Food Web & Bioaccumulation

Grade Level(s): 6th – 8th
Time: 35-45 minutes
Group Size: 20-30 students

NYS Learning Standards
Core Curriculum MST

Living Environment: Standard 4
Students will: understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

- *Key Idea 5*: Organisms maintain a dynamic equilibrium that sustains life.
- *Key Idea 6*: Plants and animals depend on each other and their physical environment.
- *Key Idea 7*: Human decisions and activities have a profound impact on the physical and living environment.

Summary

Students will be introduced to some of the animals that live in an aquatic environment. The dynamics of food chains and food webs, and the roles organisms play as consumers, producers, and decomposers in the food pyramid will be introduced. Students will participate in an activity to learn how aquatic organisms and humans play a role in the aquatic food web as consumers.

Objectives

The lesson objective is to create an understanding of the dynamics of a food web, chain, and pyramid in aquatic environments, and how humans can play an important role in the health of food webs. Other goals include understanding biotic (living) and abiotic (non-living) environmental factors, fish behavior, and bioaccumulation.

After this presentation, students will be able to:

- Explain the parts of a food pyramid and some of the inter-relationships within a food web and food chain.
- Identify different organisms found in an aquatic ecosystem.
- Classify the feeding roles of different organisms found in an aquatic ecosystem.
- Discuss human impacts on the environment and possible solutions.
- Explain how bioaccumulation affects an ecosystem

Materials

- Fish mounts or pictures
- Freshwater and/or Saltwater Life Cards
- Poker chips (at least 3 different colors; 1 color 30% of total number)
- Small plastic, paper, cloth bags or containers
- Large area (clear of desks)
- Chalk or dry erase board and markers
- Food Web worksheet

Vocabulary

- **Abiotic Factors** – the non-living aspects of the environment; ex: water, sunlight, rocks, oxygen, wind, temperature
- **Bioaccumulation** – the progressive increase in the amount of a chemical or substance in an organism
- **Biotic Factors** – the living aspects of the environment; ex: plants and animals
- **Carnivores** – are meat eaters; feed solely on other consumers
- **Consumers** - cannot perform photosynthesis; use organic substrates to get energy; ex: herbivores and carnivores
- **Decomposers** - consume dead organisms; ex: bacteria, some insects, and fungi
- **Detritus** – dead or decaying plant and animal matter; food for some consumers
- **Ecosystem** – a community of organisms and their environment
- **Eutrophication** – the process where water bodies receive extra nutrients that cause an increase in plant growth
- **Food Chain** - the transfer of food energy from plants through herbivores to carnivores; ex: plant-insect-fish-seal; phytoplankton-zooplankton-fish-osprey; algae-clam-human
- **Food Pyramid** – the flow of energy up through food chain (trophic levels), from producers through primary, secondary, tertiary and quaternary consumers
- **Food Web** – are food chains linked to form a complex interconnected web
- **Herbivores –** are primary consumers; feed solely on plants
- **Omnivores** - feed on both plants and animals
- **Photic Zone** – the sunlit portion of the water
- **Phytoplankton** – are tiny free-floating aquatic plants that drift with ocean currents
- **Producers** – are the base of food pyramid; able to produce oxygen through photosynthesis; ex: plants
- **Trophic Level** - is the level or position of an organism in a food chain
- **Zooplankton** – are tiny free-floating aquatic animals that drift with ocean currents, and feed on phytoplankton

