WYLAND
FOUNDATION

Bringing Together People For Clean Water And Healthy Oceans

TEACHER'S GUIDE
SCIENCE BACKGROUND

PLEASE RECYCLE

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BIRCH AQUARIUM AT SCRIPPS

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SCIENCE BACKGROUND

You don't have to be a science expert to use this program in your classroom. Included in this guide is all the background you'll need to conduct each of the activities. The background information is presented in a clear and understandable way that is even appropriate to hand out to your students if you desire.

AQUATIC ECOSYSTEMS

We have explored most of the surface of the earth and are now embarking on exploring the frontiers of water-based ecosystems. Only about 5% of the world's ocean has been explored and there remain many freshwater ecosystems of rivers, wetlands, and lakes with new species waiting to be discovered. We depend on these ecosystems for food, recreation, storm buffers, and transportation, yet we know so little about them.

What exactly is an ecosystem? It is all the living and non-living things in an area and how they work together in a system. An ecosystem can be as small as a tidepool or as big as the Great Lakes. An ecosystem is like a town or city with non-living things such as buildings and roads and living things like people and animals. Within the ecosystem there are different jobs to be done and various roles to play. There are parents, police, garbage handlers, and builders to name just a few. Everyone doing their job allows the ecosystem to work well and stay balanced. When a plant or animal is removed, it can disrupt the whole system. Imagine the mess in your town if all the garbage handlers disappeared.

How would you begin to study an ecosystem or create a painting of it? A good place to start would be the physical environment of non-living things such as sand, rock, and water. Non-living things are just as important to an ecosystem as living organisms. Sand and rocks can be shelter for plants and animals just as a floor, a roof and walls are protection for you. The ecosystem you will be studying is an aquatic (water) ecosystem. What can live here depends on the water and other non-living things that make up the physical part of the environment.

DID YOU KNOW

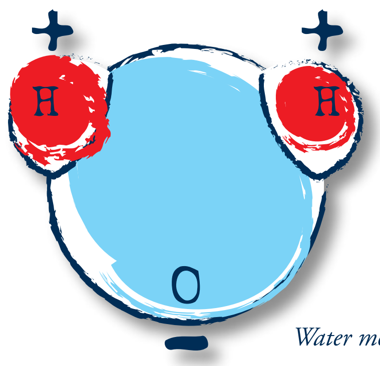
-WYLAND

When I get ready to paint a giant mural of any ecosystem, I do my homework by researching books and the Internet. I talk to local scientists or go to a zoo or aquarium, but I also scuba dive. I like to see the environment first hand. I pay attention to landscape and the water, and I carefully note of the behavior and interactions of the animals. Sometimes, I capture these images for later study with a special underwater camera, and refer to the photos as I paint.

SCIENCE BACKGROUND

WATER

Water makes life possible. It nourishes the plants we eat and the trees we sit under. It provides habitat for an endless number of living things. There is a limited amount of water on our planet and it gets used over and over again through the water cycle – that is why it is so important to keep it clean! Water connects us all. The same drop of water that flows through the Amazon may end up raining on your town someday. The arctic water a whale swam through could be in your bathtub. Every living thing depends upon water, <u>clean</u> water.



Water molecule

H_2O: THE RECIPE

What is this substance that we depend on so much? The true identity of water is revealed in its nickname, H_2O. In addition to being a catchy nickname, H_2O is water's chemical name, which reveals exactly what water is made of. Chemical names are like recipes describing what ingredients and how much of them are needed to create the element. In water, the H stands for Hydrogen and the 2 means there are two parts of hydrogen. The O stands for oxygen. So the recipe for water is two parts hydrogen and one part oxygen.

DID you KNOW
-WYLAND

We now understand that the same water the dinosaurs drank millions of years ago is the same water we are drinking today.

DID you KNOW
-DR. SYLVIA EARLE

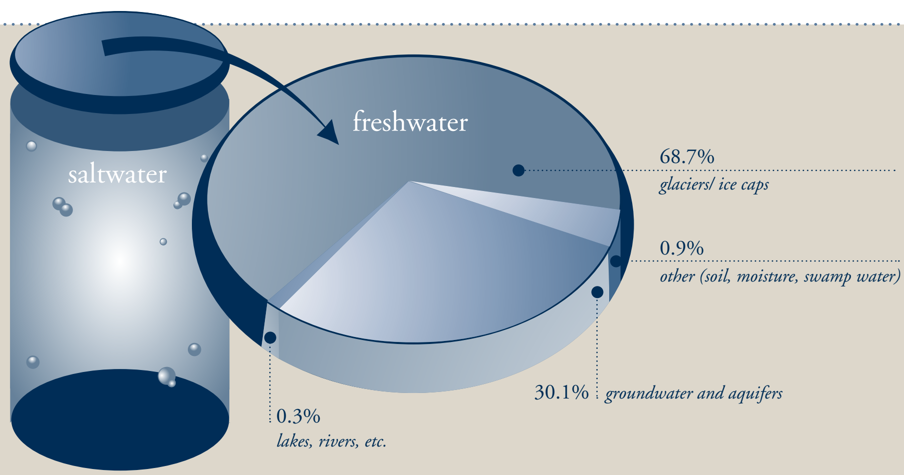
There's plenty of water in the universe without life, but nowhere is there life without water. In fact, the living ocean drives planetary chemistry, governs climate and weather, and otherwise provides the life support system for all creatures on our planet.

SCIENCE BACKGROUND

A LIMITED RESOURCE

About 70 percent of the world is covered with water, yet only a very small portion of that is accessible fresh water. Most of our fresh water is locked up in icecaps and glaciers or hidden underground. Although some scientists speculate that earth may receive small amounts of new water from meteors, the amount of water on our planet is relatively fixed.

Humans, plants, and animals have existed on that set amount of water for a long time, so everything is fine, right? Maybe, or maybe not when you consider the rising world population, a higher demand for water, and the increase in the amount of water that is so polluted it is unsuitable for use. To add to the problem, freshwater isn't spread evenly across the planet. Some places like North America have decent water supplies that replenish (if they aren't overtaxed), but others such as Saudi Arabia and parts of Africa are very dry and face constant water shortages.



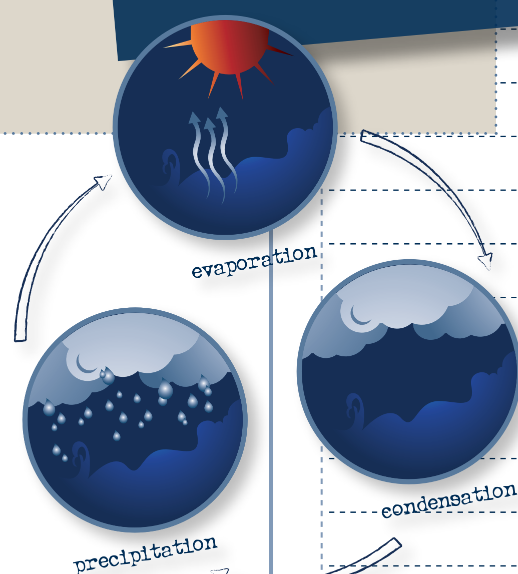
fact:

Of all the water on earth, less than 3% is freshwater.

THE WATER CYCLE: A NEVER ENDING JOURNEY

The water on earth is on a journey that never ends. Each drop is used over and over again! It travels the world by changing form during the water cycle.

