



Wyland Clean Water Challenge

FOR THE 21ST CENTURY...AND BEYOND

# EXPLORING AQUATIC ECOSYSTEMS

# LAKES

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# CASE STUDY

# GREAT LAKES

From the earliest times of human settlement, the Great Lakes have been an enormously important resource. Fish in the lakes fed Native Americans and early European settlers, and the lakes provided an efficient way to travel and carry goods from place to place.

Today, the Great Lakes are still valued for their fish and shipping on the lakes supports industry and jobs in both the United States and Canada. The lakes also are a tremendous recreation resource, providing beautiful places to enjoy nature and learn about marine life.

Balancing the uses of the Great Lakes has been one of the great challenges for leaders throughout the region. Shipping and recreational vehicles can cause water pollution and can have a huge impact on the Great Lakes environment. Because of the high number of ships that travel through the Great Lakes, the lakes have been hit very hard by many different kinds of invasive species.

Consider the tiny zebra mussel. This little shellfish doesn't look like it could cause a big problem. But in the Great Lakes, the zebra mussel is expected to cause \$5 billion in damage over the next 10 years.

The mussels were first carried from Russia in the ballast water of cargo ships. They have multiplied dramatically in Great Lakes waters, clogging drains and pipes and damaging piers where they cling. Non-native species find their way abroad through ballast water that is sucked up by cargo ships to give them weight and balance during trips. When ships pump the water out in ports where they deliver goods, they also pump shellfish, plants, fish, and microscopic organisms out into new environments.

Another invasive species that has entered the Great Lakes and caused problems is the sea lamprey. Originally from the Atlantic Ocean, sea lampreys swam along new canals and passages built for ships to travel around natural barriers, like



*Sea Lamprey*  
Photo Courtesy of: US Fish & Wildlife



*Zebra Mussels*  
Photo Courtesy of: SeaPics ©Jeff Jaskolski/SeaPics.com

# Cargo Ships Carry Risks

Niagara Falls, into the Great Lakes. Baby lampreys were also introduced to the Great Lakes when they were sucked up with seawater used as ballast.

The sea lamprey is a nasty, eel-like fish with a large round mouth full of teeth. It latches onto large recreation fish and sucks the fish's blood. In the Great Lakes, it has caused great damage to game fish like lake trout and whitefish.

Because invasive species pose such a risk to the Great Lakes, scientists and governments in both the United States and Canada are looking for ways to block them. Vessels entering the Great Lakes now are required to replace fresh ballast water with seawater to kill freshwater invasive species before they will be allowed in.

Researchers are studying ways to rid invasive species from ballast water including: filtering, heating, or using ultraviolet light. Another technique uses a spinning centrifuge device called a *hydrocyclone* to separate organisms and sediment from water to be discharged into the lakes. In addition, chemical treatments are being used to kill larvae.

Researchers are also trying to find ways to create barriers that would block invasive species, including new approaches using sound waves, electrical impulses, and visual deterrents.



## WYLAND FUN FACT

**The Great Lakes (Superior, Michigan, Huron, Erie, and Ontario) contain an estimated 6 quadrillion gallons of water. They are the largest fresh surface water system on Earth.**

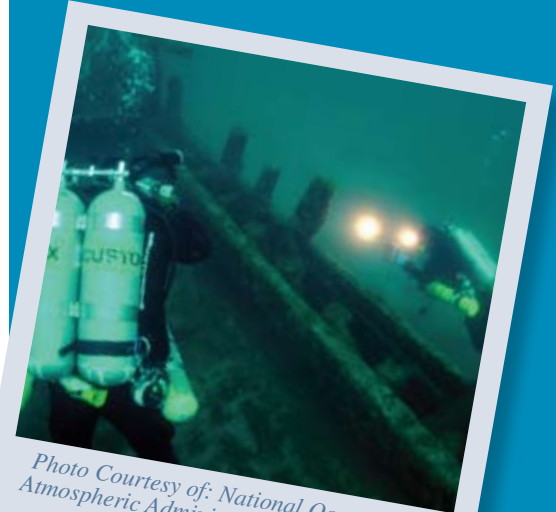


Photo Courtesy of: National Oceanic and Atmospheric Administration—Thunder Bay National Marine Sanctuary



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# HOW HUMANS



## WYLAND FUN FACT

BEAVERS  
SOMETIMES  
CREATE  
WETLANDS  
WHEN THEIR  
DAMS BLOCK  
A RIVER OR  
STREAM.

Wetlands are very delicate ecosystems. An ecosystem consists of all living and non-living things that naturally come together in a place. An ecosystem can be very large, such as an entire ocean, or very small, such as one rain puddle.