Vocabulary words will show up once in **bold**

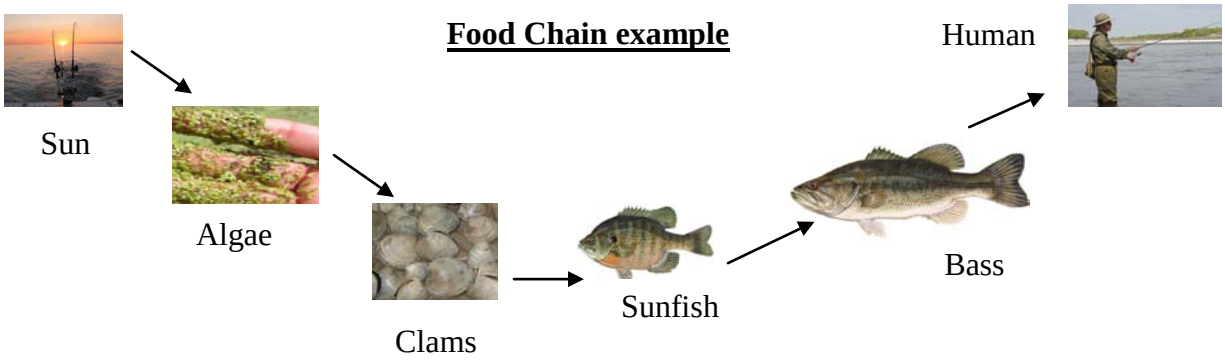
Background

Every living organism needs energy to survive. The source of energy for most life on earth is the sun. Green plants can use the energy of the sun to make their own food through photosynthesis. Because green plants produce their own food, they are called producers. All other organisms get their food energy by consuming other organisms and are thus called consumers.

Every organism can be classified by where it fits into the **food pyramid**. Most broadly, all organisms fit into one of three trophic levels: producers, consumers, and decomposers; depending on how it gets its energy. Every living organism needs energy to survive. Organisms

within a community depend on one another for food to create energy for survival. This feeding relationship is referred to as a food chain. A **food chain** is a linear arrangement of organisms up through trophic levels expressing how each receives its energy, either by making its own energy (plants) or by consuming other organisms.

Food Chain example

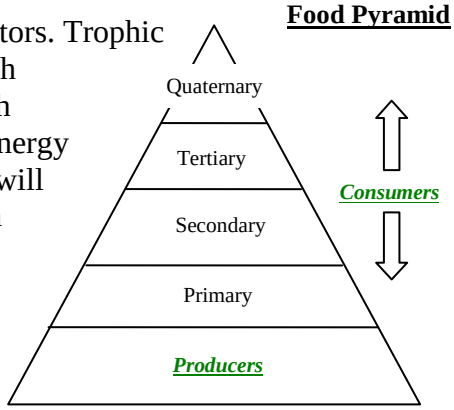


Living and Non-Living Factors

Biotic (Living) Factors

The living factors in an environment are called **biotic** factors. Trophic levels, or the feeding levels within a food pyramid, begin with **producers** at the base, which produce their own food through photosynthesis. This group contains the greatest amount of energy within a food web or chain. At the top of food pyramid, one will find a limited number of top predators, mainly due to a much smaller amount of energy to be found and shared. The **consumers** are those organisms that cannot make their own food, and therefore must eat producers or other consumers to gain energy. Primary consumers, which are **herbivores**, feed solely on plants (producers). The secondary consumers are carnivores and omnivores.

Food Pyramid



Feeding on the secondary consumers are tertiary (third level) consumers, then quaternary (fourth level) and so on to the top predators of an ecosystem. Examples of top predators are sharks, osprey, and humans.

Omnivores eat both plants and animals, **carnivores** eat only meat, and **decomposers** are those organisms that consume dead plant and animal material called **detritus**.

Decomposers are not scavengers, as scavengers are considered carnivores that eat parts of dead animals. Decomposers are recyclers. It takes an entire spectrum of organisms to decompose a large dead animal, from a scavenging raccoon to a chipmunk, to maggots, to bacteria that feed on the skin. Without them, nutrients would not cycle back into the environment, therefore making it impossible for other organisms to sustain life.