Here's how the Water Cycle works: Heat from the sun or other sources turns water on the Earth's surface into an invisible gas called water vapor through a process called EVAPORATION. The gas eventually cools through a process called CONDENSATION and forms clouds. As it cools, the water in clouds becomes heavy and sticks together to form droplets. These droplets then fall back to Earth as rain or snow known as PRECIPITATION. Some of the water soaks into the ground and collects into pools underground called aquifers. Some of the water is used by plants and then released through their leaves in a process called transpiration. Some of the water runs off the land through rivers and streams and collects in larger water bodies such as lakes, wetlands, and oceans where it evaporates and starts the cycle all over again.

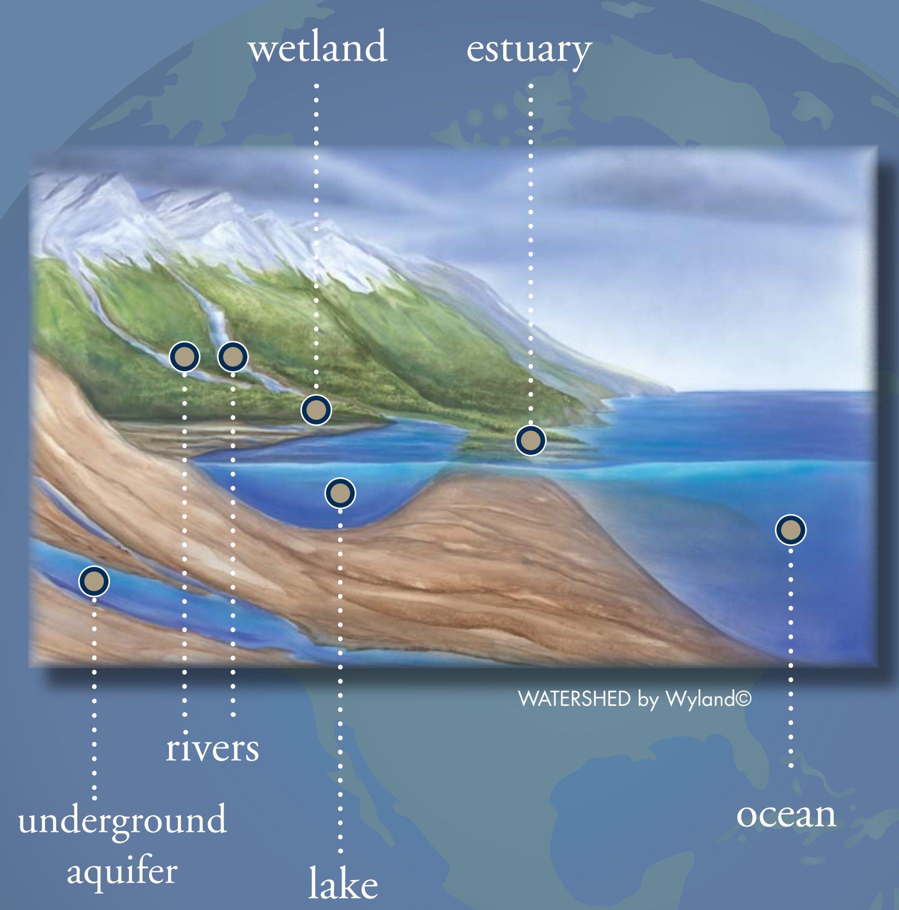


SCIENCE BACKGROUND

WATERSHEDS

Because of gravity, water runs downhill from high points like mountains and hills to lower points in lakes, rivers, ponds and wetlands. Eventually, all water drains into the world's oceans. In every area of the Earth, the highest points of land form boundaries from which water runs downhill. Each area the water drains into is called a "watershed." You can think of it as a big bowl with the high edges being the boundaries of the watershed. Smaller watersheds are contained in larger watersheds, like a stack of bowls that fit inside each other. Forty percent of the watersheds in the United States drain into the Mississippi watershed and then into the ocean in the Gulf of Mexico.

Watersheds, rivers, and oceans aren't bound by town, state, or even country lines. By looking at a map you can see that the United States shares watersheds with Canada and Mexico. Once the water reaches the ocean, currents drive it to other parts of the world, so water truly does connect us all.



WATERSHED by Wyland©

Everything that exists in a watershed affects the quality of the water in the watershed. If water runs through a mountain forest, it will pick up leaves, dirt or pine needles. If it runs through a pasture where cows graze, it will pick up bacteria or pollution from the wastes cows create. If it runs through a city or a neighborhood with a lot of people, it will pick up things people use such as food wrappers, plastic water bottles or lawn fertilizers. If it runs through factory or farm areas, it will pick up chemicals, pesticides, oil, fertilizers or other pollutants.

The pollution, trash and materials water collects on its way through a watershed is called "runoff." Rural farm areas, suburban neighborhoods and the urban areas of cities all have runoff. Urban runoff is the most severe, because cities have the most people, industries and factories. Runoff is a problem for all watersheds because the pollution it contains ends up in lakes, rivers, wetlands, estuaries and the ocean.

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STORMDRAINS VS. SEWERS

Storm drains are the openings along the sides of highways, street "gutters" by sidewalks, and often the drains you see in parking lots. Things that are used in yards such as fertilizer as well as anything you find in streets or parking lots such as motor oil and trash get washed into storm drains when it rains, which is called runoff. Runoff goes into storm drains that lead directly to bodies of water like rivers, lakes, and the ocean. Most storm drains do not clean or filter the water they carry, so those pollutants go straight into water bodies and can harm wildlife.

Sewer lines are the pipes that take used water from homes and businesses to a treatment plant. The plant has filters to clean the water before the water is sent back to lakes, the ocean, and other water bodies. Treatment plants are great for protecting water quality, but some are better than others. There are three stages of filtration for cleaning different types of pollution from the water. Some plants use only the first stage while others that are working towards the cleanest system possible use all three.

SCIENCE BACKGROUND

MESSAGE IN THE WATER

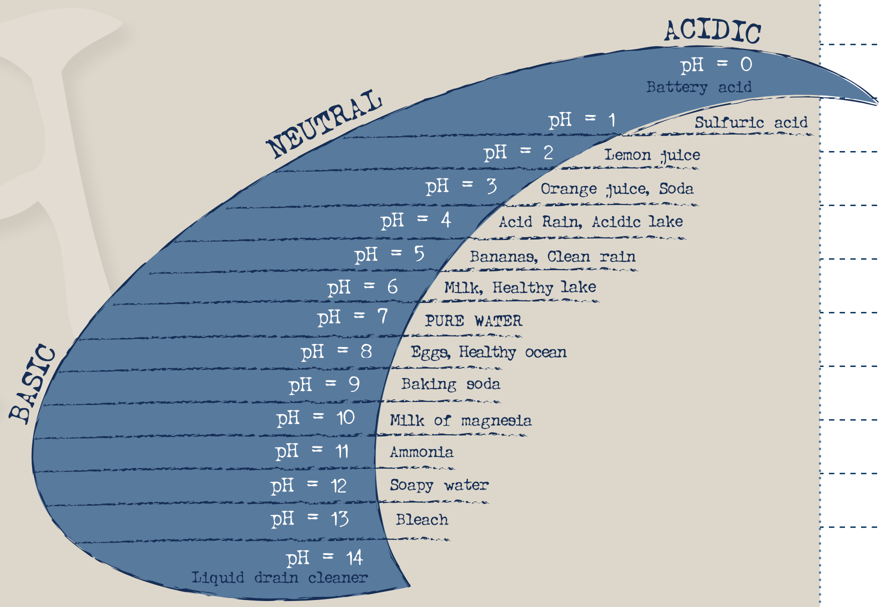
Scientists and artists need to know what the water is like to create an accurate picture of an ecosystem. All water ecosystems are not the same. The most apparent example is the difference between saltwater and freshwater, but there are many other characteristics that determine what kind of life might be found in a certain body of water. Would the same animals living in a warm tropical environment be found in a frozen one? It would be unlikely. Humans seem to be about the only animals that can survive in any climate, and we need a lot of extra gear to do that!

