4TH GRADE

TEACHER RESOURCE GUIDE

THEME:

Food webs are complex systems that consist of many organisms depending on each other for nutrients and are affected by a variety of human and natural factors.

CRITICAL ISSUE:

Plastic Pollution, Sustainable Seafood

CONTENTS:

Aquarium of the Bay
a division of bay.org

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MISSION STATEMENT:

Aquarium of the Bay's Education and Conservation Department's mission is to promote literacy in ocean and watershed health, climate change issues, and science career development through the lens of critical issues such as sustainable seafood, marine protected areas, marine debris and plastics, climate change and fresh water flows.

ACKNOWLEDGEMENTS:

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S. D. BECHTEL, JR. FOUNDATION
STEPHEN BECHTEL FUND

LESSON 1

WHAT IS A FOOD WEB?

Enduring Understanding: All living organisms are part of a complex system called a food web.

Materials

- Index cards (one for each student)
- String (about 18 inches for each index card)
- Ball of string
- Hole punch
- Scissors

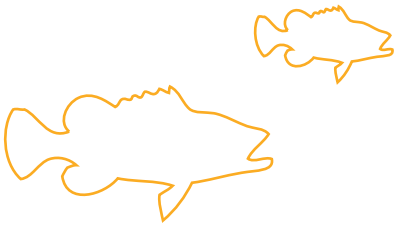
SETUP:

1. Write plant and animal names on index cards.
2. Punch holes in index cards.
3. Use string to make cards into necklaces the students can wear during the activity.

PROGRAM OUTLINE:

All living organisms, including humans, need energy and nutrients to survive.

- Talk about trophic levels and the roles—producer, consumer, and decomposer—that different animals play in the food web.
  - Have students think of examples of producers, consumers, and decomposers from ecosystems they're familiar with.



Ask the students to think of a plant or animal that they know a lot about.

- Where does this plant/animal get its nutrients from?
- What other organisms get their nutrients by eating this plant/animal?
- Discuss the terms "carnivore" (including specialized carnivores, such as insectivores and scavengers), "herbivore," and "omnivore."
  - All of these animals are consumers because they depend on other organisms for energy.

Give each student an index card with the name of a plant or animal on it to wear around their neck. Have one student be the sun.

- Examples of organisms in the San Francisco Bay Area include

- Consumers: zooplankton, worms, sand crabs, shrimp, clams, mussels, carpenter ants, duskywing butterflies, spotted cucumber beetles, anchovies, herring, salmon, bass, rockfish, giant Pacific octopus, ochre sea stars, red-legged frogs, brown pelicans, western gulls, western sandpipers, great blue herons, beavers, river otters, California sea lions, spiny dogfish sharks, sevengill sharks, leopard sharks, great white sharks, orca whales
- Decomposers: bacteria, fungi, warty sea cucumbers

• Include as many of these as you like. Feel free to add other local plants or animals the class might be studying. You can even add humans so that students can see how we are connected to the food web.

Build the food web

• Students stand in a circle and the sun starts with a ball of string.
• Have students identify an organism that gets its energy from the sun.
  - Have the sun hold the end of the string while the rest of the ball passes to that plant.
• Identify an organism that might eat that plant, or a plant similar to it, and pass the ball to them.
• Each student who gets the ball of string should hold on to the string as it's passed along through the food chain.
• The yarn can be passed to a decomposer and cut off at any point in the food chain.
  - Once the yarn has been cut, it can start over again with the sun.
• Continue this process until each member of the food web has been used at least once; some will be used many times.
  - As the students build their complex food web, discuss the different roles (producers, consumers, and decomposers) that organisms play.

Discussion

• Once the food web has been built, have the students make observations about the various connections.
  - Is it possible for an organism to be involved in multiple food chains at once?
  - Are some organisms relied on more than others?
  - Do some animals compete for the same resources?
  - How is this complex food web more stable and more realistic than a simple linear food chain?
  - What role do humans have in the food web?
    - How do our behaviors affect other organisms in the food web?
    - Do humans who eat meat have a different role than those who don't?
  - What happens if a particular animal goes extinct? How does the impact differ depending on the role that animal played in the food web?
    - You can demonstrate this by having one student drop their string and seeing how many other students in the circle are affected.
• Talk about keystone species. How is their role important? What happens if a keystone species is lost?
  - Sea otters are a local keystone species. Ask students to think about why sea otters would be a keystone species.
  - What animals do they think would be directly connected to sea otters in the local food web?

TEACHER BACKGROUND:

Producers, Consumers, and Decomposers

The food web consists of three main types of organisms: producers, consumers, and decomposers. Producers are organisms that are able to create their own food and energy through the process of photosynthesis. Consumers are herbivores, carnivores, or omnivores. They can't produce food on their own but need to consume other organisms in order to get energy. Some consumers are generalists, like many omnivores, that can eat a wide variety of foods. Others are specialists that eat a small subset of the available food source. For example, insectivores, such as frogs, are another special type of carnivore that eats only insects. There is also a special type of consumer, called a scavenger, that searches for and eats dead animals rather than hunting and killing animals itself. Decomposers, such as bacteria and fungi, eat decaying matter and break down organic material so that its nutrients and minerals can be recycled back into the soil.

LOCAL EXAMPLES OF PRODUCERS, CONSUMERS, AND DECOMPOSERS

Producers	giant kelp, pickleweed, salt grass, phytoplankton, eelgrass
Consumers	zooplankton, worms, sand crabs, shrimp, clams, mussels, carpenter ants, duskywing butterflies, spotted cucumber beetles, anchovies, herring, salmon, bass, rockfish, giant Pacific octopus, ochre sea stars, red-legged frogs, brown pelicans, western gulls, western sandpipers, great blue herons, beavers, river otters, California sea lions, spiny dogfish sharks, sevengill sharks, leopard sharks, great white sharks, orca whales
Decomposers	bacteria, fungi, warty sea cucumber

Roles in the Food Web

Plants and phytoplankton are primary producers, because they get their energy from the sun through photosynthesis. Herbivores, such as beavers and some plankton, are called primary consumers. They rely on primary producers for all of their energy. Animals like otters and many small sharks and fish that eat herbivores are called secondary consumers. They are eaten by even larger carnivores and omnivores, such as sea lions and large sharks, called tertiary consumers. At the top of this food web are apex predators. These animals have few or no predators. They include great white sharks, orca whales, and humans. Decomposers eat any matter that is dead and decaying, including both plants and animals.

