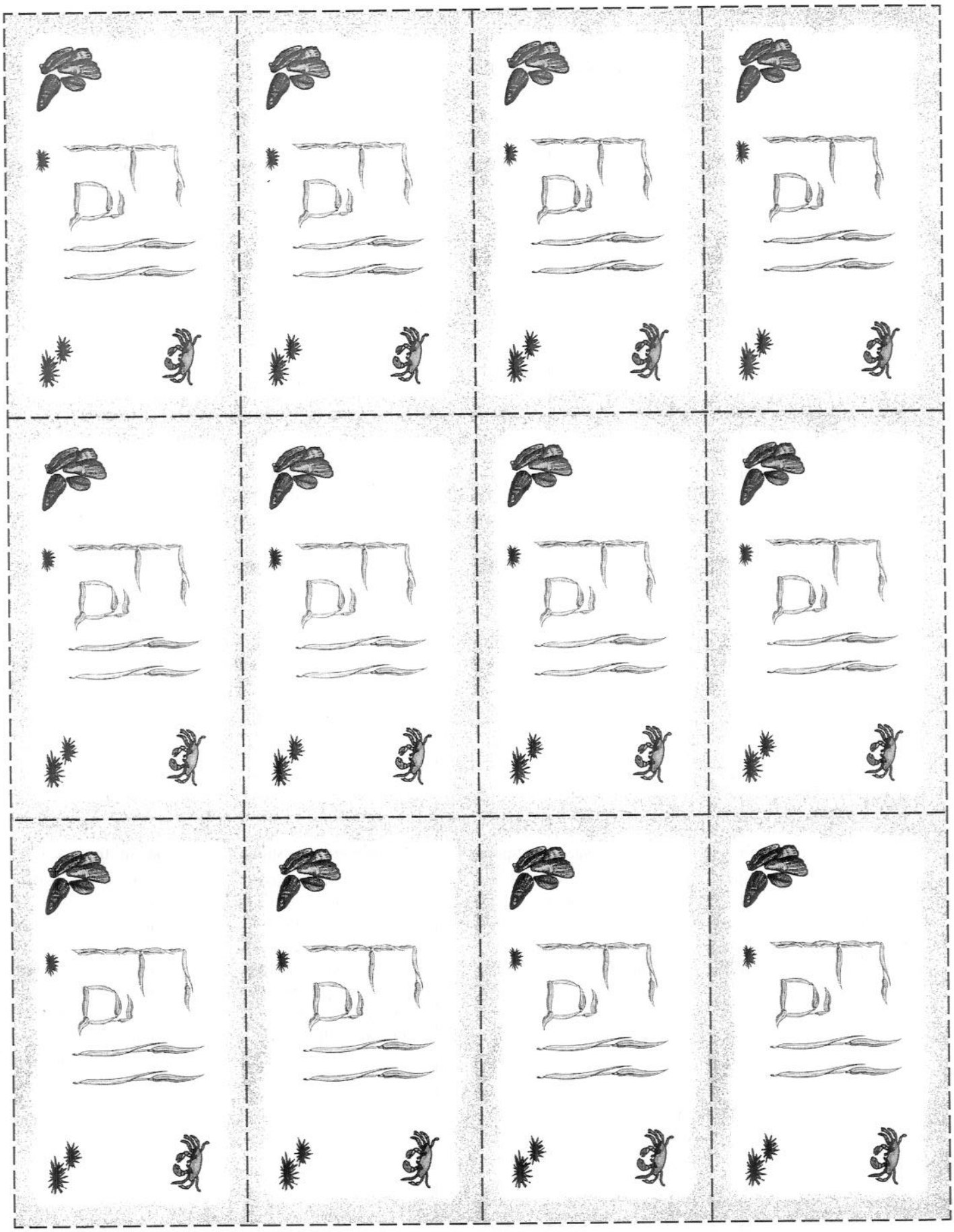
Sea otters must eat more than one quarter of their body weight in food each day to survive.

Go forward two spaces

Sea otters dive underwater to find food, and eat it at the surface. They use their chest as a lunch counter and as a place to put their favorite rock while they are eating.

Take another turn

Sea otters dive to the ocean floor holding their breath. They can hold their breath for up to 5 minutes, but 30 to 90 seconds is the average amount of time a sea otter stays underwater to search for food.



Winter Cards

An aging female sea otter has trouble finding enough food and dies of starvation.

– 1 adult female

(Check your Score chart to determine if her pup dies as well.)