By testing the water, scientists can also learn about the health and cleanliness of the water and the ecosystem. A few of the things that can be tested are:

SALINITY – The amount of salt in the water is called salinity. The ocean has a lot of salinity, averaging from 32 to 37 parts salt per thousand. Freshwater ranges from about 0 to 4 ppt. Tap water and bottled water are usually limited to about .5 ppt. Some animals can live in both salt and fresh water, but most can only survive in one or the other.

TURBIDITY – If you're describing water and using words like "brown, mucky, or murky", you are looking at turbid water. Turbid is the opposite of clear and means the water is full of floating particles such as dirt, debris, or even algae. Turbidity can be one factor in determining if water is polluted. The sediment can clog fish gills, cover laid eggs on the bottom (can be a positive or negative action), or stop sunlight from reaching aquatic plants. Turbid water can also be caused by an overgrowth of plankton that uses up all the oxygen in the water when the plankton dies and decomposes. Some bodies of water, however, are naturally turbid and promote healthy ecosystems. Animals that live in these types of water can have adaptations that help them to thrive under turbid conditions.

pH – pH measures the "base" or "acidity" of water on a 0-to-14 range. The lower the pH number, the more acidic the water is. Most living things can't survive in water that is too acidic or too basic. Healthy freshwater has a pH of about 6. Healthy ocean water has a pH of about 8. Most fish and invertebrates live within a pH range of 6 to 9.



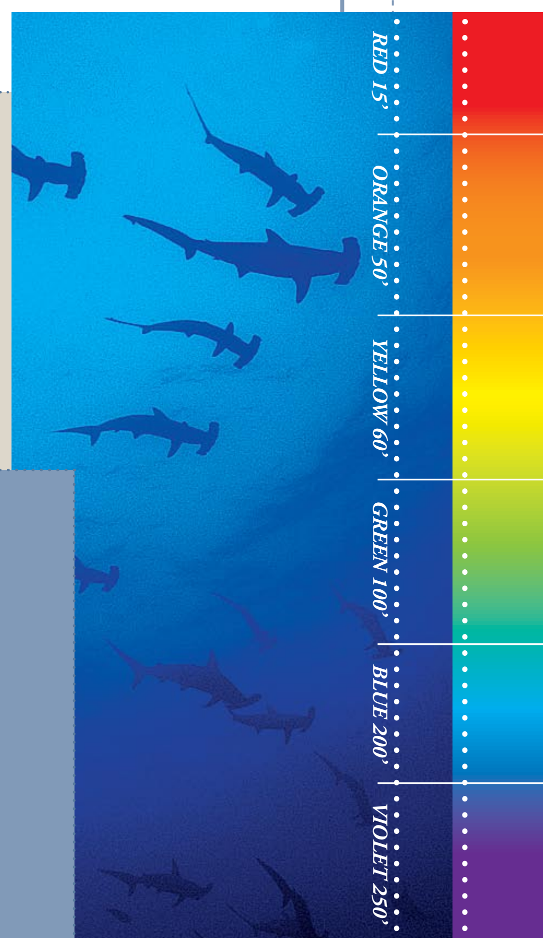
SCIENCE BACKGROUND

MACRO-INVERTEBRATES AND ZOOPLANKTON – Believe it or not, it is a good thing to find these tiny animals in the water. Many of these animals are sensitive to pollution, so they are good indicators of the cleanliness of the water. High diversity (which means many different kinds are present) is a good sign. Low diversity (meaning only a few different kinds are present) could indicate that pollution is present.

DISSOLVED OXYGEN – Living things need oxygen. Organisms that live in the water are no exception. They must have oxygen in the water or have an adaptation that allows them to breathe the air above in order to survive. Even plants need air. Part of the time they convert carbon dioxide into oxygen, but for the other part of the day they respire or breathe and need oxygen. A reading of over 8 is great, if it goes below 6 fish and other critters have a hard time living there.

THE COLOR OF WATER

Ever wonder why water looks blue? It is because of the way it absorbs light. Light contains all of the rainbow colors: red, orange, yellow, green, blue, indigo, and violet which are called the color spectrum. Each of these colors has a different strength or wavelength. Water absorbs red, orange, and yellow quickly *(they have shorter wavelengths)* leaving the green to violet range present in the water. Other factors involved, such as amounts of plankton, suspended particles, and the color and depth of the bottom, are what determine the color of the water within that green to violet range.



PHOTOGRAPHY by Wyland©

DID you KNOW
-WYLAND

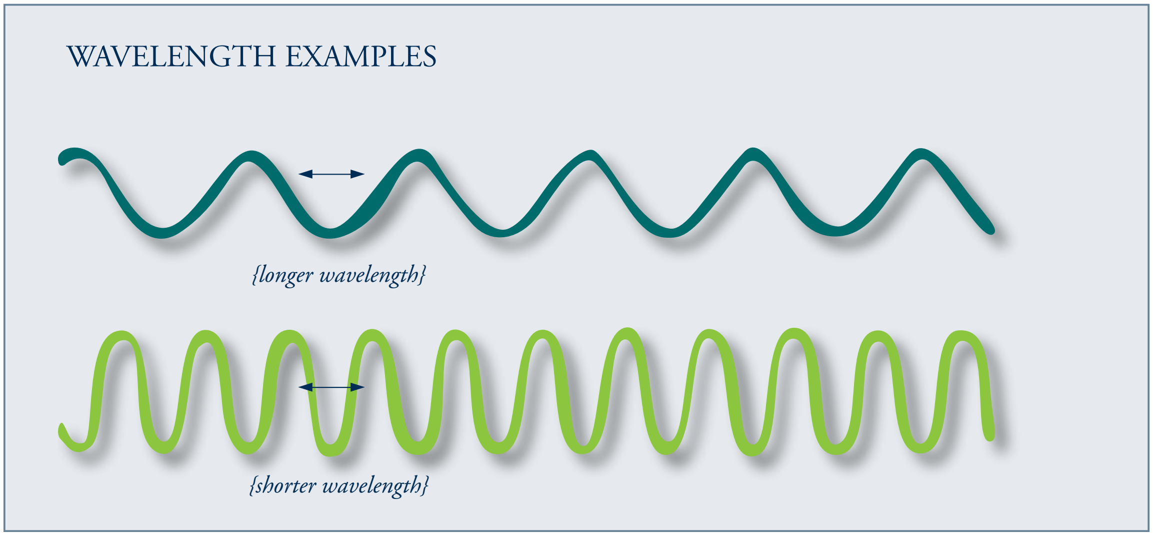
The basic color wheel artists use has almost all of the same colors as the color spectrum. Art is indeed a reflection of our natural world. The only color from the spectrum missing from the color wheel is indigo. Recently, I found out that Sir Isaac Newton (he was the first to discover the color spectrum) wanted to divide the spectrum into 7 colors to match the 7 musical tones in an octave, so he stretched a little to come up with the color indigo.

you KNOW
-DR. SYLVIA EARLE

There are places in the deep water that no sunlight can reach. Here, animals have found a way to create their own light called bioluminescence or "living light." Traveling into the deep water is like falling into a galaxy of twinkling stars.