Keystone Species

A keystone species is a species that is crucial to the structure of a particular ecosystem. If a keystone species is removed, the ecosystem is likely to change drastically. For example, sevengill sharks are a keystone species in the Bay Area. Their varied diet helps to control the populations of a large number of species, including herring, crabs, worms, and many others. A keystone species is often a predator, but not always. Bees are a keystone species because they pollinate so many different plants, allowing the plants to reproduce. The plants, in turn, provide shelter for many other animals. There are also keystone

plant species that provide important habitat or food resources for many animals. Sea otters are a keystone species in the San Francisco Bay Area because a main part of their diet is sea urchins. Eating them keeps the sea urchin population down. Without sea otters, the sea urchin population would grow much larger and cause extensive damage to kelp forest ecosystems.

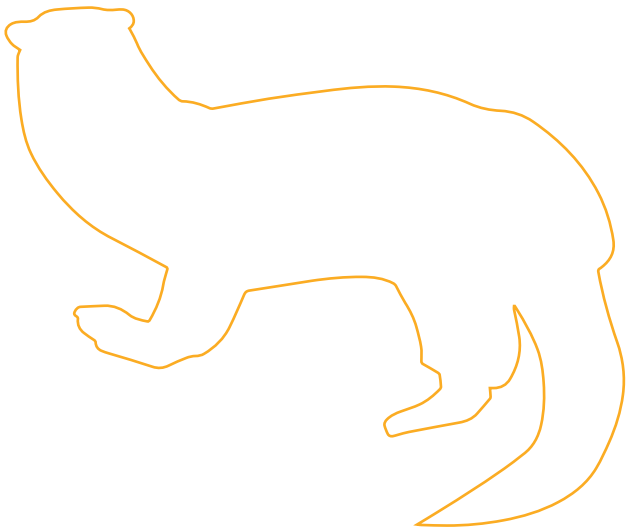
Human Impacts

Our human activities can greatly affect the intricate food webs in the ocean and elsewhere. Pollution, overfishing, and habitat destruction are just a few factors that can have a detrimental impact on animals and the environment. Fortunately, there are many simple changes we can make in our daily lives to reduce our impact on the earth.

One action students can take is to encourage their families to eat more locally grown food. Today, most people eat food that travels an average of 1,500 miles before it reaches their front door, which can have serious consequences for the environment and human health. Eating food grown and produced within 100 miles of your home reduces the amount of energy used and pollution generated to create your meal. Becoming a part of a local CSA (community supported agriculture) group is a great way to enjoy organic, seasonal, local fruits and vegetables and support local farmers.

Choosing to bike or walk instead of drive is another great way to reduce pollution, keeping both your city and Earth cleaner. Biking and walking are also great types of exercise, helping to keep you healthy and giving you more time outside. If students or parents are unable to walk or bike to school or work, carpooling is another great option that reduces pollution while saving money on gas. For more information on carpooling, biking, and air pollution, check out the Bay Area's "Spare the Air" website (http://sparetheair.org/).

One more way to reduce the human impact on ocean wildlife is by supporting sustainable seafood practices that don't overfish and are not environmentally destructive. When overfishing drastically reduces the population numbers of a certain species, it can have a big impact on other animals that prey on and are preyed upon by that species. This impact ripples outward in the food web and can end up having dramatic consequences for the ecosystem.
The Monterey Bay Aquarium Seafood Watch program helps consumers choose restaurants that support sustainable fishing and seafood that is healthy and sustainable. Participating restaurants have committed to only serving items that are Seafood Watch approved. You can support a healthy ocean by choosing to eat at such places. The Seafood Watch program also helps consumers be aware of which restaurants to avoid so that harmful fishing practices are not supported.



GLOSSARY:

Apex Predator: Carnivore that is not hunted by any other animals; apex predators are at the top of the food chain

Carnivore: Animal that eats other animals

Decomposer: Organism that eats decaying matter and breaks down organic material

Herbivore: Animal that eats only plants

Insectivore: Carnivorous animal that eats only insects

Keystone Species: Species that plays a critical role in maintaining the structure of the ecosystem and food web that they belong to; the removal of a keystone species can cause a dramatic shift in the ecosystem.

Omnivore: Animal that eats both plants and animals

Photosynthesis: Process by which plants and other organisms convert energy from the sun into energy they can use

Predator: Animal that hunts other animals

Prey: Animal that is hunted by another animal

Primary Consumer: Animal that eats plants in order to get energy

Primary Producer: Organism that makes its own food from nutrients in the soil or ocean, usually through photosynthesis

Scavenger: Animal that eats animals that are already dead

Secondary Consumer: Animal that eats herbivorous animals (and possibly plants) in order to get energy

Tertiary Consumer: Animal that eats other carnivorous and/or omnivorous animals in order to get energy

Trophic Level: Position that a group of organisms occupies in the hierarchy of the food web; these organisms share the same function within the ecosystem and have the same nutritional relationship to the primary sources of energy.

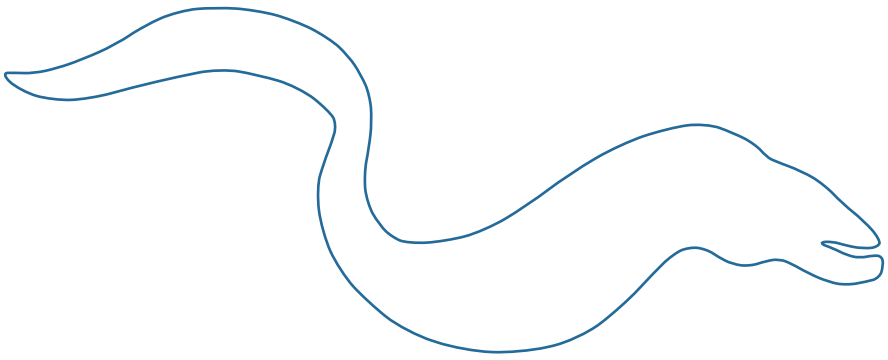
4TH GRADE STANDARDS:

California Science Content Standards

- 2. All organisms need energy and matter to live and grow. As a basis for understanding this concept
  - a. Students know plants are the primary source of matter and energy entering most food chains.
  - b. Students know producers and consumers (herbivores, carnivores, omnivores, decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.
  - c. Students know decomposers, including many fungi, insects, and microorganisms, recycle matter from dead plants and animals.

California Next Generation Science Standards

- 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
  - Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time and others are not.
- 4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
  - A system can be described in terms of its components and their interactions.



LESSON 2

ENDANGERED ANIMAL TIMELINES

Enduring Understanding: Populations of endangered animals change over time due to both human and natural factors.

Materials

- Graph paper
- Pencils and pens
- Endangered animal scenarios

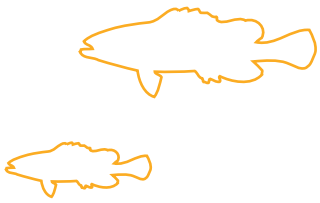
SETUP:

1. Print multiple copies of each endangered animal scenario from which students can choose.

PROGRAM OUTLINE:

What are some things that can disrupt a food web or an animal population?

