MARINE CONSERVATION SCIENCE AND POLICY SERVICE LEARNING PROGRAM

Trophic Structure refers to the way in which organisms utilize food resources and hence where energy transfer occurs within an ecosystem. There are a number of different feeding habits and feeding interactions between the various organisms as well as organisms and their environment, resulting in specific trophic groups. Organisms may also take the form of specific Guilds. Trophic Structures are represented graphically as Food pyramids, Food chains, and Food webs.

MODULE 3: OCEAN CONNECTIONS

SECTION 3: TROPHIC STRUCTURES

SUNSHINE STATE STANDARDS

SC.912.N.1.1, SC.912.E.7.3, SC.912.N.4.2, SC.912.L.15.1, SC.912.L.15.3, SC.912.L.15.4, SC.912.N.L.17.4, SC.912.L.17.8, SC.912.L.17.7, SC.912.L.17.9

OBJECTIVES

Students will be able to:

- Describe various trophic levels
- Identify the living and non-living components of an ecosystem
- Differentiate between food chains and food webs
- Describe the flow of energy through an ecosystem and the recycling of nutrients by living things

VOCABULARY

Trophic level - the feeding position in a food chain; Most food webs are made up of four trophic levels, from the plants that make their own food at the bottom level to the animals that eat other animals at the top level in a food chain.

Producer - an autotrophic organism (as a green plant) viewed as a source of biomass that can be consumed by other organisms
Consumers - an organism requiring complex organic compounds for food which it obtains by preying on other organisms or by eating particles of organic matter

Decomposer - any of various organisms that return constituents of organic substances to ecological cycles by feeding on and breaking down dead protoplasm.

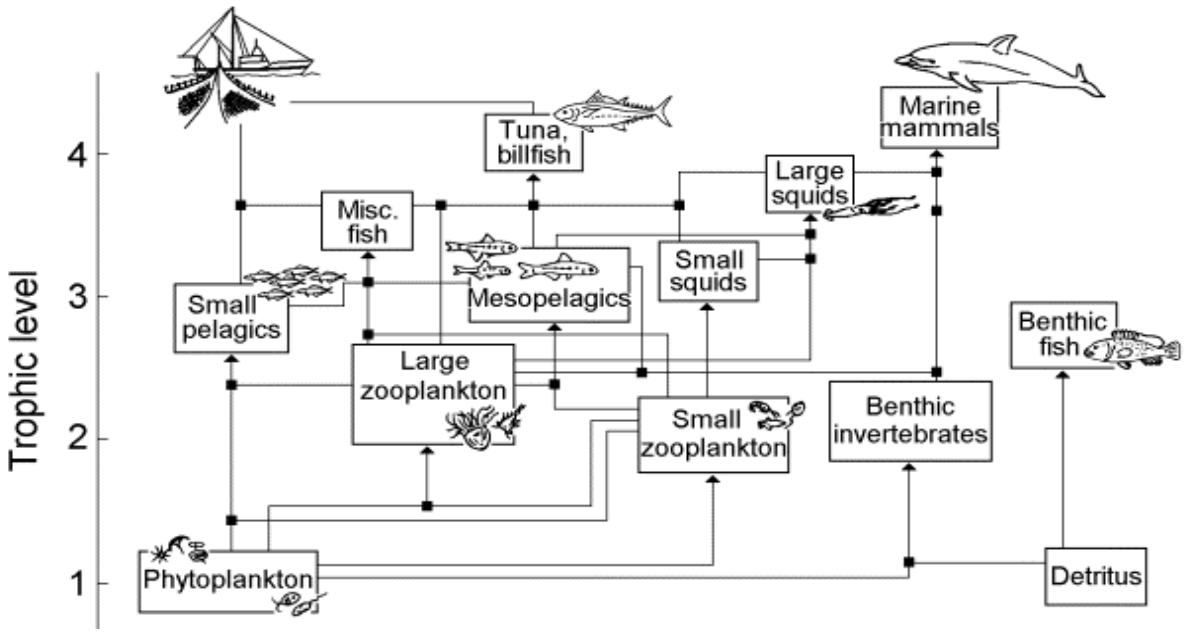
Food chain – an arrangement of the organisms of an ecological community in the order of predation, in which each uses the next lower member as a food source

Food web – the interaction of multiple food chains

Biomass - the mass of living biological organisms in a given area or ecosystem at a given time

Apex predator - predators that have virtually no predators of their own, residing at the top of their food chain.