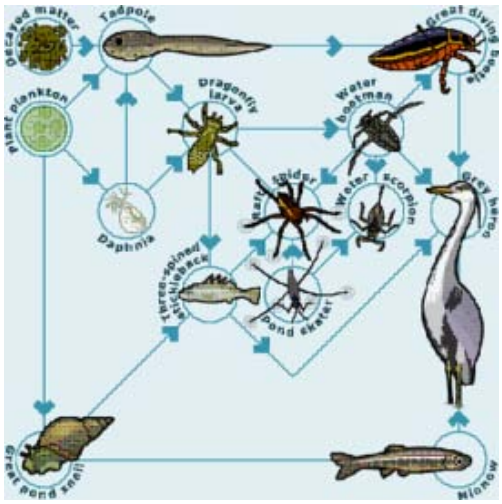
Abiotic (Non-Living) Factors

Although, not often included in the food web, **abiotic** factors or the non-living aspects (water, sunlight, temperature, etc.) play an important role. Climate will decide which food resources, and how much water and sunlight are available to organisms in any given ecosystem. Water and sunlight are necessary for plant growth and photosynthesis, and also provide animals with the basic needs of survival.

Food Web

In every environment and **ecosystem** there are different food webs. Although the organisms may be different, the food pyramid order of producers, primary consumers, secondary consumers, tertiary consumers, and so forth on up, is always the same. For the purpose of this lesson, we will focus on aquatic food webs, both saltwater and freshwater.

Within an **ecosystem**, there are many interconnected food chains which create a diverse and strong food web. For instance, at low tide the terrestrial raccoon may feed on an aquatic animal like a blue crab or mussel.



Food webs are a diverse combination of food chains linked to form a complex interconnected web.

Saltwater

Micro-organisms known as plankton are key players in the **food web** of a marine environment. Occupying the **photic zone** or sun-lit portion of the water are two types of plankton, phyto and zooplankton. **Phytoplankton** or plant plankton account for 95% of the primary productivity in the ocean. **Zooplankton** or animal plankton eats phytoplankton, and thus a primary consumer. Moreover, larger zooplankton eat smaller zooplankton; small bait fish eat larger zooplankton; and large predatory fishes eat the small bait fish. This series of feeding relationships makes up the marine food chain. When you factor in other species that feed on the same organism, then the chain becomes a web.

Freshwater

At the base of the freshwater food web are again the producers, such as phytoplankton, algae, duckweed, and lily pads. Just like on land, plants in water undergo photosynthesis and provide aquatic organisms with oxygen. Freshwater primary consumers include zooplankton and invertebrates. Smaller fish that consume the invertebrates are secondary consumers.

Predators at the top level include largemouth bass, smallmouth bass, walleye, chain pickerel, and perch. Humans and carnivorous birds like the osprey or eagle are also part of the freshwater food chain.

Human Impacts & Bioaccumulation

In many food webs, humans can be the top predator and are responsible for the decline in population, or in some cases endangering many species. Overfishing, introduction of non-native species, eutrophication, and bioaccumulation of toxic chemicals and substances are just a few examples of how humans impact aquatic food webs.

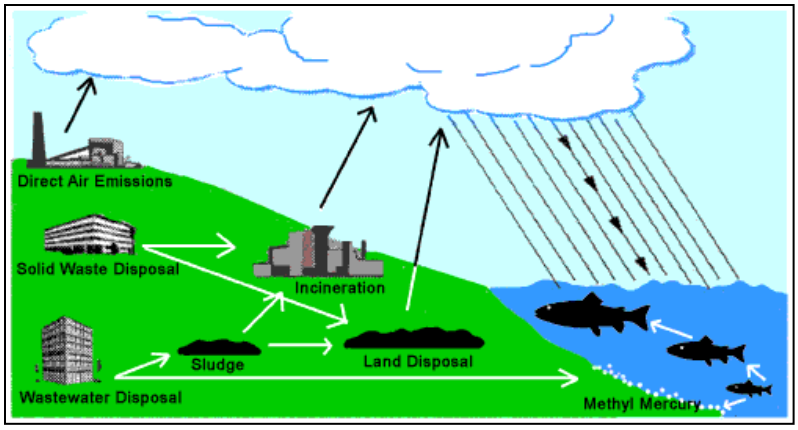
Humans can negatively impact aquatic food webs in many ways by overfishing, introducing non-native species, or polluting an aquatic ecosystem.