- Natural disasters, pollution, invasive species, carrying capacity, loss of habitat, resource competition, and extinction of a species are examples.



Ecosystems comprise both living and nonliving components. Ask students to think about aspects of an ecosystem that fit into each category.

- How do living and nonliving components affect each other?
- How is the food web affected by both living and nonliving components?
- How are specific species affected by both living and nonliving components?

Analysis of populations of endangered species over time

- Students choose from three different animal scenarios, all of which are native endangered animals from the San Francisco Bay Area.
- Students create a bar graph and a line graph from the information to show the population changes of their chosen animal over a ten-year span.

completely historically accurate, but they represent real threats to each animal species.
- Students should label key events where drastic population changes occurred.

- Students gather into groups according to the animal they chose and share their timelines with each other to see if they got similar results.
  - Or have timeline groups pick a representative to share their animal's timeline with the class (optional).

Endangered species action plans

- While still in their animal groups, have students work together to generate action plans to remove their chosen animal from the endangered list.
  - What are the main threats to this animal?
  - What are some actions humans can take to help this animal survive?
- Have each group share their action plan with the class
  - Do elements of the different plans overlap?
  - Could some actions help multiple species at the same time?
  - Are these action plans realistic and doable?

Further questions to explore

- What other endangered animals live in the San Francisco Bay Area?
- Is going extinct a natural part of life for different species?
  - What would make the extinction of a species "natural" or "unnatural"?

TEACHER BACKGROUND:

Endangered Animals

A species is considered endangered when there are so few of its kind left that they run the risk of extinction. Both plants and animals can be endangered. There are many factors that can lead to an animal becoming endangered, including both natural and human impacts. For example, loss of habitat is a major threat that can quickly decimate the population of a species. This affects most plant and animal species worldwide, whether they're endangered or not. Not only does habitat destruction reduce the amount of shelter for animals, it increases competition for food and resources and can isolate populations of species, making it harder for them to find mates and reproduce. Though most habitat loss is caused by human activities, such as land development and logging, it can also be caused by natural disasters, such as large forest fires.

Another factor that can lead to endangerment is the introduction of nonnative (invasive) species that outcompete the native species for resources. The spotted owl and the Pacific pond turtle are both good examples of this. Because invasive species are not native to the area, they aren't likely to have any natural predators, which normally help to keep population numbers in check. In addition, the native animals they prey on have not evolved strategies to protect themselves from the invasive species and are therefore less able to defend themselves and survive.

As the number of individuals in a species decreases, so does that species' genetic diversity, making it increasingly difficult to produce healthy and successful offspring. Genetic diversity allows populations to have more variability among them and increases their chance of successfully adapting to a changing environment. When there are very few members of a species left, there is very little genetic diversity, which threatens their continued survival.

Sadly, endangered species can be found all over the world. There are nearly 100 threatened or endangered species in the San Francisco Bay Area. The Wildlife of the San Francisco Bay website (http://www.sfbaywildlife.info/species/endangered.htm) gives a comprehensive overview of the many local endangered species.

Northern Spotted Owls

Northern spotted owls are native to the Bay Area and much of the Pacific Northwest. They are considered an "indicator" species because an ecosystem that can support a spotted owl is also able to support a diversity of other plants and animals. They eat many small rodents, rabbits, snakes, insects, bats, and even other small birds. They live in large trees, often in old-growth forests. They do not build their own nests but take over nests left behind by other animals. These owls have been threatened by a variety of factors in recent years. Some of these threats include loss of habitat due to logging, feeding on rats that have been poisoned by rodenticides, predation of eggs by the common raven, human activities disturbing nesting sites, and competition for resources from the barred owl, an invasive species that is bigger and more aggressive. Although the barred owl population is currently fairly small in the Bay Area, it is expected to increase.

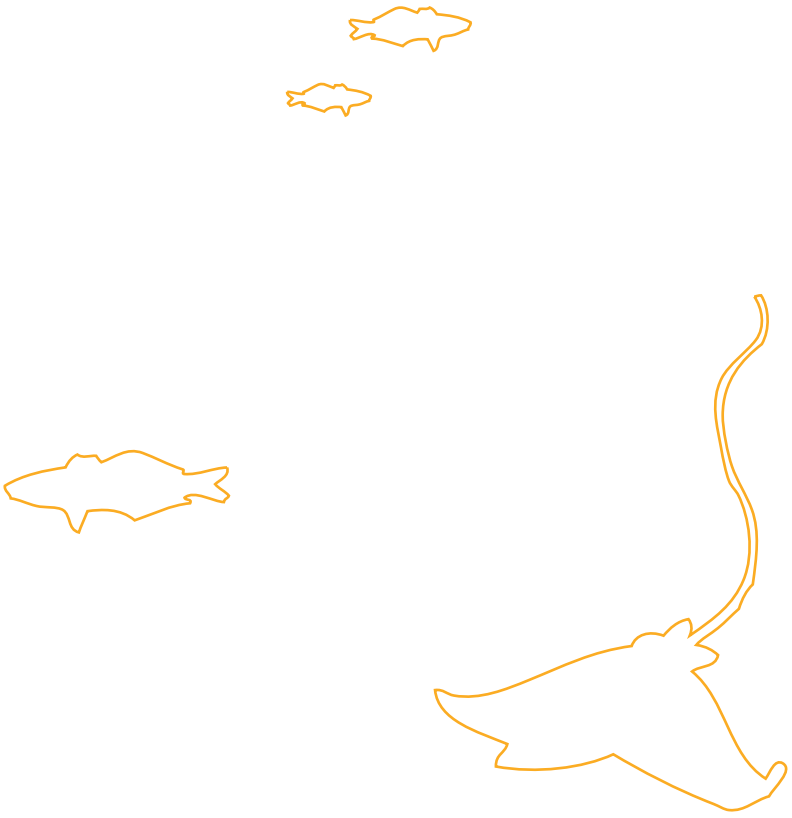
Mountain Beavers

San Francisco has a subspecies of beaver called the Point Reyes mountain beaver, which is endemic to western Marin County. Mountain beavers feed mostly at night, eating a wide variety of plants. They must consume about one-third of their body weight in water each day, which restricts them to living

near water. A fire in 1995 greatly destroyed their habitat and drastically reduced the number of beavers in the area. It is expected to take 20 years or more for their numbers to fully recover.

Western Pond Turtles

Western pond turtles (also known as Pacific pond turtles) are California's only native freshwater turtle. Many efforts are currently underway to combat declining populations in the Bay Area. Breeding programs take turtle eggs from the wild and raise the babies until they are too big to be eaten by invasive bullfrogs, at which point they are released back into the wild. They are also threatened by several invasive freshwater turtle species, many of which were released to the wild by irresponsible pet owners. Western pond turtles are usually found in ponds, rivers, marshes, lakes, or streams. They tend to prefer areas with lots of logs or boulders on which they bask in groups.