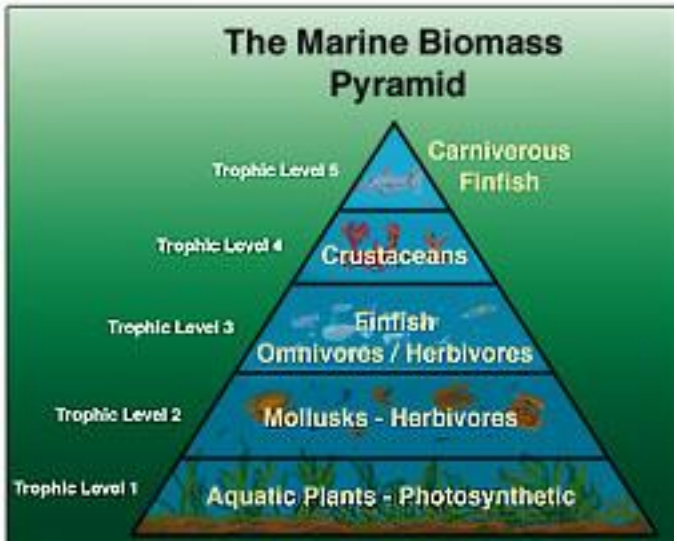
BACKGROUND



All organisms in an ecosystem can be placed in trophic levels depending on what energy source they rely upon and how they provide energy for other organisms. With the exception of life near hydrothermal vents in the deep ocean, life is always dependent directly or indirectly on energy from the sun. In every ecosystem, there is an organism at the lowest level that converts energy from the sun into useable energy for other organisms. For example, phytoplankton are photosynthesizers that provide energy for a vast number of primary consumers, which then provide energy for secondary consumers and decomposers.

There are four parts to every ecosystem: the abiotic environment, producers, consumers and decomposers. Energy from the sun and abiotic nutrients, such as carbon dioxide or minerals, are taken in by producers and transformed into usable energy through photosynthesis. Consumers, like herbivores, are dependent on producers to convert sunlight, water, and carbon dioxide into glucose, which can be then be divided through respiration to recover the sun's energy. Carnivores can be secondary consumers (if they only prey on herbivores) or tertiary consumers (if they eat other carnivores). Decomposers, the organisms responsible for decomposing dead animal and plant matter, are able to break down organic waste back into minerals that can be used by producers.

The food chain consists of trophic levels, or the levels within the food chain in which energy is transformed. A food chain illustrates only one energy and nutrient path in an ecosystem. Each platform is a trophic level with one organism; it begins with one primary producer and ends with a secondary or tertiary consumer. A typical food chain might go like this: algae-copepod-fish-squid-seal-orca. In this example the orca feeds on the seals and the seals feed on the squid which feed on fish which feed on copepods. The base of the food chain is formed by algae which are eaten by copepods.