This card affects all players

Female sea otters that have twins can only care for one pup. The second twin dies because the mother can't find enough food for herself and for two pups.

Each player should check his or her Birth card. If any twins were born, one of the twins dies. If a player has not yet drawn a Birth card, he or she should subtract one from each pair of twins after doing so.

Do not replace this card in the Winter pile. Remove it from the game.

Disease kills five sea otters: two adult males, one sub-adult, and two pups.

– 2 adult males

– 1 sub-adult

– 2 pups

During a storm a pup is separated from its mother, cannot keep itself afloat, and dies.

– 1 pup

In rough seas, an adult female sea otter is thrown against a rock and dies.

– 1 adult female

(Check your Score chart to determine if her pup dies as well.)

Diving fish harvesters strip the otters' feeding area of sea urchins, abalones, crabs, mussels, and scallops. Two juvenile sea otters die of starvation. Three pups also die because their mothers cannot find enough food to feed them.

– 2 juveniles

– 3 pups

A pup that was born small and weak becomes diseased and dies.

– 1 pup

One sub-adult and one adult male migrate down the coast and join another population.

– 1 sub-adult
(pass to the player on your left)

– 1 adult male
(pass to the player on your left)

Take another turn

Sea otters use stones to dislodge abalones from the rocks to which they are attached.

Go forward two spaces

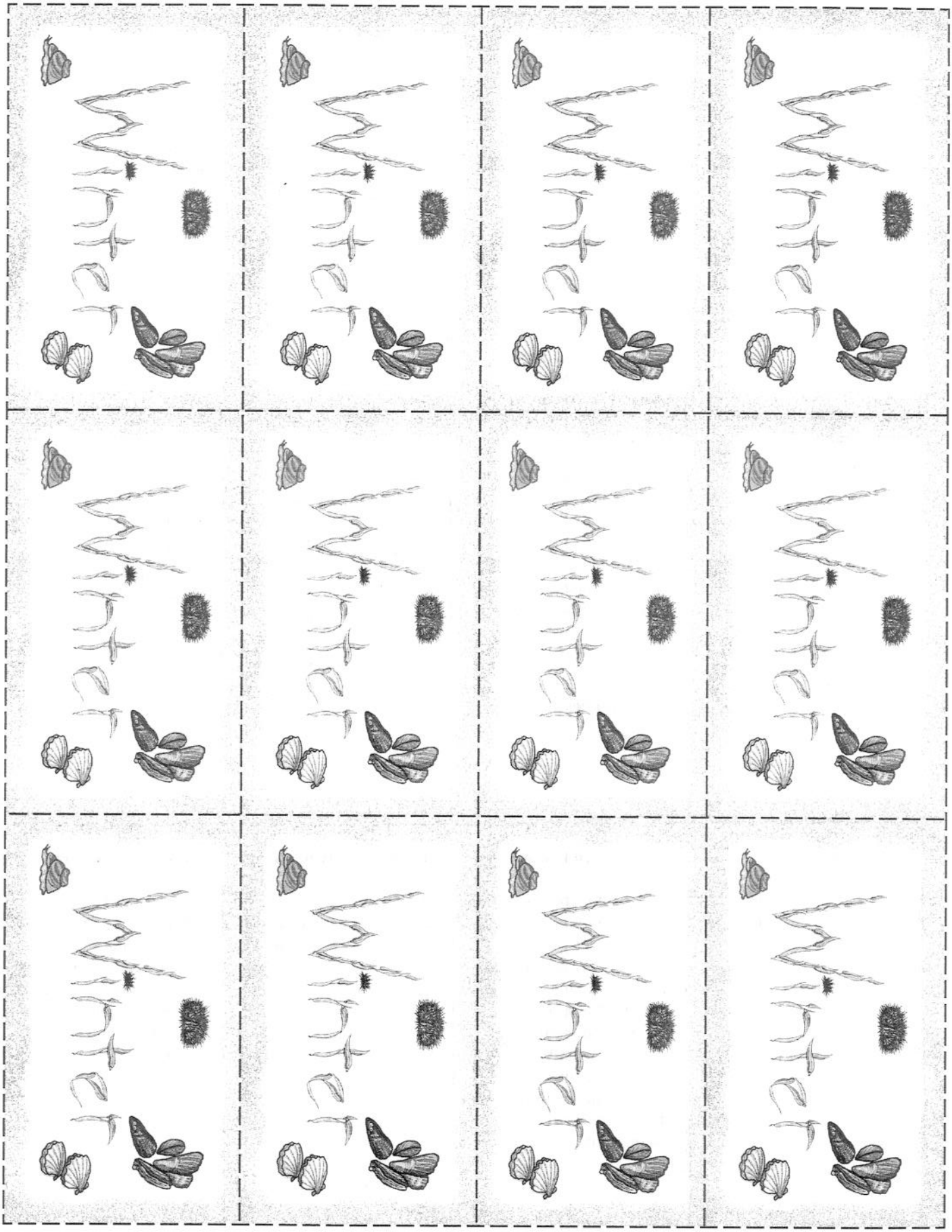
A sea otter spends hours cleaning its coat, getting rid of any oil and debris that has become attached to its fur as it has been diving and feeding. The otter lifts the fur and blows on it to dry it and trap air inside that helps keep the otter warm.