GLOSSARY:

Endangered Species: Species of plant or animal that is at serious risk of extinction

Endemic: Species of animal that is endemic to an area is found only in that particular area and nowhere else in the world.

Extinct: An animal is considered extinct if it has not been seen in the wild in 50 years or more.

Invasive Species: Organism whose introduction to a new ecosystem by human activities causes ecological harm in an environment where it is not native

Native Species: Species that naturally occurs in an area, having arrived there or become established there without human assistance or involvement

4TH GRADE STANDARDS:

California Mathematics Content Standards

Statistics, Data Analysis, and Probability

- 1.3 Interpret one- and two-variable data graphs to answer questions about a situation.

California Science Content Standards

- 3. a. Students know ecosystems can be characterized by their living and nonliving components.
- 3. b. Students know that in any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.
- 6. e. Construct and interpret graphs from measurements.

California Next Generation Science Standards

- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem
  - At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs

PROGRAM MATERIALS:

- Endangered animal scenario timelines

Name: _____

ENDANGERED ANIMAL SCENARIO TIMELINES

1.) Northern Spotted Owls

These native owls have been threatened by a variety of factors. Although the current population is considered stable, they are still considered endangered. Northern spotted owls are counted by number of pairs known in habitat conservation areas.

1990: 650 pairs known - population stable
1991: 600 pairs known - some population loss due to human disturbance of nesting sites
1992: 480 pairs known - great loss of habitat due to timber harvest
1993: 410 pairs known - still losing habitat to timber harvest
1994: 435 pairs known - some habitat restored due to logging regulations
1995: 430 pairs known - population fairly stable
1996: 310 pairs known - many owls become sick or die from eating rats that have been poisoned with rodenticide
1997: 240 pairs known - population still declining due to poisoned rats
1998: 160 pairs known - population continuing to decline
1999: 150 pairs known - public discouraged against using rodenticides for rats
2000: 115 pairs known - common raven population expands (common ravens eat northern spotted owl eggs)

2.) Mountain Beavers

The Point Reyes mountain beaver is a subspecies of beaver endemic to western Marin County, which means it is found nowhere else in the world. This information shows the number of individual beavers estimated in this habitat.

1990: 5,800 beavers - population stable
1991: 6,050 beavers - plenty of resources available; good year for reproduction
1992: 5,250 beavers - human removal of blackberry and poison oak reduces available food
1993: 5,200 beavers - population stable
1994: 5,150 beavers - population stable
1995: 20 beavers - a large fire destroys 40 percent of the mountain beaver's known habitat
1997: 35 beavers - recovery of vegetation in some areas after the fire
1998: 60 beavers - more vegetation recovery
1999: 80 beavers - numbers continue to slowly recover
2000: 95 beavers - numbers continue to slowly recover

Name: _____

ENDANGERED ANIMAL SCENARIO TIMELINES

3.) Western Pond Turtles

Western pond turtles are the only native freshwater aquatic turtle in California. Their main threats are loss of habitat and competition from nonnative animals. This set of data looks at how many individual turtles are in one particular pond each year.

1990: 120 turtles - population stable
1991: 105 turtles - invasive red-eared slider turtles bring diseases and start competing for food and shelter
1992: 85 turtles - red-eared slider populations continue to increase
1993: 95 turtles - efforts are made to remove red-eared sliders from this area
1994: 100 turtles - population stable
1995: 75 turtles - invasive bullfrogs enter the area and eat western pond turtle eggs
1996: 60 turtles - bullfrog populations continue to increase
1997: 35 turtles - bullfrog populations continue to increase
1998: 40 turtles - efforts are made to remove bullfrogs from this area
1999: 50 turtles - population stable
2000: 30 turtles - population decreases due to building development and loss of habitat

LESSON 3

WHO LIVES IN MY BACKYARD?

Enduring Understanding: All animals are part of a food web.

Materials

• "Food Web Investigation" handout

SETUP:

1. If doing this activity as a class, find a good outdoor space within walking distance in which the class can search for wildlife.
2. Make copies of the handout.

PROGRAM OUTLINE:

Introduction

- Students will learn about the various roles that animals play in food webs. They will then investigate food webs found in local outdoor areas.
- All living organisms, including humans, need energy and nutrients to survive.
- Talk about trophic levels and the roles—producer, consumer, and decomposer—played by different animals in the food web.
  - Have students think of examples of producers, consumers, and decomposers from ecosystems they're familiar with.
  - Students should write down the various trophic levels to reference while doing their investigation.
- Ask students to think about a plant or animal that they know a lot about.
  - From what does this plant/animal get its nutrients?
  - What other organisms get their nutrients by eating this plant/animal?
  - Discuss the terms "carnivore" (including specialized carnivores, such as insectivores and scavengers), "herbivore," and "omnivore." All of these animals are consumers because they depend on other organisms for energy.
  - How is this animal specially built to survive in its environment? What does this animal have on its body that helps it eat? What does it have that protects it from other

animals?

- All animals have special adaptations—parts of their body or behaviors that help them to successfully grow, reproduce, and survive in their environment.
  - How are carnivores and herbivores differently adapted to suit their needs?
  - What kinds of adaptations do humans have to help us survive?
- Before beginning the investigation, go through an example on the "Food Web Investigation" handout with students so they know what to record and where to write it (there is already one example written on the sheet).
  - While explaining the investigation, make sure students know that they are making inferences from their observations. This is a big part of how scientists get their information, by interpreting the data that they collect.
  - Let students know that science often involves making the best guess we can, given the information we have available to us from our observations.

Food web investigation

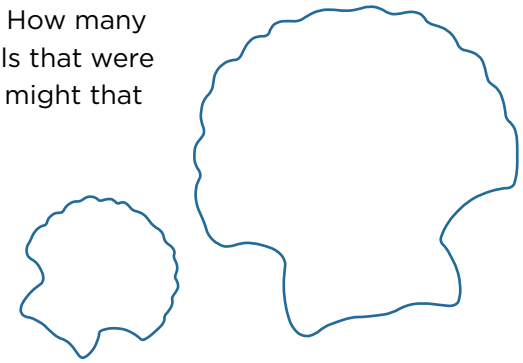
- After learning about the different roles that animals play in the food web, students will investigate an outdoor area by searching for animals and thinking about how they fit together in a food web.
- This can be done as a class in an outdoor space near the school, or students can take the worksheet home and do this investigation in their backyard or nearby park.
  - At school, students can work in small groups or individually, and you can float among groups, giving them support
- Using the "Food Web Investigation" sheet, students record up to ten animals that they are able to find in a chosen outdoor area.
  - Students record the animal, what they think it eats, what they think eats it, and what trophic level they think it is.
  - If students are having a difficult time with the concept of trophic level, they can write whether the animal is an herbivore, omnivore, or carnivore.
  - Students should think about how all the animals in the area fit together into a food web. They should make observations to support their ideas.