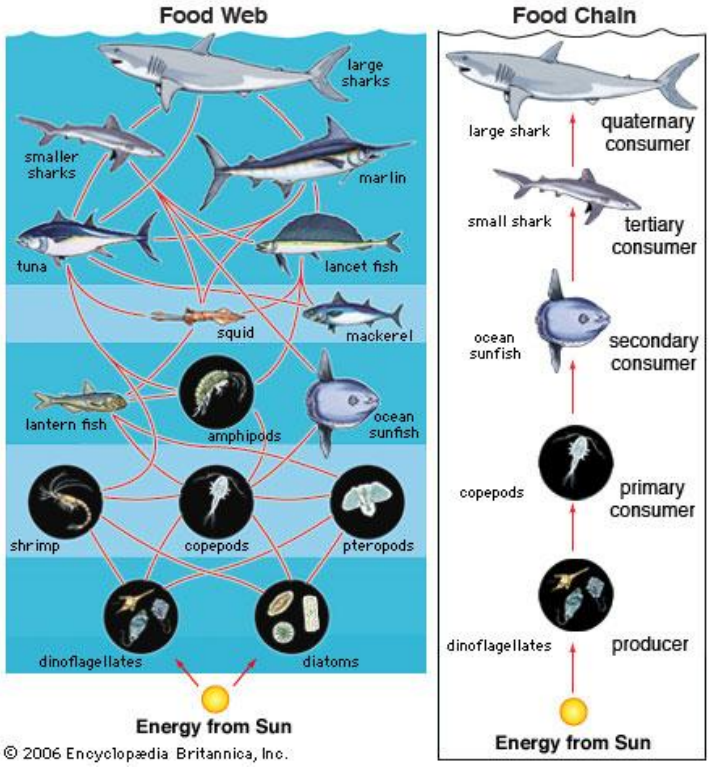


Due to basic principles of thermodynamics, energy is always lost to the environment any time an organism at one trophic level uses the energy from the trophic level below. For example, the energy gained by animals that eat phytoplankton is less than the amount of energy initially available. Every trophic level loses energy, so trophic levels are often illustrated as a triangle with primary producers forming the base and the top occupied by tertiary consumers, or apex predators. The primary producers yield the most profit from the energy of the sun. By the time this energy has been transferred up to the higher trophic levels much of it has been lost to the environment.

Trophic levels begin with phytoplankton, a primary producer capable of transforming inorganic carbon into protoplasm. Zooplankton is the second level because they eat phytoplankton and are a source of energy for crustaceans at the third level. The fourth level is fish that eat crustaceans and the fifth is seals and other animals that eat fish. The more trophic levels present, the less energy is conserved at higher trophic levels.

With a few exceptions, every species fits into the ecosystem as something consumed and something that consumes other things. Many prey are eaten by more than a single predator and most predators have diversified to eat more than one type of prey, creating food webs, as opposed to chains. Food webs are more intricate than food chains and illustrate the feeding relationships between a number of organisms at different trophic levels in an ecosystem. Food chains are useful to illustrate relationships in a simple way, and food webs are more accurate as they can illustrate more relationships. Another aspect evident in a food web is the diversification of prey by predators in order to survive the loss of one species.

The amount of biodiversity in an ecosystem is directly related to its degree of stability. When organisms eat a variety of foods, the loss of one type of prey is not as devastating to the overall ecosystem. Many organisms consume both plants and animals (omnivores) and prey on a variety of species to avoid starvation in case their primary prey becomes scarce; therefore they are sometimes categorized into more than one trophic level depending on the circumstances. Biodiversity can be lost through destruction of habitats, overexploitation, biological activity that upsets the balance of the ecosystem such as an invasive species, and pollution. Biodiversity loss upsets the balance of ecosystems, which is why it's important to ensure its sustainability in the ocean.



ACTIVITY: MARINE FOOD WEBS

Students become part of an ocean food web as they learn that life in the ocean is interconnected.

DURATION: 1 hour

MATERIALS:

- 28 Peel and Stick Name Badges (or index cards and safety pins)
- Ball of yarn
- 1 Scissors

PROCEDURE:

1. Using the chart below as a guide, place the name of different organisms on the Name Badges and give one to each student. The numbers in the parenthesis refer to the number of students who should be assigned that particular organism. (Feel free to add additional organisms or to increase the number of primary producers/primary consumers if your class has more than 30 students.)

Primary Producers	**Primary Consumer**	**Secondary Consumer**	**Tertiary Consumer**	**Fourth-Order Consumer**
Phytoplankton (3), seagrass (3), algae (3)	Copepods (2), fish larvae (2), crab larvae (2), sponges (2), starfish, sea urchins	Herring, squid, blue whales, jellyfish, whale sharks	Tuna, sea turtles, seals, seagulls,	Orcas, sharks

2. Ask students to stand in a circle.
    - Have each student identify themselves within the 5 different guilds.
    - Explain to them that this activity will help to illustrate how a food web is created.