For example, in a saltwater ecosystem, clams may filter out pollutants in the water such as heavy metals, coliform bacteria from sewage contamination, or oil washed off the land. When pollutant levels are high, they build up inside of the clams, concentrating the toxic substances.

Higher up the food chain, a blackfish eats the clams and stores the toxins in its body. Pollution can accumulate from species to species, moving up the food chain until it eventually affects the whole food web. This process is known as bioaccumulation.

Bioaccumulation

Bioaccumulation is the accumulation or buildup of toxic substances in an organism. Let's take mercury for example. In an ecosystem, phytoplankton may take up mercury, zooplankton eat the phytoplankton, taking in the toxin. A school of small fish will eat the zooplankton and larger fish will feed on the small school. Top predators like orcas, sharks, and humans will catch the larger fish and consume them. The outcome is a buildup of mercury in the tissues of the different organisms in the food chain. In some cases, this build up of toxic substances is so great that it can contaminate fish and render them unhealthy to eat.



Toxins are absorbed or eaten by plants and animals, and move up through the food chain with increasing accumulation.

As a result, many states issue a health advisory to inform people which fish are safe and which to avoid due to contaminate levels. Specifically in New York State, the Department of Health states that a person should eat no more than one meal per week of fish taken from the state's freshwaters and certain coastal waters. In addition, it recommends that women of childbearing age and children under the age of 15 not eat any fish from specific water bodies included in the advisory lists.

Eutrophication

Eutrophication is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth. In aquatic systems this is often referred to as an algal bloom. Nutrients that cause these algal blooms can come from a variety of sources such as, fertilizer sprayings on golf courses, parks, home lawns, and sometimes sewage release from treatment plants. The influx of nutrients can have adverse effects upon an ecosystem, namely loss of water clarity, fish habitat, and open water. For example, as plant numbers increase, they cover the surface and reduce the amount of sunlight to the bottom. If plants do not receive sunlight, they cannot perform photosynthesis and eventually die. In addition, this process causes the dissolved oxygen, which plants provide to the water, to drop thereby influencing fish and many other organisms.

Eutrophication causes algal blooms, which in turn, may take all the oxygen out of the local system and cause fish kills, and oxygen deprived waters. Note a dead fish in photo above.

Main Activity

Introduction

The instructor will begin the program by introducing themselves and describing to the students what they will be learning. The instructor will explain that the students will be learning about a few local fish species, and the living (biotic) and non-living (abiotic) factors that make up a food web. Begin with discussing/explaining the food chain, food web, food pyramid. Describe zooplankton, phytoplankton, producers, consumers (primary, secondary, tertiary), ecosystem, herbivores, carnivores, omnivores, and decomposers. Ask and discuss what & how human impacts affect the food chain/web and ecosystems.

Brainstorming Activity – "Food Web"

1. Ask students to brainstorm, and list: (*15 minutes*)
    a) Plants and animals that live in an aquatic ecosystem (choice of fresh or salt water)
    b) Biotic and abiotic factors
    c) Human impacts on the ecosystem(s)

2. Asking the students, write their results of brainstorming on the board. Draw as many lines as realistically possible from one animal or factor to another, creating a food web. Draw lines from any human actions/impacts to parts of web.
    Ask:
    a) What tropic level are your animals? (primary, secondary, tertiary, quaternary)
    b) Are these animals are herbivores, carnivores, or omnivores?
    c) How can human activity impact an ecosystem?

3. Next, draw a large pyramid (triangle) on the board with four or five horizontal sections, for Producers, and Primary, Secondary, Tertiary, and Quaternary Consumers. Have the students assign their examples to appropriate stages of food pyramid. This will visually clarify various food chains within a ecosystem's food web.

Bioaccumulation Game "Trace the Toxin"

A. Designate an area for your freshwater or saltwater "ecosystem", which will be everyone's "home" for the game. Determine the boundaries of your "ecosystem home" in the classroom.

B. Representing different phytoplankton, disperse the colored poker chips around within the boundaries of the "ecosystem home".