Optional activity

- Using the data they gathered from their first exploration, students can choose a second site to explore and predict what animals they think they will find in the area.

- Students use the same "Food Web Investigation" sheet and record the animals they find at the new site.

- What animals did they predict they would see and why? How many animals were found in both areas? Were there any animals that were different? How were the outdoor sites different and how might that attract different animals?



PROGRAM OUTLINE CONTINUED:

Group discussion

- Once students have finished their investigations and filled out their sheets, gather them in small groups to discuss their findings.
- You can help guide their discussions with some of the following questions.

  - Did any students find the same animals? What did they find that was different?
  - What other animals do they think might be there that they didn't observe?
  - Are there animals that live in burrows or somewhere else they can't see?
  - What about nocturnal animals that only come out at night?
  - Do all the animals stay in one area or do they move around between spaces?
  - Do all areas have their own separate food webs or do food webs overlap throughout the world?
  - How could they investigate more of these questions?

TEACHER BACKGROUND:

The food web consists of three main types of organisms: producers, consumers, and decomposers. Producers are organisms that are able to create their own food and energy through the process of photosynthesis. Consumers are herbivores, carnivores, or omnivores. They can't produce food on their own but need to consume other organisms in order to get energy. Some consumers are generalists, like many omnivores that can eat a wide variety of foods, while others are specialists that eat a small subset of the available food source. For example, insectivores, such as frogs, are another special type of carnivore that eats only insects. There is also a special type of consumer, called a scavenger, that searches for and eats dead animals rather than hunting and killing animals itself. Decomposers, such as bacteria and fungi, eat decaying matter and break down organic material so that its nutrients and minerals can be recycled back into the soil.

Local Examples of Producers, Consumers, and Decomposers

Producers	giant kelp, pickleweed, salt grass, phytoplankton, eelgrass
Consumers	zooplankton, worms, sand crabs, shrimp, clams, mussels, carpenter ants, duskywing butterflies, spotted cucumber beetles, anchovies, herring, salmon, bass, rockfish, giant Pacific octopus, ochre sea stars, red-legged frogs, brown pelicans, western gulls, western sandpipers, great blue herons, beavers, river otters, California sea lions, spiny dogfish sharks, sevengill sharks, leopard sharks, great white sharks, orca whales
Decomposers	bacteria, fungi, warty sea cucumber

Every animal and plant is specially adapted to survive in its environment, and animals with different roles in the food web have different adaptations to suit them. For example, many herbivores tend to have teeth or mouths that are good for grinding or chewing plants, whereas carnivores tend to have sharper teeth for ripping apart meat. Animals that live in the water will most likely have adaptations that allow them to swim, hold their breath for a long time or breathe underwater, and be able to see underwater. Adaptations can also be behaviors, such as living in groups and raising young together, or coming out at night because it is cooler than during the day. Both plants and animals evolve over time to be well adapted to the environments in which they live.

GLOSSARY:

Adaptation: Something on an animal's body, or a behavior, that helps it survive in its environment

Carnivore: Animal that eats other animals

Decomposer: Organism that eats decaying matter and breaks down organic material

Herbivore: Animal that eats only plants

Insectivore: Carnivorous animal that eats only insects

Inference: Reaching a conclusion about something based on information and observations

Observation: Something that you notice or perceive; the scientific process of gathering information by studying a subject firsthand using the senses

Omnivore: Animal that eats both plants and animals

Predator: Animal that hunts other animals

Prey: Animal that is hunted by another animal

Primary Producer: Organism that makes its own food from nutrients in the soil or ocean, usually through photosynthesis

Primary Consumer: Animal that eats other plants in order to get energy
Scavenger: Animal that eats animals that are already dead

Secondary Consumer: Animal that eats herbivorous animals (and possibly also plants) in order to get energy

Tertiary Consumer: Animal that eats other carnivorous and/or omnivorous animals in order to get energy

Trophic Level: Position that a group of organisms occupies in the hierarchy of the food web; these organisms share the same function within the ecosystem and have the same nutritional relationship to the primary sources of energy.

4TH GRADE STANDARDS:

California Science Content Standards

- 6. a. Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.
- 6. d. Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.
- 6. f. Follow a set of written instructions for a scientific investigation.

California Common Core Standards

ELA/Literacy

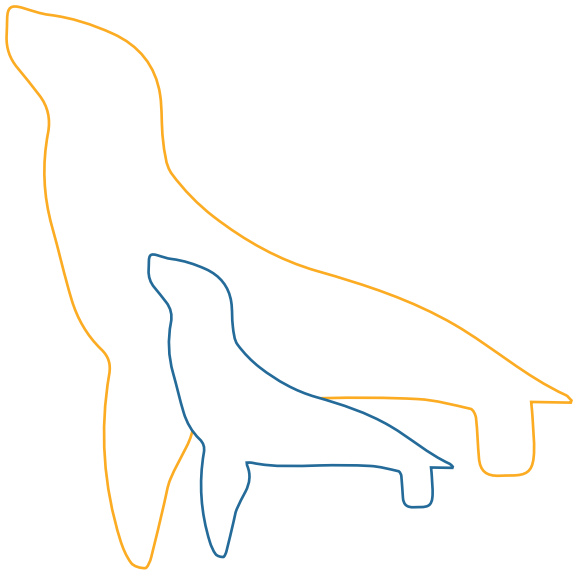
- W 7. Conduct short research projects that build knowledge through investigation of different aspects of a topic.

California Next Generation Science Standards

- 4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
  - Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

PROGRAM MATERIALS:

- "Food Web Investigation" handout



Name: _____

FOOD WEB INVESTIGATION

Animal	What does it eat?	What is it eaten by?	Trophic Level
sea lion	fish, squid, octopus	great white sharks	Consumer (tertiary)

LESSON 4

FOOD WEB TRIVIA

Enduring Understanding: Food webs are intricate systems made up of a variety of organisms with different roles, which are affected by both human and environmental influences.

Materials

- Food Web Trivia questions
- Paper and pens/pencils
- Scoreboard

SETUP:

1. Set up four tables at which teams can sit together to answer questions.
2. Provide each team with scratch paper and pens/pencils.