Go forward two spaces

Sea otters use their forepaws to dig clams from the sand on the seafloor.

Take another turn

Three quarters of a sea otter's diet is sea urchins and mussels. They also eat abalones, limpets, scallops, annelid worms, crabs, fish, fish eggs, and octopuses.



Birth Cards

Due to El Niño, warm, nutrient-poor water from the south flows into the sea otters' range. Coastal food webs are affected and the sea otters stop breeding. No young are born.

Keep this card, and record this information on your Score chart.

Due to water contamination by PCBs, the male otters' reproductive systems are affected. Only one out of every two females in the sea otter population gives birth to a pup.

Keep this card, and record this information on your Score chart.

Each female in the sea otter population gives birth to a single pup.

Keep this card, and record this information on your Score chart.

One female gives birth to twins. All the other female sea otters give birth to a single pup.

Keep this card, and record this information on your Score chart.

Two female sea otters give birth to twins. All the others give birth to a single pup.

Keep this card, and record this information on your Score chart.

Two adult female sea otters do not bear young. All the others give birth to a single pup.

Keep this card, and record this information on your Score chart.

One adult female sea otter does not bear young. All the others give birth to a single pup.

Keep this card, and record this information on your Score chart.

One adult female sea otter does not bear young. Another gives birth to twins. All the others give birth to a single pup.

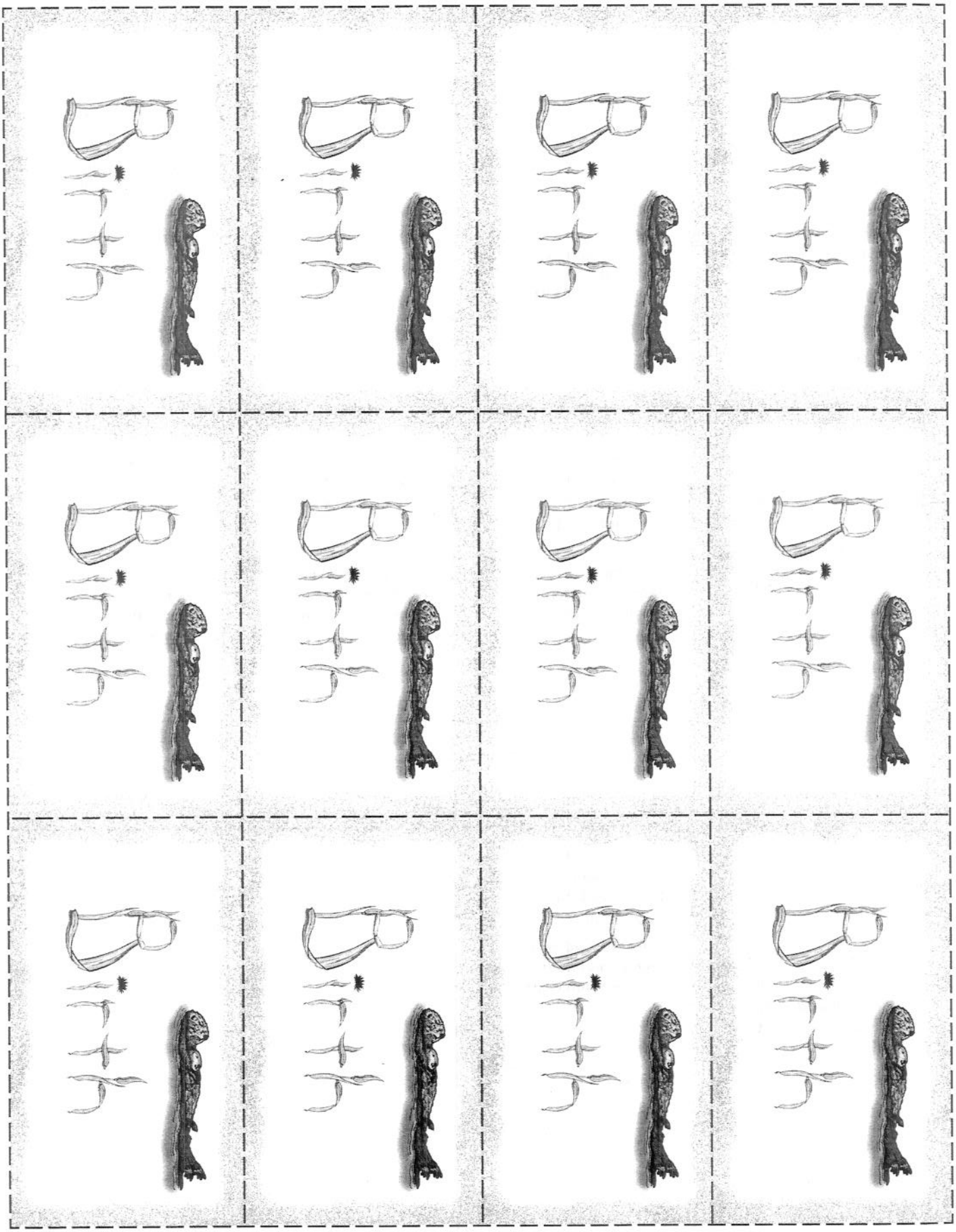
Keep this card, and record this information on your Score chart.