3. Give the ball of yarn to the student representing the squid. Explain that s/he can pass the ball of yarn either to something that the squid eats (fish larvae) or something that eats the squid (tuna). Before passing the yarn, the student must state "I'm a _____ and I eat _____" or "I'm a ____ and ____ eat me"; thus identifying who must be ready to catch the ball of yarn. They must also keep a hold of some of the yarn.

4. The person who catches the yarn must follow the same instructions.
5. Eventually, everyone will be all tied together in a tangle of yarn. Ask students to explain why this happened. They should understand that all living things are connected in some way.

6. Use the scissors to cut the string at any point. The web is now broken. What might cause this to happen? What will happen to the various organisms in the food web if it is broken?

ACTIVITY: ENERGY AND ECOSYSTEMS (PREDATOR PROFILING PRE POST - MODIFY FOR MARINE HABITATS)

Explore how energy travels through an ecosystem.

DURATION: 1 hour

Students are introduced the concept of energy within ecosystems through a reading assignment.

MATERIALS

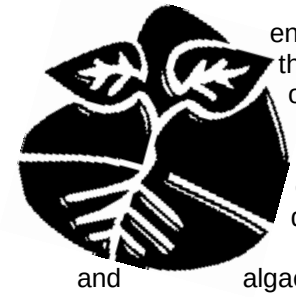
- Energy and Ecosystems Article
- Energy and Ecosystems Vocabulary Cards
- Cardstock

PROCEDURE

1. Before class, print the Energy and Ecosystems Vocabulary Cards sheet on cardstock and cut into cards
2. Give each student an Energy and Ecosystems Article.
3. Ask students to silently read the article (this can be done in class, or assigned the previous day as homework).
4. Lead a class discussion on the article using the following questions:
    - Why are decomposers important to a food web and an ecosystem?
    - What do you think would happen if a particular organism became extinct? How would that affect the ecosystem?
    - What are the different energy needs of organisms in a food web?
    - How have humans affected animal food chains/webs?
5. Give each student a card cut from the Definitions sheet.
6. Instruct to students that the cards they have either contain a vocabulary word from the article or a definition
    - Students must find their matching card. Students with only a word need to find its definition and vice versa.
    - Ask the class to stand up and begin searching
7. Once all students have found their match, allow the students to present their words to the class.

Energy and Ecosystems

All living things, or organisms, need energy to live. This energy comes from the Sun and can pass from one organism to another (in the form of food) but can only be used once.

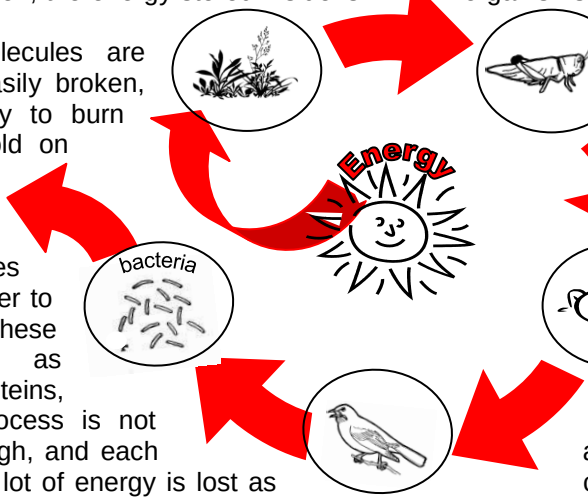


An ecosystem is an environment and the organisms that live together in it. Each organism helps energy flow through the ecosystem by acting as a producer, a consumer, a scavenger, or a decomposer.

Producers, like plants and algae, take basic materials and turn them into something useful. In a process called photosynthesis, plants use sunlight and a green chemical, called chlorophyll, to convert carbon dioxide and water into sugar and oxygen.

The Sun's energy is trapped within sugar's molecular bonds. Whenever those molecules are broken, the energy stored inside is released.