If any one thing changes in an ecosystem, how the whole ecosystem works will also change. For example, if water levels change, if water is polluted, or if new plants or animals begin to live in a wetland, the balance of the wetland ecosystem can quickly change and plants and animals can die.

**People** are the biggest threat to the world's wetlands. One of the ways that people have changed wetlands is that they have drained them for farmland, or filled them in to build houses or businesses. Because of such activity, half of the world's wetlands were destroyed in the last century. At that time people did not understand how important wetlands are to keeping the world healthy. Many countries are now working to protect and even restore wetlands.

Other human activities also can affect or damage wetlands.

The building of **dams** on rivers can stop or divert water that would normally enter wetlands. This can make wetlands much smaller in size or dry them up completely.

**Pesticides** pollute wetlands and can kill the plants and animals that live there. On farms, for example, people use pesticides to keep bugs away from crops. Unfortunately, many of the pesticides that help farmers raise fruits and vegetables also pollute and poison wetlands. When it rains, pesticides wash off of crops, enter the water system, and eventually reach wetlands.

# AFFECT WETLANDS

Although wetlands act as filters to draw pollution from water, they do have a saturation point. The saturation point is the point when a wetland cannot absorb any more pollutants. When this happens, the extra pollutants begin to poison the wetland.

Beyond pollution and destruction of habitats, animals in wetlands face two big problems.

The first problem is **poaching**.

Sometimes, people don't have much money and know that they can make some if they sell animal skins and furs illegally. Other times, people are just greedy for money they can make through poaching or buying furs and skins.

In South America's Pantanal Freshwater Marsh, for example, poachers kill jaguars, wolves, and caimans, a cousin of alligators. They skin the animals and sell their fur. Other times, poachers steal beautiful, colorful birds and sell them as pets.

**Invasive species** are another problem. Invasive species are plants and animals that are not naturally a part of the ecosystem of an area. Invasive species can be carried naturally by wind or water, but, increasingly, they are being introduced accidentally to areas by human activities. Sometimes, invasive species can kill or take over an animal or plant species that already lives in an area. This can change an ecosystem forever.





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Chad Pregracke

FOUNDER  
LIVING LANDS AND  
WATERS ORGANIZATION

# People

## Chad Pregracke

*Tires, barrels, even refrigerators. These are just a few of the many items people leave behind in the Mississippi River. Every year, thousands of pounds of trash like this are dumped in the river. Now, thanks to Chad Pregracke, thousands of people sign up every year to help clean up that trash.*

*Pregracke grew up along the banks of the Mississippi. He swam and fished in its waters. Playing in his backyard, he enjoyed the water rushing by. He never noticed the garbage accumulating around him. But in high school and college, he worked as a commercial diver for mussels and he realized he could no longer ignore what he saw happening to the Mississippi. He says simply, "I didn't like what I was seeing and I just started to pick stuff up."*

*This individual effort launched a large movement to clean up the Mighty Mississippi. Today, 3,000–4,000 people a year join Pregracke to "pick stuff up" all along the river through a non-profit group he founded called Living Lands and Waters. "We just*

*make it a fun experience and create an opportunity for people to do good things" he says of this grassroots effort.*

*Today, Living Lands and Waters organizes community clean-ups and sponsors a variety of programs, including Adopt-a-River-Mile and the Riverbottom Reforestation Program. Two barges and several workboats aid the efforts. Recently he sent his boats into the area devastated by Hurricane Katrina to help demolish damaged homes and start the rebuilding process. "We basically loaded the boats with building materials and handed them out," Pregracke says. He feels that while they made a great deal of progress, there is still much more to be done.*

*Recognition of his efforts came at a young age for Chad Pregracke. He was just 28 years old when he received the Jefferson Award for Public Service in 2002. While he once believed that his youth was an obstacle to achieving goals, he has come to realize that it was actually an asset. "People want to see*



# CLEANING UP RIVERS

## One Piece at a Time

*young people succeed,” he says. To that end, he encourages kids to get involved in environmental projects, and he also urges young people not to be shy in asking for the help of adults to find ways to make a difference.*

*In his river work, he has seen first hand how individuals can make things better. “The great thing is that the garbage is not coming back,” he says. “People are becoming aware of the problem and they are not dumping as much.” People also are realizing that garbage is a broad environmental problem.*

*For Chad Pregracke, the key to real change is “getting people involved and maybe they’ll take what we are doing along the river a step further and work toward changes in local government and Congress.”*

**MAKING A DIFFERENCE**





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# WHAT IS AN ESTUARY?