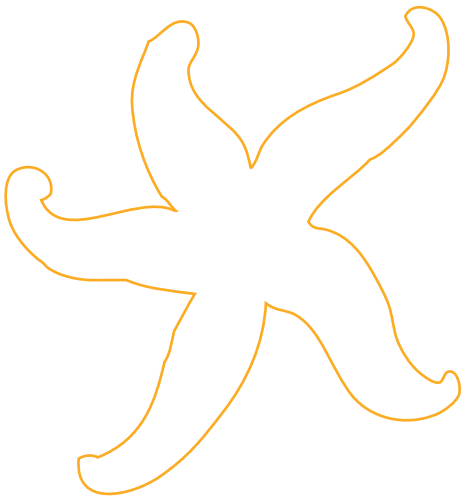
PROGRAM OUTLINE:

Introduction

- This trivia game will help students review what they have learned about the food web. It should be played after completing at least one of the other lessons in this guide.
- This activity is also a great assessment tool for teachers to see how well the students have learned the material.

Food webs are intricate systems in which every member is vital to survival.

- There are many organisms that make up a food web, with a variety of functions. When these organisms are balanced, they create a healthy, resilient ecosystem.
- There are also many factors, both human and environmental, that can cause a food web to change or collapse.



Let students know that this game will give them a chance to show off what they have learned about the food web in other lessons.

- They should work together as a group to answer the questions and be supportive of other teams as well.

PROGRAM OUTLINE CONTINUED:

Students may use the paper and pens/pencils to communicate or to write down answers, but will not be turning them in.

- All answers will be given orally.

Set up the game

- Divide students into teams of about four to six members. Allow each group to come up with a team name. Keep track of their points on the board as you play the game.
- Use the questions provided, but also use this opportunity to allow students to come up with their own questions.
  - One option is to ask each student to submit three questions of their own creation before the game. You can determine which questions you would like to add and how many points they will be worth.

Play the game

- There are three categories of questions provided: questions worth one point, questions worth two points, and final round questions where groups must come up with more involved answers.
  - Give Team A the option to answer a one- or two-point question. You can choose which question to ask out of the category they pick or pull the questions at random.
  - For each question, allow the team who picked first to answer first. If they get the answer wrong, open the question up to other teams.
  - In order to give each team an equal opportunity to answer, rotate who gets to pick the question each time (i.e., Team A picks the first question, Team B picks the second question, Team C picks the third question, etc.)
- Each team starts at the level of "Primary Producer."
- For every three points a team earns, the team moves up the food chain: Producer, Primary Consumer, Secondary Consumer, Apex Predator, Decomposer.
- If a team makes it all the way up to Decomposer, they can start over as a Producer, keeping the points they have earned. (This drives home the idea that the food web is cyclical and has no end.)
- For the final round, students must work as a group to come up with a solution to solve a scenario problem. The solution should include human steps that can be taken in order to restore balance to the food web.
  - There isn't necessarily one right answer to this scenario. Students should be awarded up to five points based on the creativity of their solution and how well they considered the issue from different angles.
  - All students should be given the same scenario so they can compare their solutions with the other groups and see that there can be multiple ways to solve the same problem. Encourage a group discussion about the pros and cons of each approach.
  - Groups will be given ten minutes to create their solution and will then choose a representative to present their ideas to the rest of the class.
- The team with the most points after the final round wins!
  - Reward the winning team in whatever way you like. It's nice to have consolation prizes for the other teams as well.

PROGRAM OUTLINE CONTINUED:

Post-game reflection

- Ask the students to individually write down three important things they learned about food webs from these lessons.
  - Each student should share one of these facts with the class.
  - This is also a great way for you to assess what students are getting from the curriculum and what they might be missing.

TEACHER BACKGROUND:

(NOTE: In order for students to get the most out of this game, they should participate in two or three of the other lessons in this guide.)

Producers, Consumers, and Decomposers

The food web consists of three main types of organisms: producers, consumers, and decomposers. Producers are organisms that are able to create their own food and energy through the process of photosynthesis. Consumers are herbivores, carnivores, or omnivores. They can't produce food on their own and need to consume other organisms in order to get energy. Some consumers are generalists, such as many omnivores that can eat a wide variety of foods, while others are specialists that eat a small subset of the available food source. For example, insectivores, such as frogs, are a special type of carnivore that eats only insects. There is also a special type of consumer, called a scavenger, that searches for and eats dead animals rather than hunting and killing animals itself. Decomposers, such as bacteria and fungi, eat decaying matter and break down organic material so that its nutrients and minerals can be recycled back into the soil.

Local Examples of Producers, Consumers, and Decomposers

Producers	giant kelp, pickleweed, salt grass, phytoplankton, eelgrass
Consumers	zooplankton, worms, sand crabs, shrimp, clams, mussels, carpenter ants, duskywing butterflies, spotted cucumber beetles, anchovies, herring, salmon, bass, rockfish, giant Pacific octopus, ochre sea stars, red-legged frogs, brown pelicans, western gulls, western sandpipers, great blue herons, beavers, river otters, California sea lions, spiny dogfish sharks, sevengill sharks, leopard sharks, great white sharks, orca whales
Decomposers	bacteria, fungi, warty sea cucumber

Roles in the Food Web

Plants and phytoplankton are primary producers, as they get their energy from the sun through photosynthesis. Herbivores, such as beavers and some plankton, are called primary consumers. They rely on primary producers for all of their energy. Animals like otters and many small sharks and fish that eat herbivores are called secondary consumers. They are eaten by even larger carnivores and omnivores, such as sea lions and large sharks, called tertiary consumers. At the top of this food web are apex predators. These are animals that have few or no predators and include great white sharks, orca whales, and humans. Decomposers eat any matter that is dead and decaying, including both plants and animals.

Keystone Species

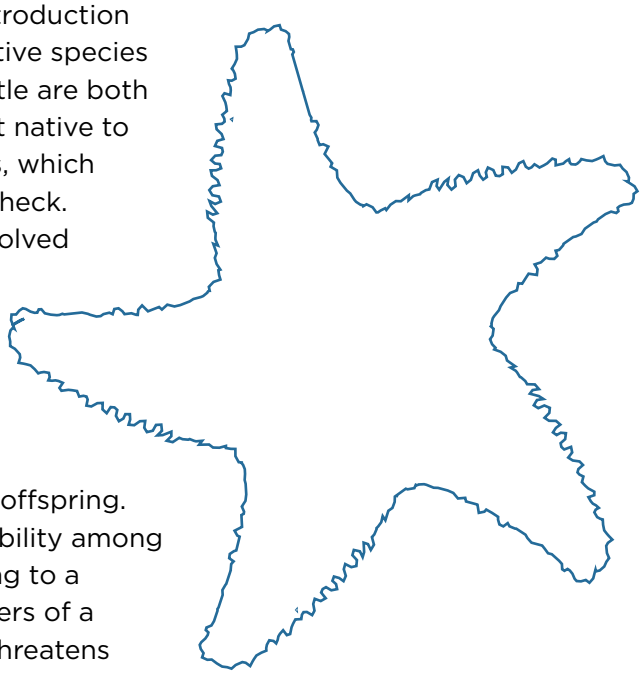
A keystone species is a species that is crucial to the structure of a particular ecosystem. If a keystone species is removed, the ecosystem is likely to change drastically. For example, sevengill sharks are a

keystone species in the Bay Area. Their varied diet helps to control the populations of a large number of species, including herring, crabs, worms, and many others. A keystone species is often a predator, but does not have to be. Bees are a keystone species because they pollinate so many different plants, allowing the plants to reproduce. The plants, in turn, provide shelter for many other animals. There are also keystone plant species that provide important habitat or food resources for many animals. Sea otters are a keystone species in the San Francisco Bay Area because a main part of their diet is sea urchins. Eating them keeps the sea urchin population down. Without sea otters, the sea urchin population would grow much larger and cause extensive damage to kelp forest ecosystems.