SCIENCE BACKGROUND

WAVELENGTHS – Wavelengths are measured in nanometers (a very small measurement). It is the distance between the top of one "wave" to the top of the next "wave" or from bottom to bottom. Long wavelengths have less energy and don't reach as far as short wavelengths.



COLOR	WAVELENGTH
RED	625-740 *nanometers*
ORANGE	590-625 *nanometers*
YELLOW	565-590 *nanometers*
GREEN	500-565 *nanometers*
BLUE	440-485 *nanometers*
INDIGO	430-450 *nanometers*
VIOLET	380-440 *nanometers*

SCIENCE BACKGROUND

TYPES OF WATER POLLUTION

SOURCES

All the different types of water pollution fall into two groups called point pollution and non-point pollution.

Point pollution occurs when harmful substances are discharged directly into a body of water and the source, or point, of the pollution can be clearly identified. Examples would include an oil spill from a tanker like the Exxon Valdez incident of 1989 or a sewer system overflowing and dumping untreated waste into a river.

Non-point pollution occurs when harmful substances enter the water in a watershed through runoff or through seepage that occurs after pollutants sink into the ground. Non-point pollution comes from more than one source and more than one place. It accounts for most of the contamination in rivers, lakes and wetlands. Because it can affect areas far from the original source, it is much more difficult to control. From motor oil to fertilizers to pesticides to trash, everyday people are responsible for most non-point pollution. That is why every person has a huge responsibility to control non-point pollution.

TRASH/PLASTICS: Trash is a huge problem in waterways and plastic trash is a very big issue. In the United States alone people empty an average of 2.5 million plastic water bottles AN HOUR, and only 10 percent of these get recycled. Many improperly disposed plastics end up in waterways and the ocean. When plastics degrade, they end up as tiny chemical polymers that never go away. Plankton and jellyfish eat these these polymers, and some places in the ocean have now been shown to have a ratio of 60 percent plastic polymers to 40 percent plankton. Bigger pieces of plastic are eaten by sea birds, turtles, and other wildlife.

• *For special trash facts, see Wyland's Trash Timeline.*

SEDIMENTS AND SOLIDS: When soil or sediments are washed into bodies of water by rain or runoff, they clog the water with sediments that make breathing hard for animals or plants that live in the water. They also fill in waterways when the sediments sink to the bottom, a process called "eutrophication" (YOU-tro-fik-AY-shun).

NUTRIENTS: An overabundance of nutrients for plant life might seem like a good thing. But it is one of the most damaging forms of water pollution. Sewage and farm fertilizers contain nutrients such as nitrates and phosphates that cause extreme growth of plants like algae that live in waterways. When overfed plants "bloom" like this, they use up dissolved oxygen as they decompose, starving fish and other organisms of the element they need to breathe.

ORGANIC PATHOGENS: Pathogens are things that make people or animals sick. Organic pathogens are living organisms such as bacteria or viruses that can cause illnesses ranging from typhoid to dysentery to respiratory diseases. These enter waterways from untreated sewage, storm drains, septic tanks, farms and boats that dump untreated sewage in lakes or the ocean.

SCIENCE BACKGROUND

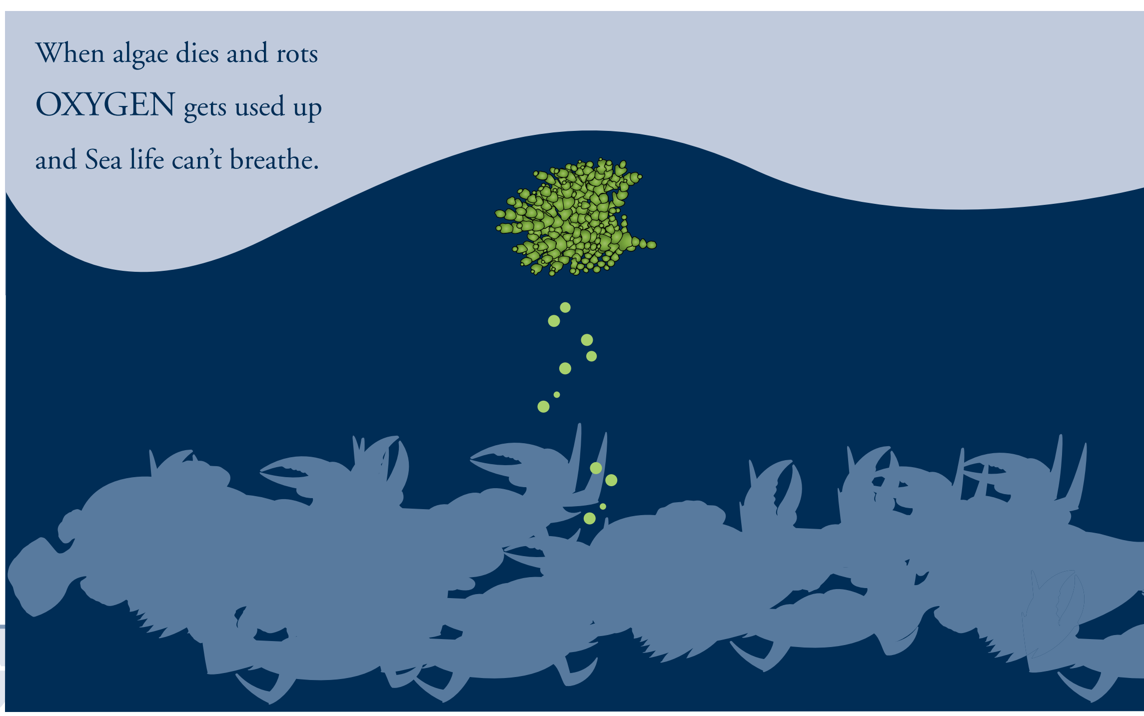
CHEMICAL PATHOGENS: Chemicals that get into watersheds from factory discharges, improper disposal or runoff have been shown to cause cancer and other diseases. In the 1970s, scientists discovered a connection between factories that manufactured electrical equipment, such as transformers, and PCBs, a harmful cancer-causing chemical. The improperly disposed PCBs were finding their way into waterways next to the factories and negatively affecting wildlife. Although PCBs are no longer in widespread use, traces of the chemical still remain in many waterways.

PETROLEUM: Petroleum pollution occurs when there are spills caused by accidents involving oil tankers, offshore oil drilling and runoff from streets, roads and parking lots.

RADIOACTIVITY: Radioactive substances are given off in the form of waste from nuclear power plants and from industrial, medical and scientific uses of radioactive materials. When radioactivity gets into the water system, it remains there for thousands of years.

HEAT: Heat is often overlooked as a source of water pollution. Many industries use water to cool machinery or products. Even if it is not contaminated by chemicals or other materials, it can alter the environment when it is discharged by raising the natural temperature of waterways. This can be damaging or fatal to both plants and wildlife.

