Oceans: The Heart of Earth's Climate

What is Climate?

Climate is not the same as weather. **Weather** changes day to day and hour to hour and is a measurement of the temperature, humidity, wind speed and other factors in the atmosphere at a given place or time. **Climate** is a much longer record of conditions over years, decades, and centuries. Climate is determined by studying weather patterns in a region over a large scale of time. One way to think about the difference between climate and weather is to imagine weather as your mood and climate as your personality. You might be grumpy one day and happy the next, but whether you are generally a grumpy or happy person would have to be measured by your attitude over your entire lifetime.

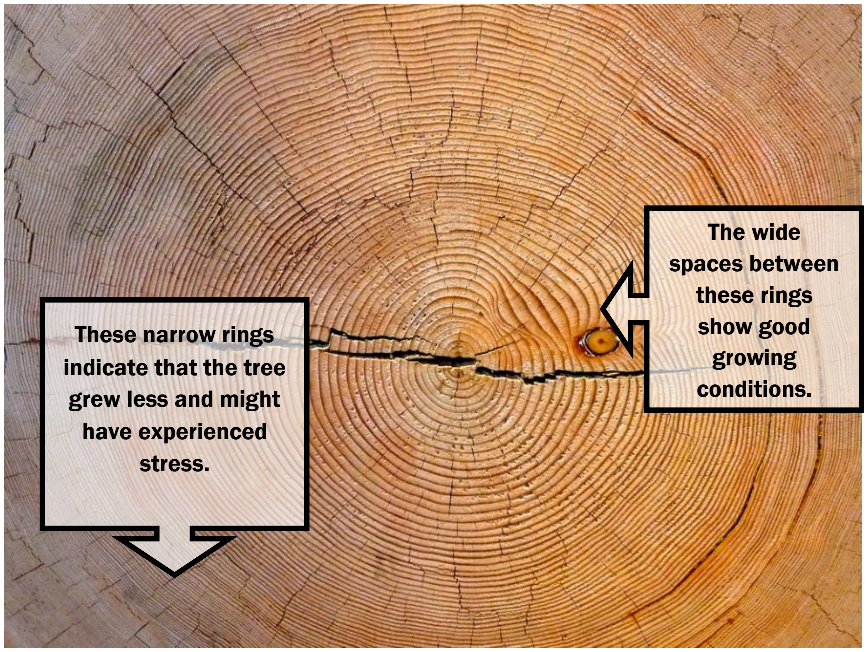
Extreme weather events, or extreme, unusual, or unseasonal weather, should not be confused with climate or seen as indicators of climate change. A very wet winter, an unusually cold spring, or a drought lasting several years are common events on Earth and can't be used to predict future weather patterns.

How Do Scientists Study Climate?

In order to study climate, scientists have to look beyond local weather patterns for information recorded over huge periods of time. Humans have been using instruments to record data about local weather patterns for less than 200 years. Because we need many centuries of data to understand how climate has changed over time, scientists have to look for information about climate history in Earth's natural environmental records.

Scientists can find data about ancient climate patterns in tree rings, ocean sediment samples, coral reefs, and frozen in glaciers and ice caps. Many of the natural climate records form in rings or layers in a predictable cycle.

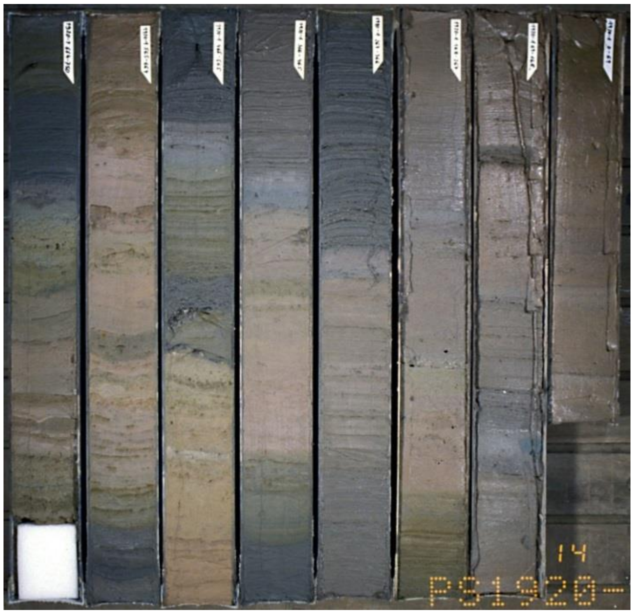
For example, the cross section of a tree shows one ring for each year of growth. The light rings represent spring and summer when water and sunlight are abundant and the tree can grow quickly. The dark rings represent winter and fall when cooler temperatures and fewer hours of sunlight slow the tree's growth. Many rings packed close together indicate several years of stress and reduced growth. This could be caused by a period of drought, a change in the amount of sunlight available to the tree, or a shift in the chemistry of the soil. Tree rings that are spread far apart from each other show scientists periods of rapid growth and ideal conditions. If many trees in a region show similar patterns of stress at the same time in their rings, scientists can conclude that there was a wide-ranging event that impacted plant growth. The study of tree rings is called **dendrochronology**.