Endangered Animals

A species is considered endangered when there are so few of its kind left that they run the risk of extinction. Both plants and animals can be endangered. There are many factors that can lead to an animal becoming endangered, including both natural and human impacts. For example, loss of habitat is a major threat that can quickly decimate the population of a species. This affects most plant and animal species worldwide, whether they're endangered or not. Not only does habitat destruction reduce the amount of shelter for animals, it increases competition for food and resources and can isolate populations of species, making it harder for them to find mates and reproduce. Though most habitat loss is caused by human activities, such as land development and logging, it can also be caused by natural disasters, such as large forest fires.

Another factor that can lead to endangerment is the introduction of nonnative (invasive) species that outcompete the native species for resources. The spotted owl and the Pacific pond turtle are both good examples of this. Because invasive species are not native to the area, they aren't likely to have any natural predators, which is what normally helps to keep population numbers in check. In addition, the native animals they prey on have not evolved strategies to protect themselves from the invasive species and are therefore less able to defend themselves and survive.



As the number of individuals in a species decreases, so does that species' genetic diversity, making it increasingly difficult to produce healthy and successful offspring. Genetic diversity allows populations to have more variability among them and increases their chance of successfully adapting to a changing environment. When there are very few members of a species left, there is very little genetic diversity, which threatens their continued survival.

Sadly, endangered species can be found all over the world. There are nearly 100 threatened or endangered species in the San Francisco Bay Area. This Wildlife of the San Francisco Bay website (http://www.sfbaywildlife.info/species/endangered.htm) gives a comprehensive overview of the many local endangered species.

TEACHER BACKGROUND CONTINUED:

Human Impacts

Our human activities can greatly affect the intricate food webs in the ocean and elsewhere. Pollution, overfishing, and habitat destruction are just a few factors that can have a detrimental impact on animals and the environment. Fortunately, there are many simple changes we can make in our daily lives to reduce our impact on the earth.

One action students can take is to encourage their families to eat more locally grown food. Today, most people eat food that travels an average of 1,500 miles before it reaches their front door. This can have serious consequences for the environment and human health. Eating food grown and produced within 100 miles of your home reduces the amount of energy used and pollution generated to create your meal. Becoming a part of a local CSA (community supported agriculture) group is a great way to enjoy organic, seasonal, local fruits and vegetables and support local farmers.

Choosing to bike or walk instead of drive is another great way to reduce pollution, keeping both your city and Earth cleaner. Biking and walking are also great types of exercise, helping to keep you healthy and giving you more time outside. If students or parents are unable to walk or bike to school or work, carpooling is another great option that reduces pollution while saving money on gas. For more information on carpooling, biking, and air pollution, check out the Bay Area's "Spare the Air" website (http://sparetheair.org/).

One more way to reduce our human impact on ocean wildlife is by supporting sustainable seafood practices that don't overfish and are not environmentally destructive. When overfishing drastically reduces the population numbers of a certain species, it can have a big impact on other animals that prey on and are preyed upon by that species. This impact ripples outward in the food web and can end up having dramatic consequences for the ecosystem. The Monterey Bay Aquarium Seafood Watch program helps consumers choose restaurants that support sustainable fishing and seafood that is healthy and sustainable. Participating restaurants have committed to only serving items that are Seafood Watch approved. You can support a healthy ocean by choosing to eat at such places. The Seafood Watch program also helps consumers be aware of which restaurants to avoid so that harmful fishing practices are not supported.

GLOSSARY:

Adaptation: Something on an animal's body, or a behavior, that helps it survive in its environment

Apex Predator: Carnivore that is not hunted by any other animals; apex predators are at the top of the food web.

Carnivore: Animal that eats other animals

Decomposer: Organism that eats decaying matter and breaks down organic material

Endangered Species: Species of plant or animal that is at serious risk of extinction

Endemic: A species of animal that is endemic to an area is found only in that particular area and nowhere else in the world.

Herbivore: Animal that eats only plants

Inference: Reaching a conclusion about something based on information and observations

Insectivore: Carnivorous animal that eats only insects

Invasive Species: Organism whose introduction causes ecological harm in an environment where it is not native

Keystone Species: Species that plays a critical role in maintaining the structure of the ecosystem and food web that they belong to; the removal of a keystone species can cause a dramatic shift in the ecosystem.

Native Species: Species that naturally occurs in an area, having arrived there or become established there without human assistance

Observation: Something that you notice or perceive

Omnivore: Animal that eats both plants and animals

Photosynthesis: Process by which plants and other organisms convert energy from the sun into energy they can use

Predator: Animal that hunts other animals

Prey: Animal that is hunted by another animal

Primary Consumer: Animal that eats plants in order to get energy

GLOSSARY CONTINUED:

Primary Producer: Organism that makes its own food from nutrients in the soil or ocean, usually through the process of photosynthesis

Scavenger: Animal that eats animals that are already dead

Secondary Consumer: Animal that eats herbivorous animals (and possibly also plants) in order to get energy

Tertiary Consumer: Animal that eats other carnivorous and/or omnivorous animals in order to get energy

Trophic Level: Position that a group of organisms occupies in the hierarchy of the food web; these organisms share the same function within the ecosystem and have the same nutritional relationship to the primary sources of energy.

4TH GRADE STANDARDS:

California Common Core Standards

ELA/Literacy

- W.8. Recall relevant information from experiences or gather relevant information from print and digital source; take notes, paraphrase, and categorize information, and provide a list of sources.
- L.6. Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., quizzed, whined, stammered) and that are basic to a particular topic (e.g., wildlife, conservation, and endangered when discussing animal preservation).

California Science Content Standards

- 2.a. Students know plants are the primary source of matter and energy entering most food chains.
- 2.b. Students know producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.
- 2.c. Students know decomposers, including many fungi, insects, and microorganisms, recycle matter from dead plants and animals.