DEAD ZONES: Dead zones are places in the ocean where there isn't enough oxygen to support sea life. They are caused by non-point pollution. How does this happen? Too much phosphorus, nitrogen and waste in the water from fertilizers, pesticides and animals cause algae "blooms" which use up the available oxygen in the water along coasts. Every year, an enormous dead zone forms in the Gulf of Mexico near the mouth of the Mississippi River. Why there? The Mississippi is where watersheds from 40 percent of the United States drain into the ocean.



SCIENCE BACKGROUND

THE WONDERS OF AQUATIC LIFE

The number of species of plants and animals that live in aquatic ecosystems is enormous. Scientists estimate that 90% of all life on earth lives in or around water. As scientists continue to explore water-based ecosystems, new species are constantly being discovered

These aquatic ecosystems play an important role in the survival of most land animals. For example, wolves eat small mammals that eat fish from lakes. Many migrating birds need wetlands as a feeding and nesting area. Many foods that people enjoy like ice cream, salad dressing, and cheese spreads contain kelp from the ocean. Can you think of an animal that doesn't need an aquatic ecosystem?

DID you KNOW?

Aquatic habitats such as wetlands are disappearing faster than we can explore them. Some species become extinct before we even know they exist.

-WYLAND

DID you KNOW?

School-room maps tend to depict continents in exquisite detail, but show the oceans as big blobs of blue, with no suggestion of the immensely important diversity of features, and creatures, below. The greatest era of exploration on earth, venturing into the vast unknowns of inner space, has barely begun.

-DR. SYLVIA EARLE

{Trash Timeline provided by Reef Relief, www.reefrelief.org}

WYLAND'S TRASH TIMELINE

COULD PEOPLE IN 2025 CALL THIS A BEAUTIFUL OCEAN?

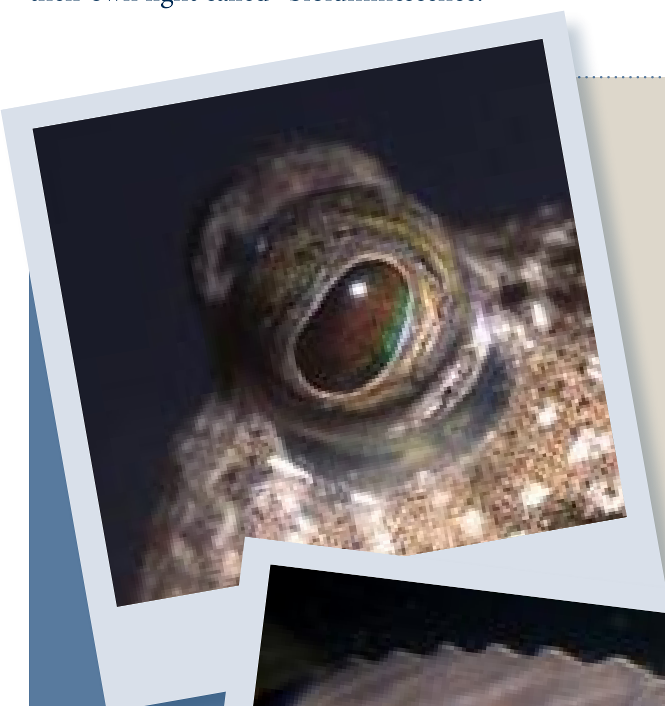
This is where we're headed if we don't clean up our act.

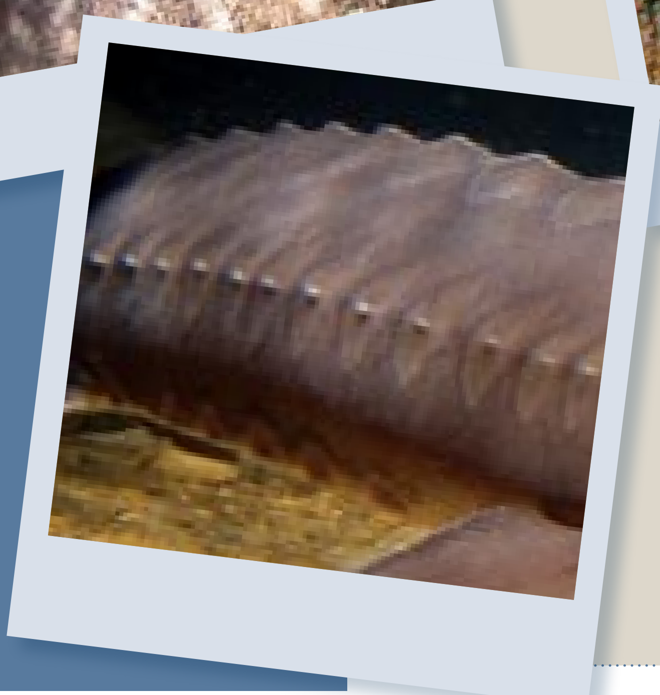
SCIENCE BACKGROUND

ADAPTATIONS FOR SURVIVAL

Organisms adapt to the physical conditions of their environment in order to survive. Adaptations occur over many generations and are often very slow to take place. Adaptations are as varied as the creatures themselves. An adaptation could help an animal hide, hunt, move, or find a mate.

Looking closely at a fish and its habitat can give you clues about it adaptations. Even looking at its eyes can tell you a lot. Large eyes could mean the fish lives in water where there is little light (in which case it needs big eyes to help it see). If the eyes are very small, maybe it has a great sense of smell. Many animals that live in the deep sea where there is no natural light have the ability to make their own light called "bioluminescence."





SCIENCE BACKGROUND

Being adapted to a particular environment does have a downside. If the environment changes, that could be trouble for the animal. If the change is slow, it may have a chance to adapt to the new circumstances, but if it is a quick and dramatic change, the animal may not be able to survive. Here are some examples of adaptations:

Examples:

1 Frogfish

are found in the ocean and look like the bumpy sponges or algae they sit on. They have a built-in fishing lure right on their heads that they wiggle to try to attract prey. Frogfish don't swim much, they walk on their fins instead.

1. Frogfish Photo Credit: National Oceanic and Atmospheric Administration Department of Commerce

2 Sturgeon

These fish have been around before the dinosaurs and haven't adapted all that much! Instead of scales, they have five rows of bony plates that act as armor. Lakes, rivers, and estuaries are the most common places to see these prehistoric giants. Some get as large as five feet in length.

2. Sturgeon Photo Credit: US Fish adnd Wildlife Service

3 Mudskipper

Can a fish live out of the water? A mudskipper can! Seawater stored behind their ears is used to keep their gills moist and allows them to breathe when they are out of the water. They move across the land by walking on their fins. Mudskippers can be found in wetlands and estuaries.

3. Mudskipper Photo Credit: Paddy Ryan • ryanphotographic.com

SCIENCE BACKGROUND

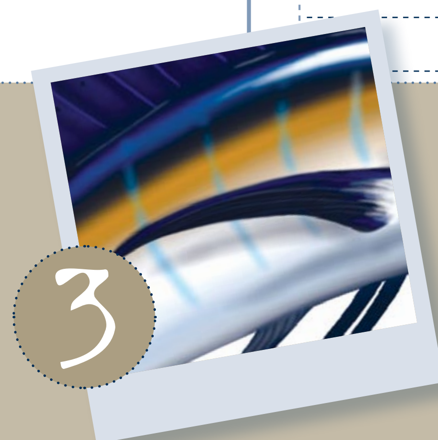
FISH FINS

Typically every fin on a fish has a function just like all your body parts have a function, even if you aren't aware of it all the time. Here are the basic functions of the most common fins on a fish. Not all fish have each of these fins and some have more!