An estuary contains some of the most interesting and complex water habitats.

Estuaries are places where freshwater from rivers meets saltwater from the ocean. These meeting places don't have precise boundaries like the boundaries between states, however.

In an estuary, fresh and saltwater mix in a variety of ways depending on the shape of the land, the strength of the flow of water in the river, and the force of tides from the ocean.

Estuaries usually are partly closed areas that slow down the river water, giving it time to mix with saltwater and elements found in the land along the shore. The mixing creates a rich and complex environment that can support thousands of varieties of plant and marine life.

Bays, harbors, lagoons, sounds, and coves can all be estuaries. The Chesapeake Bay in Maryland, is in fact, the largest estuary in the United States. Coral reefs, sandbars, spits of land, or rock deposits that create sheltered areas along the ocean's shore can also form estuaries. They may also contain swamps, marshes, and various other wetland habitats.

Many shellfish, birds, and fish spend their whole lives in and around estuaries. Even many fish that live most of their lives in the ocean come to estuaries to lay eggs or give birth to young. An estuary is a safer and more protected environment for young animals. Spending their young lives in an estuary habitat gives them a better chance for surviving than they would have in the open ocean.

Home to countless plant and animal species, many estuaries are among the most life-filled places on the planet.



*Frog*



*Crab*



*Raccoon*

## HOW ARE ESTUARIES FORMED?

To understand how estuaries are formed, you need to first understand the different shapes that land takes along rivers and oceans.

The study of the way land is shaped is called *topography*. Topography is one way that scientists put estuaries into categories so that people can better understand them. Using topography, scientists divide estuaries into four main categories.

### FLOODED, DROWNED, OR COASTAL

The first type is known by several names: flooded river valley estuary, drowned river valley estuary, or coastal plain estuary. This type of estuary was generally formed at the end of the last ice age about 10,000 years ago. When the glaciers of the ice age melted, the level of seawater rose all around the world because water from melting glaciers went into the oceans. As the sea level rose, the areas where many rivers met the sea were covered by water. In these shallow areas, fresh and salt water mixed in an estuary.

### BAR-BUILT

The second kind of estuary is a bar-built estuary. A sand bar is a place where sand and sediment build up, creating an obstruction that forces water to flow around it. When a river meets the ocean, sediment sometimes falls out of the water as the river water slows down. At the same time, sand pushed toward the shore by the ocean builds up from the other side. When this sand or sediment forms bars that block the river from the ocean, a bar-built estuary is formed.

### FJORDS

Fjord estuaries were formed by the movement of glaciers sliding over land. Fjords (pronounced FEE-ords) are narrow inlets bordered by steep cliffs that were created during the last ice age. When the earth warmed and the ice melted, the ocean flowed into the steep fjord river valleys, mixing with freshwater to form fjord estuaries. One important feature of a fjord estuary is that many of them have a sill of rock formed from debris dropped by the

glacier at the place where the fjord meets the open sea. As a result, fjord estuaries have shallow water at their entrance but very deep water inside.

### TECTONICS

The last category scientists have created for estuaries is a tectonic estuary. Earth's outer layer, or crust, contains large sheets of rock, called *tectonic plates*, which can overlap or push against each other. When pressure and energy cause the plates to move in coastal areas, land near the plates sometimes drops or collapses, and seawater moves into the collapsed area. If there is a river flowing through this area, it mixes with seawater to form a tectonic estuary. The famous San Francisco Bay in California is a tectonic estuary.



### WYLAND FUN FACT

There are 102 major estuaries in the United States, according to the U.S. Environmental Protection Agency. Of these, 28 have been designated by their states and the federal government to be of national importance.



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# OCEAN HABITATS AROUND THE WORLD

## POLAR SEAS

Cold polar seas don't sound like a comfortable place to live, but they support a great deal of life. Tiny algae are at the base of a chilly food web. Algae grow in the water and on the ice. A shrimp-like animal called *krill* come by the thousands to eat the algae. These tiny krill are food for many animals such as whales, sea birds, and fish. The fish are food for seals and the seals are eaten by top predators like orcas.

Beyond the food webs they support, polar seas have another important role on our planet. Polar seas affect the currents and climate on our planet. The polar seas are like giant mixing machines. Cold water is denser (heavier) than warm water so it sinks to the bottom of the ocean and pushes warmer water upwards. This mixing keeps nutrients moving and ocean currents like the Gulf Stream running.

There has been concern in recent years because levels of polar ice seem to be getting smaller every year. Scientists say this is due to global warming of Earth's atmosphere and some even estimate that the ice pack may completely disappear within the next 80 years. If this happens, many animals will lose their homes and the weather around the globe could change.