California Next Generation Science Standards

- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
  - At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
  - Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

PROGRAM MATERIALS:

- Food Web Trivia questions and final round scenario

Name: _____

FOOD WEB TRIVIA QUESTIONS

1-Point Questions

- Q: Give a definition of an apex predator (bonus: name an apex predator in the Bay Area).
- A: An apex predator is an animal that hunts other animals and is hunted by few or no other animals. Great white sharks and orca whales are the main apex predators in the Bay Area.

- Q: What do you call an animal that eats only insects?
- A: Insectivore

- Q: How is a scavenger different from a predator?
- A: Scavengers don't kill the animals themselves. They eat the meat that is left from what other animals have killed, or animals that have died of natural causes.

- Q: What is the role of a decomposer?
- A: Decomposers eat decaying matter and break down organic material so that its nutrients and minerals can be recycled back into the soil.

- Q: What is photosynthesis?
- A: Photosynthesis is the process by which plants and other organisms convert energy from the sun into energy they can use.

- Q: Name two adaptations that humans have.
- A: A big brain for thinking, opposable thumbs for grabbing things, hair to stay warm, fingernails and toenails to protect our fingers and toes, long legs for walking and running, etc. (Just about anything is an adaptation for something!)

- Q: What is a keystone species?
- A: A species that plays a critical role in maintaining the structure of its ecosystem and food web despite having small numbers compared to other species

- Q: What are the definitions of predator and prey?
- A: A predator eats other animals and prey is eaten by other animals.

- Q: What do you call an animal that eats both plants and animals?
- A: Omnivore

- Q: Give a definition of the term "trophic level."
- A: A trophic level is the position that an organism occupies in the food web, such as producer, consumer, or decomposer.

Name: _____

FOOD WEB TRIVIA QUESTIONS

2-Point Questions

- Q: Which category of organisms uses photosynthesis to create their energy?
- A: Producers

- Q: What would happen if we didn't have any decomposers?
- A: Decaying matter would pile up and never get recycled back into the earth. Decomposers are very important for keeping our planet livable!

- Q: Name two Bay Area animals that have a predator/prey relationship.
- A: Examples include sea lion and salmon, sea otters and clams, great white sharks and seals.

- Q: What can happen if a keystone species disappears from the food web?
- A: The removal of a keystone species can cause a dramatic shift in the ecosystem, allowing animals that the species preys on to explode in numbers, possibly wiping out the plant species that the prey animal eats, dramatically altering the ecosystem.

- Q: Name the three categories of organisms in the food web (bonus points: name one organism from each category).
- A: Producers, Consumers, and Decomposers

- Q: Name at least two issues caused by invasive plants and/or animals.
- A: In general, they disrupt the natural ecosystem that has evolved in an area. They compete with native plants/animals for resources; they have no natural predators in the area so they tend to spread and grow quickly; they can bring diseases with them; they might eat native species and greatly decline their numbers or cause them to go extinct; it costs money for humans to try to control invasive populations. (There are many other possible answers!)

- Q: Name three plants or animals that are native to the San Francisco Bay Area.
- A: Some possibilities include algae, pickleweed, salt grass, phytoplankton, zooplankton, worms, sand crabs, shrimp, clams, insects, anchovies, herring, salmon, bass, frogs, pelicans, western sandpipers, great blue herons, beavers, otters, sea lions, spiny dogfish sharks, sevengill sharks, leopard sharks, great white sharks, orca whales

- Q: Why is a food "web" more resilient than a simple food "chain"?
- A: If one species is disturbed or goes extinct, a food web has more ability to adapt because there is a greater diversity of organisms involved.

- Q: Name two factors that could either raise or lower an area's carrying capacity.
- A: Temporary or permanent destruction of habitat; introduction of a new species; diversion of a waterway; climate change; change in other plants or animal populations

Name: _____

FOOD WEB TRIVIA QUESTIONS

- Q: Construct a three-level food chain from plants/animals you might find in your backyard
- A: Examples include grass - rabbit - hawk; fly - spider - bird; mouse - cat - coyote.

Third Round Question

This scenario takes place in the ocean. Anchovies are a vital part of the San Francisco Bay food web. They mainly eat plankton. Many animals rely on anchovies as a food source, such as sea lions, salmon, pelicans, and many others. Due to increased public demand for anchovies, the anchovy population has been overfished and dramatically reduced. More fishing means more jobs for local fishermen and is good for the economy, but some people are concerned that overfishing of anchovies will have a damaging effect on the ecosystem. With your team, design a realistic action plan to address this issue, taking into account all the different viewpoints involved.

4TH GRADE

RESOURCES

Books and Media

• Bill Nye the Science Guy, Food Web [videorecording] Disney Educational Productions (available at the San Francisco Public Library)

• Capeci, Anne. Food Chain Frenzy (The Magic School Bus Chapter Book, No. 17). Scholastic, 2004.

• Crenson, Victoria. Horseshoe Crabs and Shorebirds: The Story of a Food Web. Amazon: Two Lions, 2009. (available at the San Francisco Public Library)

• Crossingham, John and Bobbie Kalman. Seashore Food Chains. New York: Crabtree, 2005.

• Fleisher, Paul. Ocean Food Webs (Early Bird Food Webs). Minneapolis: Lerner Publications, 2007.

• Kalman, Bobbie. What Are Food Chains and Webs? (Science of Living Things). New York: Crabtree, 1998.

• Lauber, Patricia and Holly Keller. Who Eats What? Food Chains and Food Webs (Let's-Read-and-Find-Out Science, Stage 2). New York: HarperCollins, 1994.

• Macaulay, Kelley and Bobbie Kalman. Coral Reef Food Chains. New York: Crabtree, 2005.

• Moore, Heidi. Ocean Food Chains (Protecting Food Chains). Portsmouth, NH: Hienemann, 2010.

• Slade, Suzanne. What If There Were No Sea Otters? A Book about the Ocean Ecosystem (Food Chain Reactions). Picture Window Books, 2010.

• Solway, Andrew. Food Chains and Webs: The Struggle to Survive; Life Science (Let's Explore Science). Rourke Educational Media, 2008.

• Spilsbury, Louise and Richard Spilsbury. Food Chains and Webs: From Producers to Decomposers (Science Answers). Portsmouth, NH: Heinemann, 2004.

• [Various authors], Fascinating Food Chains (book series), Magic Wagon.

4TH GRADE

RESOURCES

Websites

• Monterey Bay Aquarium Seafood Watch
http://www.seafoodwatch.org/cr/seafoodwatch.aspx

• San Francisco Estuary Partnership
http://www.sfestuary.org/

• Spare the Air
http://sparetheair.org/

• Wildlife of the San Francisco Bay Area
http://sfbaywildlife.info/