Sailfish:

1. DORSAL FIN: located on the back of the fish, this fin helps the fish stay upright when it swims through the water.

2. CAUDAL FIN: otherwise known as the tail fin. Most fish use this tail for swimming power.



3. PECTORAL FIN: a set of fins on the each side of the fish near the head. These fins can be used to steer, provide lift, and to brake. Some fish also use them for swimming.

4. PELVIC FINS: a set of fins on the underside of the fish near the head. Pelvic fins help provide stability when swimming. Some bottom or reef dwelling fish will "sit" on their pelvic fins.

5. ANAL FIN: a fin on the underside of the fish located near the back and helps with stability while swimming.

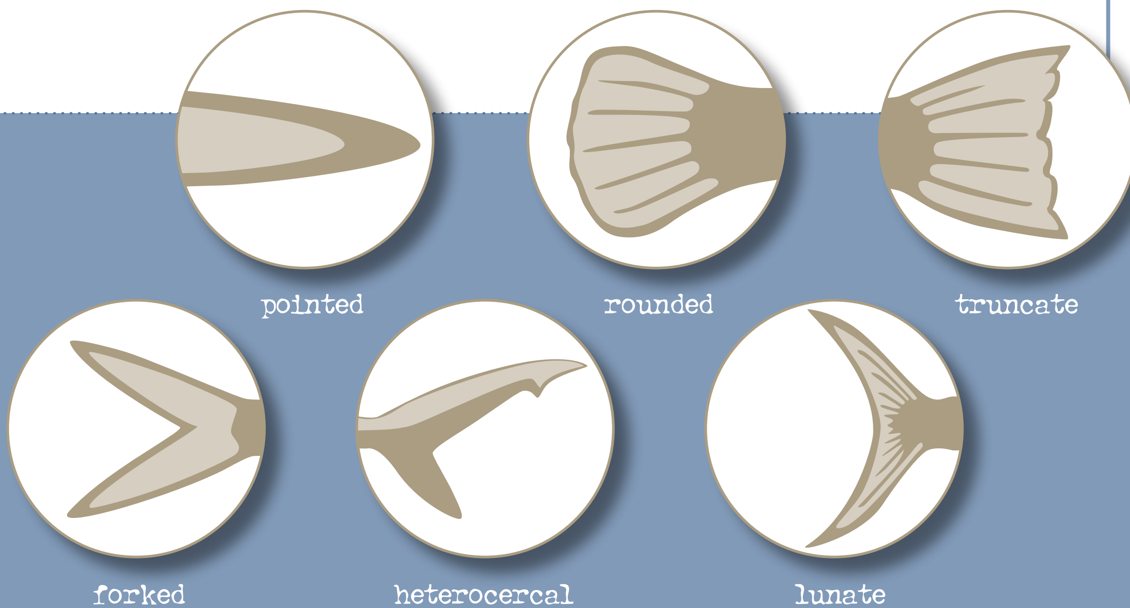
Sailfish *(istiophoridea)* by WYLAND

Average Adult length: 7 ft.

Average Adult weight: 80-90lbs.

SCIENCE BACKGROUND

CAUDAL (TAIL) FIN SHAPES:
The shapes of the caudal fins are adaptations too and can tell you a lot about a fish, including where they might live and how quickly they move. Take a look at these examples, shown from slowest to fastest.



DID you KNOW
-WYLAND

I've seen some fish that have amazing fin adaptations that allow them to better survive in their environment. The walking catfish has sturdy pectoral fins with a very strong spine that, along with a special air-breathing organ, allows it to walk on land.

SCIENCE BACKGROUND

{flying fish}

FISH SHAPES: The shape of a fish can tell you a lot about it. Some shapes are faster than others, some shapes allow fish to camouflage, some shapes even help protect the fish. The most common body shapes are fusiform, rod, depressed, compressed, sphere, and ribbon. Here are some examples.

1 Depressed (stingray)

Flatfish and rays are "depressed." That isn't a state of mind, it is the name of their body shape. Being flat allows them to hide on the bottom and wait for prey to wander by, a sneaky but effective hunting strategy!

2 Sphere or Box (puffer)

Would you like to eat a large ball with spines all over it? Not many animals would find that to be an appealing meal. Perhaps that's why sphere shaped puffers don't have many natural predators.

3 Rod (freshwater gar)

Rod shaped fish like freshwater gar are quick and stealthy.

3. Freshwater Gar Photo Credit: US Fish adnd Wildlife Service

4 Fusiform (shark)

The fastest fish in the ocean need to be hydrodynamic, or "shaped efficiently" to move through the water. Fish like great white sharks and bluefin tuna have a shape called "fusiform" that resembles a football. As it turns out, shapes that move efficiently through the air move efficiently through water as well.

5 Compressed (angel fish)

Compressed fish like Moorish idols and angelfish look like they were flattened from the sides. This skinny shape allows them to hide in thin cracks in coral reefs where larger predators can't reach them.

6 Ribbon (eel)

Ribbon-shaped fish like eels have the perfect body shape for wandering through holes in reefs, rocks, and logs to look for food and to find protected places to rest.

SCIENCE BACKGROUND

CAMOUFLAGE

Camouflage comes in many shapes, textures, colors, and forms. Just about anything that helps an animal hide can be considered camouflage. Take a look at these amazing examples:

Camouflage:

1 Patterns (octopus)

Texture, pattern, color, and shape! This master of disguise can change them all at will to blend into the background in an instant. Can you find the octopus in this picture?

1. Octopus Photo Credit: Mark Rosenstein

2 Coloration (trout)

When the top half of a fish is darker in color and the lower half is lighter, they can hide in open water! Imagine if you were underwater looking up towards the surface, you'd see some light up there and the light belly of the fish would blend in. If you were looking down, it would be darker and the dark back of the fish would blend in. Trout have this type of coloration called "Countershading"

3 Shapes (leafy sea dragon)

Is this even an animal? The color and shape of these fanciful frills help the leafy seadragon to blend right into the seaweed.

3. Leafy Seadragon Photo Credit: Mike Shields, shieldsnet.org

SCIENCE BACKGROUND

COLORS FOR SURVIVAL

The colors and patterns of most animals aren't just for beauty, they actually help the animals in daily activities such as attracting mates, camouflaging to hunt or hide, and warning other animals to stay away. In many cases the animals ability to survive depends on its coloration. Take a look at these examples of how colors and patterns are used by some aquatic animals.

1 Disruptive (blue lined snapper)

Breaks up the body shape of the fish so that it can't be easily identified. May make it easier for it to blend in with background. When a bunch of disruptive fish school together, it is really hard for a predator to focus on one individual fish and catch it. Could be stripes, bars, or other markings.

2 Cryptic (scorpion fish)

Cryptic means secret or hidden. Cryptic coloration is a variety of patterns and colors that help a fish blend in with the background, like soldiers camouflage. Many fish and other aquatic creatures can change their colors and patterns when trying to camouflage.