One adult female dies during birth and her pup does not survive. All the other females in the population give birth to a single pup.

Keep this card, and record this information on your Score chart.

Every adult female in the sea otter population gives birth to a single pup.

Keep this card, and record this information on your Score chart.



Spring Cards

Even though hunting sea otters is illegal, people still occasionally kill sea otters for their fur. Two adult sea otters, one male and one female, are killed for their furs, which are sold illegally.

– 1 adult male
– 1 adult female

(Check your Score chart to determine if the female's pup dies as well.)

This card affects all players who are in Spring

During a spring storm, the seas around Otter Cove are high for days on end. Mother sea otters have trouble finding enough food, and some pups are abandoned. The pups soon starve to death.

– 1 pup
(all players in Spring)

Do not replace this card in the Spring pile. Remove it from the game.

An adult male sea otter is attacked by a shark and dies from the wounds.

– 1 adult male

Three sub-adults from a population farther down the coast migrate and join this population.

+ 3 sub-adults
(take from the player on your left)

A pup that is left floating on the surface while its mother dives underwater for food is eaten by an eagle.

– 1 pup

A pup that is tired from swimming in rough seas is resting on a rock. A coyote catches and eats it.

– 1 pup

A sub-adult leaves the population and joins one further up the coast.

– 1 sub-adult
(pass to the player on your right)

A sub-adult sea otter becomes caught in a fishing net and drowns.

– 1 sub-adult

Take another turn

Sea otters use their sensitive forepaws to find snails on the kelp stems and to turn over rocks to search for limpets and small crabs to eat.