C. Hand out a *Life Card* to each student. Tell students to quietly read their *Life Card* to themselves. Tell students that each *Life Card* is different. Class size may vary, but use over 55% or more of zooplankton to other animals.
   1) For a marine environment: zooplankton, small fish, seal, & shark. Assign roles: 15 zooplankton, 9 fish, 3 seals, 1 shark.
   2) For a freshwater environment: zooplankton, small fish (panfish), large fish (gamefish) & osprey. Assign roles: 15 zooplankton, 9 small fish, 3 gamefish, and 1 osprey.

<u>Round 1:</u>

Ask students which organism(s) out of the 4 eats the phytoplankton (zooplankton – primary consumers).

1. Hand out a food bag or cup to each of the 'zooplanktons'. Tell students that the zooplankton have 10-15 seconds to graze on or eat the phytoplankton. In order to pick up the chips, students must bend down, pick up one chip, stand up, and then place it into their cup. Tell the students they are not allowed to take handfuls of chips at a time. Emphasize that students follow their *Life Card* instructions.

2. At the end of pre-determined time due to class dynamics (ex:10-15 seconds) tell the zooplankton to stop picking up chips.

<u>Round 2:</u>

Ask students who is in the next level in our food chain (small fish). Now involve the fish (secondary consumers).

3. Tell the 'zooplankton' to continue feeding on the phytoplankton, but to be aware of predators. If they are tagged, they must hand their food bag or cup to the student who tagged them.
4. Tell the 'small fish' they have 10 seconds to "eat" (by tagging on elbow) the zooplankton. Remind students to follow their *Life Card* instructions. If need be, ask each student how much they can eat.
5. After 10 seconds, tell all the zooplankton, tagged or not, to return to their seats along with their bag/cup.

Round 3:

Ask students who is the next level in our food chain (gamefish & seals). Now involve the gamefish or seals (tertiary consumers).

6. Tell the 'fish' to symbolize a predator "eating" their prey by tagging their prey's elbow. Again, if tagged, the student hands their food bag/cup to the student who tagged them.
7. Tell the 'gamefish' or 'seals' they have 10 seconds to eat the small fish. Emphasize that the gamefish/seals follow their *Life Card* instructions. If need be, ask each student how much they can eat.
8. After 10 seconds, tell all the small fish, tagged or not, to return to their seats along with their bag/cup.

Round 4:

Ask students who is the next level in our food chain {osprey/shark}. Now introduce the shark or osprey (top of food chain).

9. Tell students to symbolize a predator "eating" their prey by tagging their prey's elbow. Again, if tagged, the student hands their food bag/cup to the student who tagged them.
10. Tell students they have 10 seconds to eat the gamefish/seals. Emphasize that they must follow their *Life Card* instructions. If need be, ask the student how much they can eat.
11. After 10 seconds, tell all the remaining players, tagged or not, to return to their seats.

D. Summarize the game, vocabulary, and anything else you wish to reinforce learning.

E. Tell students that some of the phytoplankton are toxic, specifically the Red chips! Note: if there are multiple classes, change the color of the toxic chip.
   1) Have students go through their food bag and sort food. If a student does not have a bag, tell them to work with a partner.
   2) Have students count the total number of poker chips and the total of red poker chips they collected.

F. Using the board, create 3 columns: organism, total # poker chips, and total # of red poker chips. (Option: This can be done after each Round or at then end)
   1) Ask each group (zooplankton, fish, etc.) to tell you their answers; write on board.
   2) Average amount of red chips per feeding level.

Wrap Up

Worksheet Activity (see Worksheet at end of Lesson)

Review

Students should be able to name and describe:

1. Parts of **Food Pyramid** (trophic level)

2. An organism in each **trophic level** of pyramid
3. A simple food web
4. Some human impacts on an environment or ecosystem
5. Bio-accumulation

Questions for Discussion

Q: What is a food web?
A: A system of food chains, interconnected with one another, that form an ecosystem or specific environment.

Q: What can you do to lessen the impacts of eutrophication?
A: Never dump waste water directly into rivers, lakes or the sea. Stop the use of artificial fertilizers and pesticides in your garden as they can end up in water systems. Dispose of animal waste properly.