3 Countershading (great white shark)

When the top half of a fish is darker in color and the lower half is lighter. This helps the fish to hide in open water. Imagine you were underwater looking up towards the surface, you'd see some light up there and the light belly of the fish would blend in. If you were looking down, it would be darker and the dark back of the fish would blend in.

4 Warning (garibaldi)

Some fish actually want all the other animals to see them. Really brightly colored fish, especially in ecosystems where most fish are trying to camouflage are sometimes sending a signal that says don't mess with me. They might be have venom, poison, or be really fiesty!

SCIENCE BACKGROUND

COLORS FOR SURVIVAL
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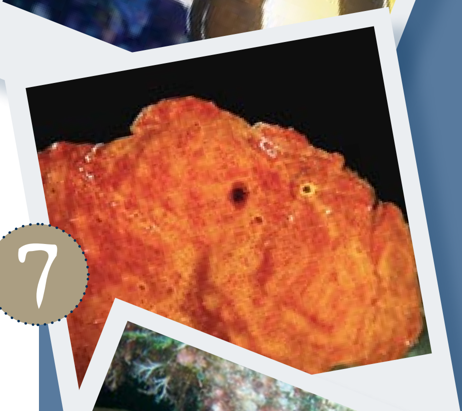


5 False Eye Spots (butterfly fish)

Ever wish you had eyes in the back of your head? These animals use false eye spots to confuse predators about where their eyes are and what they are looking at. Flase eye spots are also usually larger than the fish's real eyes and that can make a predator think the fish is bigger than it really is. Both these strategies make predators think twice before attacking.

6 Vertical bars (angel fish)

This color strategy helps to break up the shape of the body and allows the fish to disappear into the background, especially in areas where light and shadow mix or where there is a lot of background such as a coral reef. When these fish school together in a large group it is also difficult for a predator to focus on catching one individual fish.

7 Mimicry (Frogfish)

These animals could also be called "copy cats". They take on the color, shape, and pattern of something else so they can hide. Frogfish look like the bumpy sponges they sit on and are very difficult to find. Another type of mimicry is when an animals tries to look like another one. There is a small octopus that imitates a shrimp so it can sneak up on its prey.

8 Advertisement (cleaner fish)

Some animals want to be seen. Cleaner fish have brightly colored stripes and want others to come to them. When other fish come by, the cleaner fish eat parasites and dead skin from them. Both fish benefit from this arrangement, so the larger fish won't eat the cleaners.

SCIENCE BACKGROUND

THE FOOD WEB

Every organism needs some kind of food and the base for most food webs are plants. Plants can make their own food by using energy from the sun to convert water and carbon dioxide into sugars in a process called photosynthesis. Because they can make their own energy, they are called producers. Animals are called consumers because they must eat (consume) other things to get their energy. This energy transfers from one organism to another up the food chain.

For a long time it was thought every food chain started with the sun and photosynthetic plants, but recently scientists have discovered creatures in the deep dark sea that can use chemicals instead of sunlight to create energy. Chemosynthetic creatures live on or near hydrothermal vents in the deep sea where temperatures can be up to 750 degrees Fahrenheit! The chemicals from these vents are so toxic they would kill a human being (and the extreme heat wouldn't help either).

In every Food Web, living things have specific roles to play in the recycling of energy. Organisms playing each role are needed to create a complete and healthy Food Web. In most food webs, the cycle starts with energy from the sun and the energy gets passed through the web.

DID ? KNOW

-DR. SYLVIA EARLE

Even though the water is 750 degrees, it doesn't boil because of the weight pressure from the weight of all the ocean water on top of it.

PRODUCERS: like phytoplankton, algae, and plants make their own food, typically from sunlight.

PRIMARY (first-level) consumers: are plant-eating herbivores and meat producers.

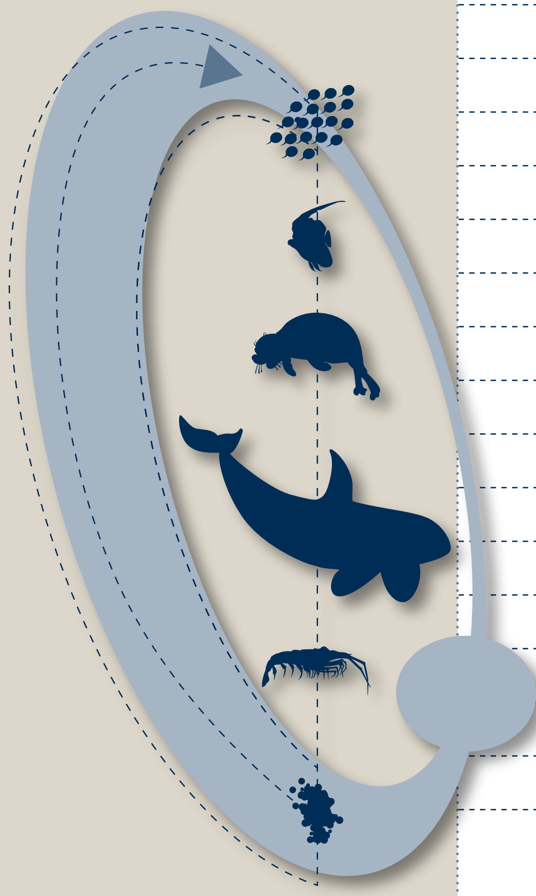
SECONDARY (second-level) consumers: eat primary consumers.

TERTIARY (third-level) consumers: eat secondary consumers and are sometimes considered the top predators.

TOP PREDATORS: have no natural predators besides humans.

SCAVENGERS: are the "clean up crew" eating leftovers and plants and animals that have died.

DECOMPOSERS such as bacteria, insects, or worms turn small dead particles and waste particles back into nutrients and the cycle starts over again.