Go forward two spaces

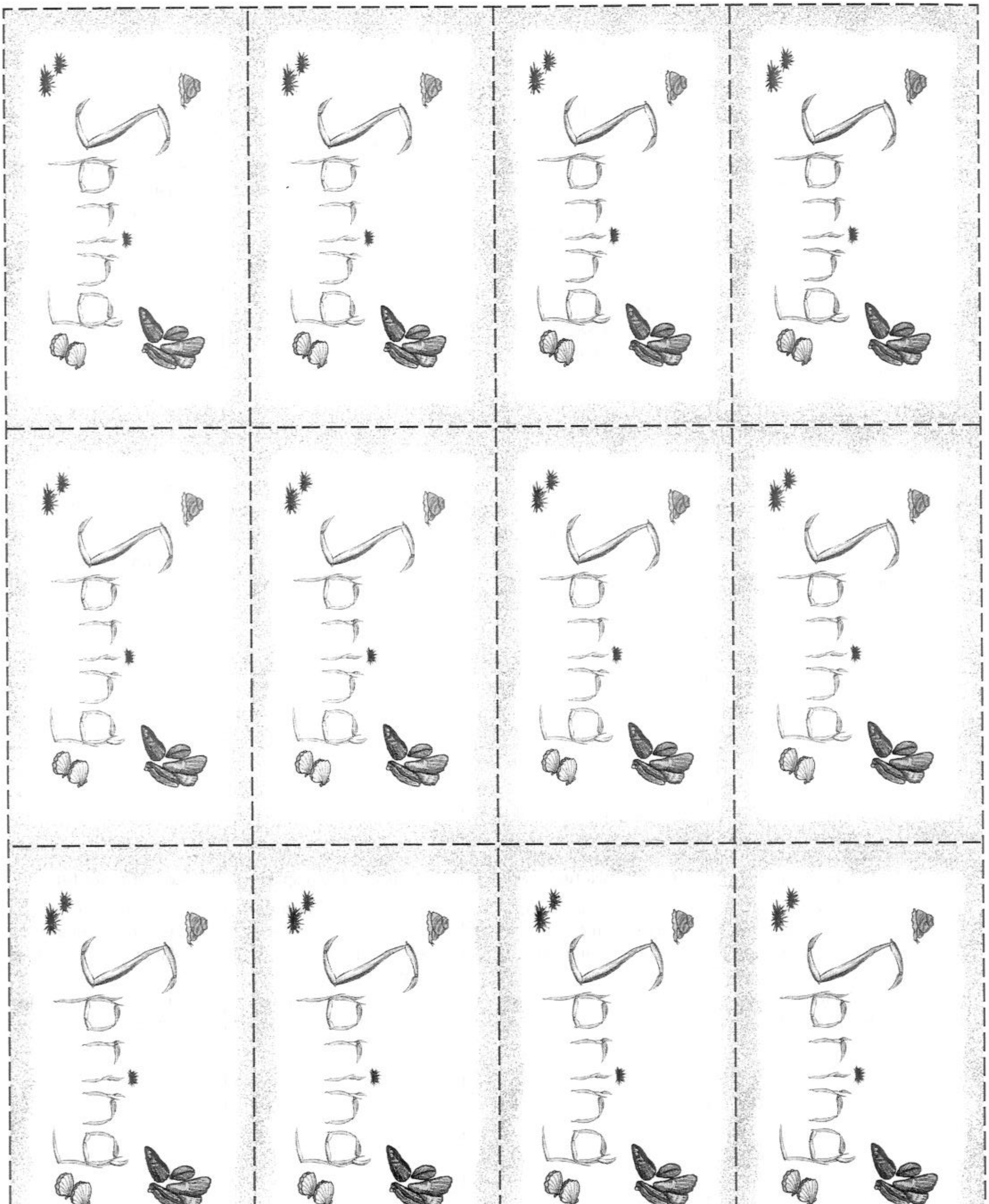
Sea otters pull octopuses from discarded soda cans and eat them.

Go forward two spaces

The sea urchin population declines and the kelp bed flourishes. Kelp crabs and snails form a larger part of the sea otter's diet.

Take another turn

A sea otter uses its paws to stash food taken from the bottom of the ocean in baggy pockets of skin under its forelegs.



Summer Cards

A sub-adult sea otter becomes entangled in a plastic bag that was floating in the water and can't get loose. It starves to death.

– 1 sub-adult

This card affects all players who are in Summer

Heavy northwesterly winds blow. The stormy waters make it difficult for the sea otters to find food. Some juvenile sea otters that aren't very good hunters can't find enough food. Two juveniles in each population die of starvation.

– 2 juveniles
(all players in Summer)

Do not replace this card in the Summer pile. Remove it from the game.

Juvenile sea otters leave their mothers and go off on their own.

Two leave the area and join another group of sea otters.

– 2 juveniles
(pass to the player on your right)

An adult male sea otter is killed by a boat propeller.

– 1 adult male

Five juveniles from a cove farther up the coast join this population.

+ 5 juveniles
(take from the player on your right)

Between 5 and 8 months of age, sea otter pups become juveniles. They leave their mothers and go off on their own. Six leave the area and join other populations.

– 3 juveniles
(pass to the player on your left)

– 3 juveniles
(pass to the player on your right)

Great white sharks sometimes mistake adult sea otters for their regular prey — seals.

A great white shark attacks and kills an adult female sea otter.

– 1 adult female

A sub-adult sea otter develops an infection after being bitten by an adult male. She soon dies from the wound.

– 1 sub-adult

Take another turn

Adult male sea otters weigh about 65 pounds, and females weigh about 45 pounds.

Go forward two spaces

Young juvenile sea otters play energetically together. They attack and destroy everything they find.

Go forward two spaces

Males reach their prime at age 8 or 9. They develop a territory and mate with many females.

Take another turn

Females mature at the age of 3 and have their first pup at age 4 or 5.