Q: What can you do to keep ecosystems diverse?
A: Be mindful of what you throw away. Promote or get involved with a habitat restoration project. Do not plant or introduce non-native plants or animals to an ecosystem (ex: don't throw your old fish tank into the neighborhood pond!). Allow land to be as natural as possible.

Web Resources

Lesson & games, Bigelow Laboratory for Ocean Science's education page:
http://www.bigelow.org/edhab/tracing_toxins.html - lesson plan on toxins in the food web.

Food Chains & Food Webs:
http://www.goldridge08.com/foodchain.htm - interactive site using games and pictures.

"The Food Web," Water on the Web. 3 March 2004. 7 November 2012.
http://waterontheweb.org/under/lakeecology/11_foodweb.html - simple diagrams and descriptive explanations of food webs, with many topics.

USGS: "You are what you eat"
http://wwwrcamnl.wr.usgs.gov/isoig/projects/fingernails/foodweb/whyfoodweb.html - importance of studying food webs, with links.

Eutrophication
US Geological Survey. 13 March 2008. 16 January 2009
http://toxics.usgs.gov/definitions/eutrophication.html - variety of definitions; and many links.
http://waterontheweb.org/under/lakeecology/17_eutrophication.html - descriptive explanations.

DOH lists stricter advisories for specific water bodies:
http://www.health.state.ny.us/environmental/outdoors/fish/fish.htm - health advisory on fish we eat with advice, tips, and links to further information.

Ecosystem Interactions: Food Chains and Bioaccumulation

Name: _____

1. Identify one or more carnivores from the ecosystem brainstorm or bioaccumulation game.

2. Identify one or more herbivores from the ecosystem brainstorm or bioaccumulation game.

3. List three fish species you might catch on your fishing trip.

4. Which group contains the greatest amount of energy in a food chain?

Group A	Group B	Group C	Group D
algae phytoplankton	zooplankton small fishes	large fishes seals	sharks ospreys

Circle your answer:

Group A

Group B

Group C

Group D

5. Describe how bioaccumulation works. Use examples from the bioaccumulation game.

6. Describe one action that can be taken to reduce bioaccumulation from occurring locally.

What is a Food Chain?

A food chain is an arrangement of organisms in an ecosystem according to the order of predation. In most cases, a lower member in the ecosystem is used as the next food source.

What is a Food Web?

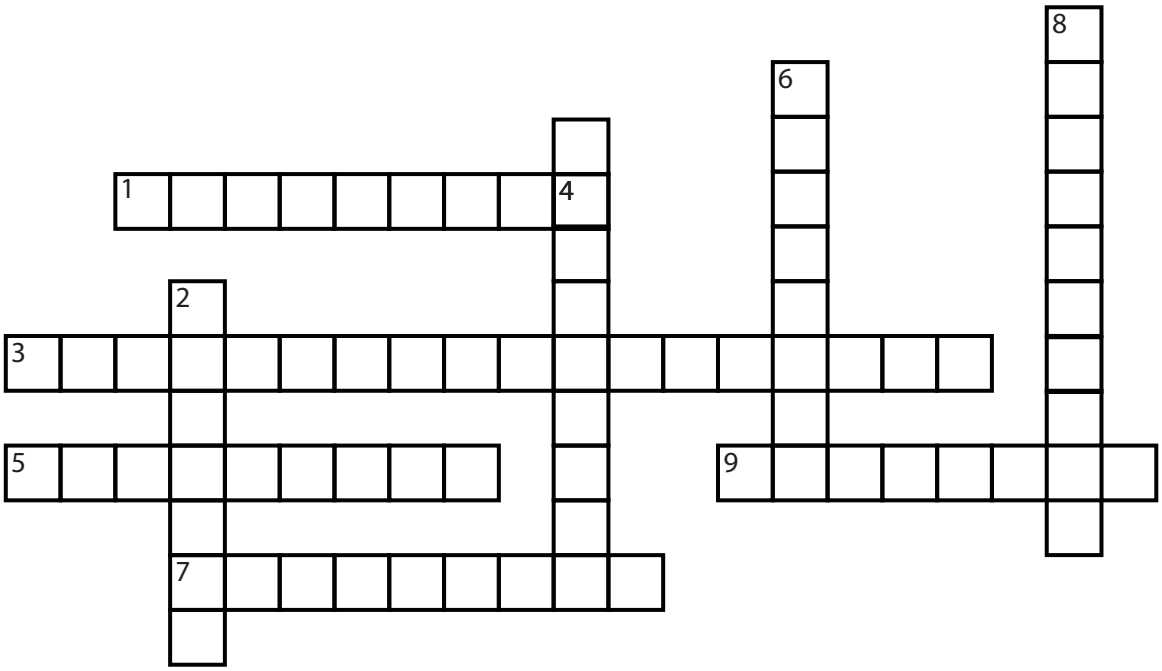
A food web is made up of all the interactive food chains in an ecosystem.