## KELP FORESTS

The giant forests of the ocean are made up of kelp instead of trees. Kelp is often referred to as seaweed, and if you've ever visited the beach, you may have seen some washed up on the shore. Out of its element, kelp may seem smelly, sticky, and not very important. Those who have been lucky enough to visit an underwater kelp forest will tell you a different story. Giant kelp, called *Macrocystis pyrifera*, can grow to be 200 feet tall and its beauty rivals that of any forest on land.

Kelp needs sunlight and cool, nutrient-rich water to grow, so it is found in the temperate areas of the ocean. When conditions are just right, giant kelp can grow up to two feet in one day! Kelp forests, like forests found on land, offer food and shelter

for an amazing number of animals. Even people use kelp for food and other products. If you've ever eaten ice cream, salad dressing, or cheese spread you've eaten kelp. Kelp is also in most toothpaste, so chances are you use it daily.

The residents of kelp forests tend to be a lot less colorful than critters that live in coral reefs, but they are just as fascinating. Lobsters, octopuses, eels, bat rays, giant black sea bass, and leopard sharks all make the kelp forest their home.

## CORAL REEFS

Tiny animals the size of a button are responsible for creating some of the ocean's most important and impressive habitats — coral reefs. An individual coral animal is called a *polyp*. Thousands of polyps together create stone-like structures that they live in. When the polyps die, new ones settle on top and keep building. Coral reefs are built slowly over thousands, sometimes millions, of years. The Great Barrier Reef in Australia is the largest living structure on the planet at about 93 miles wide and 1,240 miles long!

Most reef-building corals need sunlight and warm clear water to grow, so they are found in tropical waters. Corals have algae called *zooxanthellae* (zo – zan – thel – ee) that live inside their bodies. The zooxanthellae use the sunlight in a process called *photosynthesis* to create food. A great example of a symbiotic relationship where both organisms benefit, the coral uses some of the food and the algae has a protected place to live. The algae is also the source of the beautiful and bright colors of coral.



WYLAND FUN FACT

**Fish and other animals from coral reefs feed between 30 and 40 million people a year!**

Scientists believe that one-third of all life in the ocean depends on coral reefs for survival. A coral reef habitat serves as a nursery for all kinds of young creatures that may move out to the open sea in their adult years. It acts as a hiding place or temporary shelter for some and is a permanent home to many others. Coral reefs are also a great hunting ground and source of food for large predators such as sharks.

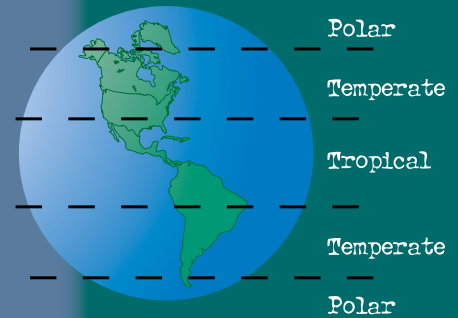
Living in a coral reef are brightly colored fish, moray eels, lobsters, clams, urchins, sea stars, and snails. Cruising by might be sharks, giant manta rays, or large schools of barracuda.

## DEEP SEA

The deep sea is one of the least explored places on the planet. A deep sea submersible (which is like a submarine) and a lot of other expensive equipment are required to safely get there. As technology gets better, scientists are venturing into the deep more often and are making amazing discoveries. The Mariana Trench is the deepest part of the ocean. It reaches over 36,000 feet below the surface of the ocean. That is almost seven miles! The Mariana Trench is located in the Pacific Ocean near the island of Guam and is almost 1,500 miles long and 45 miles wide.

Amazingly, there is life in these depths. No sunlight reaches that far down, yet scientists have seen flashing lights in the dark waters. Some of the fish and other animals that live there have found a way to create light that they store inside their bodies like fireflies. This type of living light is called *bioluminescence*.

Bioluminescence isn't the only strange thing going on in the deep sea. Scientists have discovered hydrothermal vents that resemble underwater volcanoes. Hot, mineral-rich water comes out of the vents. With temperatures reaching 750 degrees Fahrenheit and toxic chemicals like sulfur surrounding the vents, it might seem like nothing could survive in these areas, but life exists. Tube worms, crabs, shrimp, and other animals have adapted ways to live on hydrothermal vents.



*Kelp Forest*



*Coral Reef*



*Polar Seas*



## WYLAND FUN FACT

The planet's longest mountain range is underwater! The Mid-Oceanic Ridge is more than 35,000 miles long and wraps around Earth.