Sugar molecules are very small and easily broken, making them easy to burn and difficult to hold on to; so, organisms rearrange and combine sugars into larger molecules to make them easier to store. We know these molecules as carbohydrates, proteins, and fats. This process is not very efficient, though, and each time it happens, a lot of energy is lost as heat.



Consumers use things made by producers. Animals are consumers that get their energy by eating plants (herbivores), animals (carnivores), or both (omnivores).

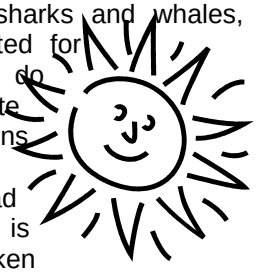
A food chain begins with a producer and ends with a consumer: A plant is eaten by an animal (primary consumer); that animal is eaten by another animal (secondary consumer); and *that* animal is eaten by an even bigger animal (tertiary consumer). In this way energy and nutrients move up the chain, but (remember!), as one organism consumes another, a lot of energy goes to waste. That's why there are a lot of herbivores but few large predators in most ecosystems.

There are many food chains in an ecosystem, and each type of organism is usually part of more than one chain. All of the interconnected food chains within an ecosystem make a food web.

When organisms die, some energy is still left in their remains, and it is the job of scavengers and decomposers to use it up. Scavengers feed on dead organic matter, such as old fruit, garbage, and rotting meat. This may seem disgusting, but it serves to break up the bodies of dead plants and animals and helps begin the process of decomposition.

Decomposers break down molecules in waste, essentially serving the opposite function as producers. They release the last tiny bits of energy from dead organisms and recycle nutrients back into the soil.

In marine ecosystems, microscopic phytoplankton carry out most of the photosynthesis that occurs. The microscopic character of most of the marine primary producers imposes size restrictions on many of the occupants of higher marine trophic levels. Since very few animals are adapted to feed on organisms much smaller than themselves, marine herbivores also are usually quite small, such as zooplankton, and small invertebrates or fish. Phytoplankton are extremely small but grow very rapidly, allowing them to support large populations of herbivores. Consequently, the upper levels of the food chain are occupied by larger organisms. The primary producers are consumed by small marine carnivores (that may also be zooplankton), and these are consumed by larger marine carnivores and so on, up to the apex predators, the highest level within the marine food web. These large organisms, like sharks and whales, while not specifically targeted for consumption, do produce waste. The waste may be either excretions from digestive processes or dead tissue. It is eventually broken down by decomposers, primarily bacteria, in a process that releases nutrients that oceanic primary producers can use to start the whole cycle again.



Energy and Ecosystems

Vocabulary Cards

Print these cards onto a sheet of cardstock and cut them out.

Carnivore	Eats only plants.	Flow of energy and nutrients from one organism to another.
Consumer	Eats both plants and meat.	An environment and the community of organisms that interact within it.
Decomposer	Organisms that get their energy and nutrients from the foods they eat.	Help break down the remains of dead organisms.
Ecosystem	Process by which plants change sunlight, carbon dioxide, and water into sugars.	All of the interconnected food chains within an ecosystem
Food chain	Omnivore	Eats only meat.
Food web	Organism	Release the last bits of stored energy and nutrients from waste.
Herbivore	Photosynthesis	Organisms that store energy from the sun and nutrients from soil
Insectivore	Producer	Eats only insects, grubs, and other invertebrates.
	Scavenger	Living thing.

RESOURCES

http://marinebio.org/oceans/trophic-structure.asp

http://en.wikipedia.org/wiki/Trophic_level

http://www.bcb.uwc.ac.za/sci_ed/grade10/ecology/trophics/troph.htm

http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/biogeography/trophic_levels_and_food_chains.html

http://www.mesa.edu.au/friends/seashores/trophic_levels.html

http://www.marietta.edu/~mcshaffd/lead/trophic.pdf

http://www.bioinquiry.vt.edu/bioinquiry/cheetah/cheetahpaid/cheetahhtmls/ecosystroph.html

http://marinebio.org/oceans/trophic-structure.asp