I ♥ NY

Sea Grant

Name_____

Food Web Crossword Puzzle



Clues Down:

2. I am an interaction of food chains in an ecosystem.

4. I primarily consume autotrophs such as plants and algae.

6. I am a heterotroph. I am unable to perform photosynthesis.

8. I am a heterotroph that consumes dead organisms.

Clues Across:

1. I primarily consume meat.

3. I include the non-living aspects such as water, sunlight, atmospheric gases, temperature, wind, and climate.

5. I am an arrangement of organisms in an ecological community according to the order of predation in which each uses the next usually lower member as a food source.

7. I am a community of organisms working together in my environment.

9. I am an autotroph, which means I produce oxygen through photosynthesis.

Name_____

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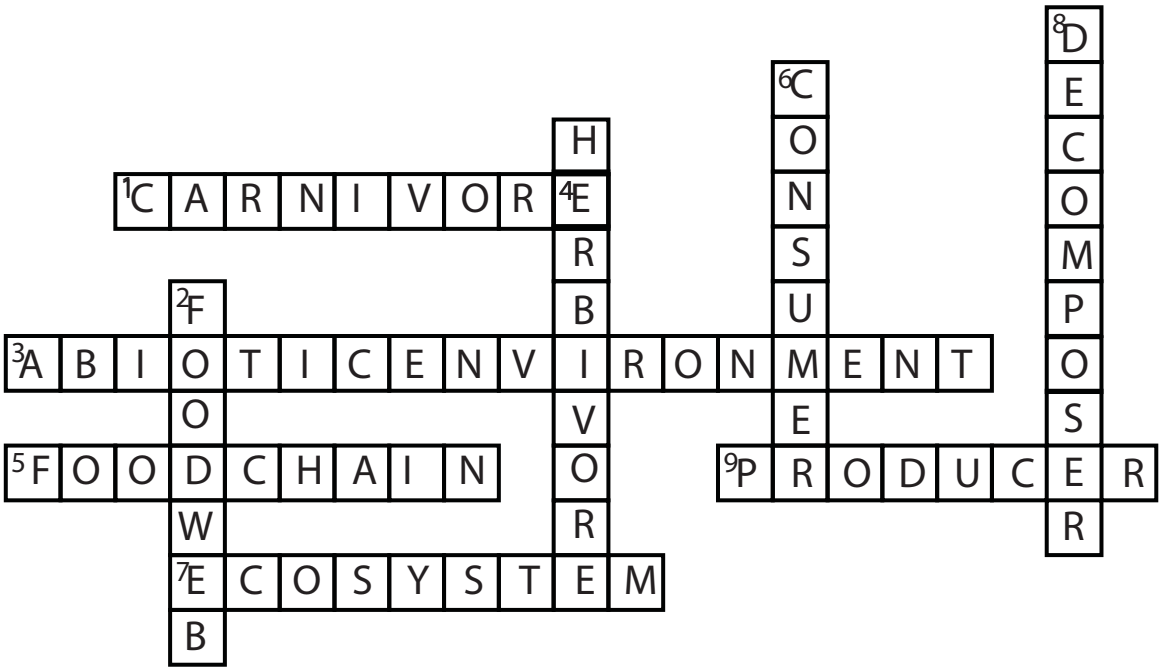

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Gamefish

You came across a school of small fish feasting on zooplankton. You were busy investigating a new deep hole you found, so you arrived late. Because you're a fast swimmer you were able to catch 3 small fish.