SCIENCE BACKGROUND

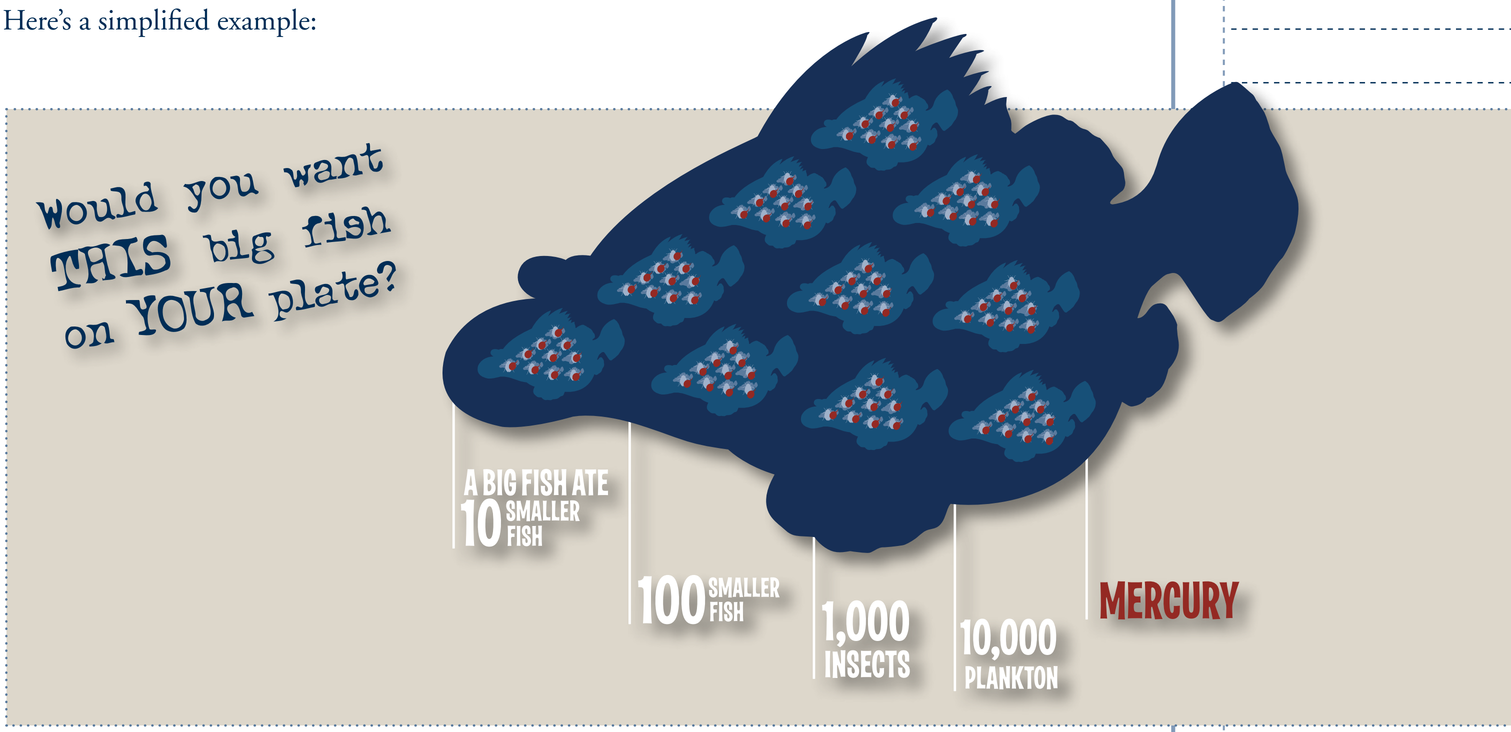
THE FOOD WEB *(continued)*

In a balanced ecosystem, nothing goes to waste. Matter and energy are recycled over and over again and the ecosystem has somewhat stable numbers of organisms called populations. The numbers of a population are limited by the amount of energy (food) and matter available. When something changes in an ecosystem it affects each population and the delicate balance can be broken.

A good example is the kelp forests off the coast of Southern California. Sheephead are being over-fished in some areas, which can create a population explosion of purple urchins. The large number of urchins eat all the kelp in the area. What do you think happens from there? The whole system crashes because there is a limited amount of kelp (energy) available and it was all consumed quickly. The kelp is not only food for many animals, but provides shelter for them as well so the effects are far reaching.

WHAT IS BIOMAGNIFICATION?

When chemicals, minerals, metals and other toxic substances get into water supplies, their impact grows as they spread up through a Food Web. This effect is called "biomagnification." Here is how it works: Toxic substances like mercury or the pesticide DDT enter the water supply from air pollution or runoff from higher ground. They are absorbed by plants and microscopic life like plankton. The plankton are eaten by clams and fish. The clams and fish are eaten by gulls, birds of prey like ospreys or eagles or marine mammals. There may not be a lot of a chemical in each plankton or clam. But because each larger animal eats many of the smaller animals, the total adds up, or is "magnified." Here's a simplified example:



SCIENCE BACKGROUND

Mercury pollution is raising concerns for oceans, lakes, rivers and wetlands. In recent years, scientists concerned about water pollution have focused increasingly on mercury. Mercury is one of the 103 elements and is found in both nature and man-made environments. It is used in laboratories for making thermometers, barometers and other instruments and in medicine for dental fillings. It is used in industry for making pesticides, advertising signs, electrical equipment and batteries. Most mercury pollution is spread through air as a result of burning trash in incinerators, burning coal in factories or power plants, and through industrial activities like metal processing. Some mercury air pollution also occurs naturally from volcanoes and "outgassing" from oceans or natural mercury deposits. Mercury in the air gets into oceans, lakes, rivers and wetlands when it rains. Bacteria in the water cause chemical changes that transform mercury into methylmercury, an organic form of the element that can be toxic. In humans mercury can cause damage to the nervous system, birth defects and learning disabilities, among other effects.

Because mercury pollution is spread mostly through the air, it affects both salt and fresh water. In oceans, biomagnification of mercury in the food chain has led to high levels of mercury in large fish like swordfish, shark, king mackerel, tuna, sea bass, halibut, marlin, pike and white croaker. In some fresh-water lakes, mercury has built up in large game fish, as well as in smaller fish people fish for fun. Around the world, health leaders have warned people about mercury dangers from eating large food fish. In the United States, more than 40 states now offer advisories about eating fish that could have high mercury content. With so many advisories, the U.S. Geological Survey has declared that "mercury is a serious national problem."

The Everglades in Florida are one of the nation's most spectacular wetland habitats. The Everglades also are an area where mercury pollution is getting special attention. The U.S. Environmental Protection Agency, the U.S. Geological Survey and water officials in South Florida are co-funding an extensive study to see how mercury is affecting the delicate ecosystem of the Everglades. The study is trying to determine where the mercury is coming from in the Everglades, how it is cycling through the habitat, and how it is affecting the food chain. What the scientists find is expected to shed light on the effects of mercury on other ecosystems in the U.S. and around the world.

Mercury is just one example of toxins that build up in the food chain. Prescription drugs, pesticides, and other man-made chemicals can also build up in fish, shellfish, and marine mammals and affect their health.

SCIENCE BACKGROUND

When it comes to chemical pollution, the bigger the animal, the bigger the problem. In no case is that clearer than in the community of killer whales that live in the Pacific Ocean off British Columbia and Washington State. Killer whales, also known as orcas, are some of the most impressive mammals in the sea. They also are some of the hardest hit by pollution. The 85 resident killer whales that swim between Georgia Straight and Puget

Sound are considered some of the most polluted marine mammals in the world. Their bodies are contaminated with chemical pollutants like PCBs and DDT, which were banned years ago but are still in the environment. These chemicals have accumulated in the whales' blubber through biomagnification. As a result, the whales have problems reproducing, lowered immunity to diseases and disruptions to the endocrine system, which produces hormones necessary for good health.

DID you KNOW

-WYLAND

Diving in Belize I saw a six foot grouper fish following a moray eel as it wove its way in and out of cracks and holes in the reef. Since grouper don't usually eat eels, I wondered what it was doing. I discovered that in its search for food, the eel was scaring small animals out of their hiding places in the reef and the grouper was gulping them down!

Moray Eel

DID you KNOW

-DR. SYLVIA EARLE

What has always interested me are the connections between living things. Though it may sound strange, one of the most important things a scientist can do is stay still and observe. You'll always be rewarded with a glimpse of interesting behaviors that other people pass right by.

THE HUMAN CONNECTION

As you take part in this art and science program, the connections become clear. Clean water means healthy ecosystems which means healthy people. What happens in one body of water can spread to another and in this way the people of the entire world are tied together. The struggle to keep water clean is an issue facing everyone.

So what can one person do to make a difference? Plenty! The Eco-guides and activities are filled with ways anyone can help and examples of real people choosing to get involved. It may take a small step like recycling, a piece of community art with a message, or a life decision like choosing a career, but we urge you to make a choice to make a difference.