Take the food bag of the small fish that you caught.

Gamefish

You came across a school of small fish feasting on zooplankton. You were very stealthy in your hunt, and as a result you were successful at catching 4 of them for your afternoon meal.

Take the food bags of the small fish that you caught.

Gamefish

You came across a school of small fish feasting on zooplankton. You were a bit late in joining the hunt, and as a result you caught 2 small fish – not bad for a snack.

Take the food bags of the small fish that you caught.

Small Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. You feast on the zooplankton, eating 4 in one dive through the swarm.

Take the food bags of the zooplankton that you caught.

Small Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. While you were trying to feed on the zooplankton, the algae irritated your gills.

You have died and are washed ashore.

Osprey

While hunting, you saw a group of gamefish chasing a school of fish. You were successful at catching two of them for your afternoon meal.

Take the food bag of the gamefish that you caught.

Small Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. You have just finished eating a few small baitfish near the lily pads, so you aren't very hungry. You eat only 1 of the zooplankton.

Take the food bag of the zooplankton that you caught

Small Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. You have just finished eating a few small baitfish near the lily pads, so you aren't very hungry. You eat only 1 of the zooplankton.

Take the food bag of the zooplankton that you caught.

Small Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. You are able to catch a couple (2) of zooplankton.

Take the food bags of the zooplankton that you caught.

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Take the food bag of the zooplankton that you caught

Zooplankton

You came across an algal bloom filled with phytoplankton and it's a feeding frenzy! You only have limited time to graze before the current causes the bloom to dissipate. Grab everything that you can to get those needed nutrients!

Place the phytoplankton that you find in your food bag.

Zooplankton

You came across an algal bloom filled with phytoplankton and it's a feeding frenzy! You only have limited time to graze before the current causes the bloom to dissipate. Grab everything that you can to get those needed nutrients!

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Small Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. Your hunt is successful and you are able to catch 3 zooplankton.

Take the food bags of the zooplankton that you caught.

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Place the phytoplankton that you find in your food bag.

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Seal

You came across a school of fish feasting on zooplankton. You were too busy investigating a new cavern you found, so you were only able to catch 1 fish – you are probably going to be hungry again soon!

Take the food bag of the fish that you caught.

Seal

You came across a school of fish feasting on zooplankton. You were very stealthy in your hunt, and as a result you were successful at catching 4 of them for your afternoon meal.

Take the food bags of the fish that you caught.

Seal

You came across a school of fish feasting on zooplankton. You were a bit late in joining the hunt, and as a result you caught 2 fish – not bad for a snack.

Take the food bags of the fish that you caught.

Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. You feast on the zooplankton, eating 4 in one dive through the swarm.

Take the food bags of the zooplankton that you caught.

Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. While you were trying to feed on the zooplankton, the algae irritated your gills.

You have died and are washed ashore.

Shark

You came across a group of seals feasting on a school of fish. You were successful at catching one of them for your afternoon meal.

Take the food bag of the seal that you caught.

Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. You have just finished eating a bunch of small baitfish along the coast, so you aren't very hungry. You eat only 1 of the zooplankton.

Take the food bag of the zooplankton that you caught

Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. You have just finished eating a bunch of small baitfish along the coast, so you aren't very hungry. You eat only 1 of the zooplankton.

Take the food bag of the zooplankton that you caught.

Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. You are able to catch a couple (2) of zooplankton.

Take the food bags of the zooplankton that you caught.

Fish

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Take the food bags of the zooplankton that you caught.

Fish

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Take the food bag of the zooplankton that you caught

Fish

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Fish

You came across a swarm of zooplankton feeding on phytoplankton in an algal bloom. Your hunt is successful and you are able to catch 3 zooplankton.

Take the food bags of the zooplankton that you caught.

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