Even the oldest trees can only show a few thousand years of climate data. By examining samples from ocean sediment, scientists can extend the picture of Earth's climate far beyond human history. Ocean **sediment**, or matter that settles to the bottom of a liquid, forms in layers over time. Each year, a new layer of mud is deposited on the sea floor. This mud contains millions of clues to life on Earth. Encased in the mud at the bottom of the ocean are the dead bodies of plankton and marine organisms, the sediments washed into the sea from rivers and lakes, and pollen and dust that has blown into the water from across the world.

Scientists can use special tools to collect long tubes of mud from the ocean floor called **sediment core samples**, some of which date back millions of years. The study of these samples is called **Paleoceanography** (paleo= before humans, oceanography=study of the ocean).

By examining the chemical and physical composition of the core samples, scientists can track changes in the Earth's climate. For example, a sample may contain several layers with the remains of many shelled organisms. There will be large amounts of calcium in these layers because sea shells are made of calcium. If the number of shelled organisms in the core sample suddenly decreases, scientists can conclude that there was a change in the chemistry of the ocean that made it harder for shelled organisms to survive at that point in time. By comparing many sediment samples from all around the world, scientists can piece together a picture of global climate as far back as 150 million years ago.



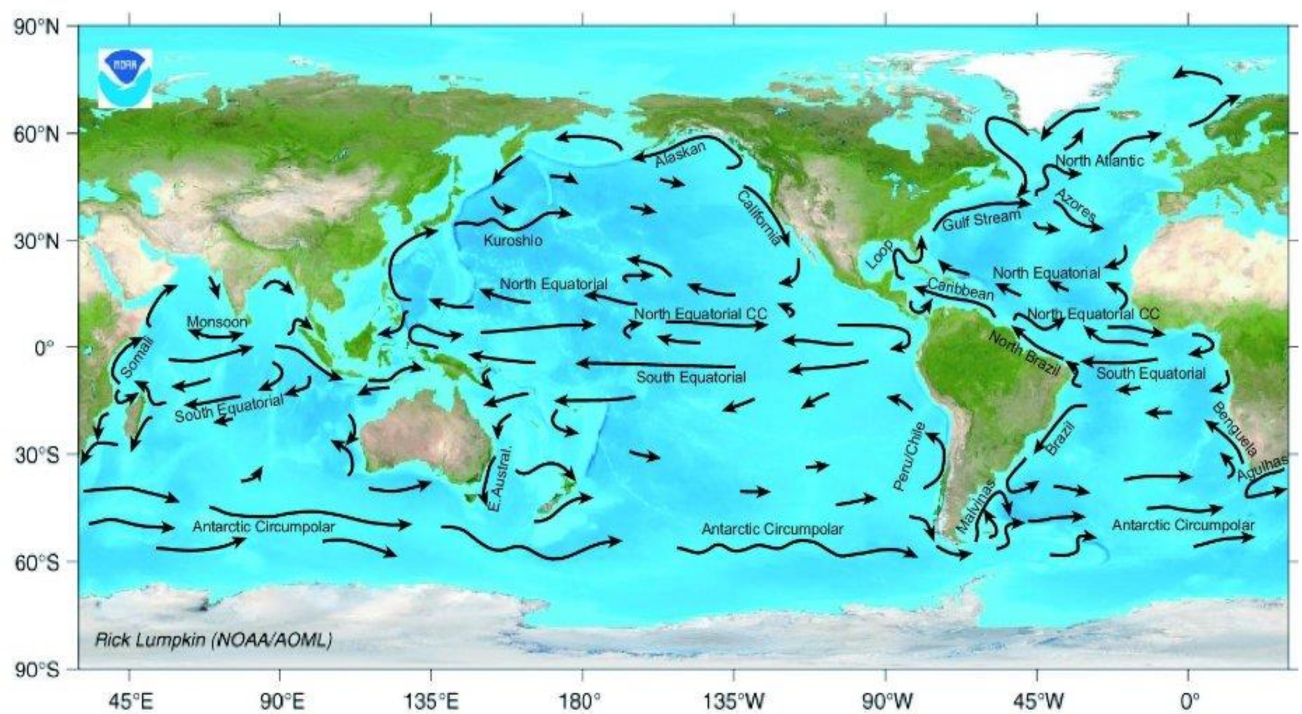
Like each ring in a tree represents a year of growth, each tiny layer in these ocean sediment cores represents a year of marine deposits. By looking at how the layers change over time, scientists can study climate from millions of years ago.

The Climate's Heart

Imagine that the Earth's climate flows around our planet like the blood that flows through your body. Like your blood supports your organs by delivering nutrients and removing waste, the climate supports life on earth by distributing moisture and regulating temperature. Your heart regulates the flow of blood around your body, and the ocean regulates the climate on Earth. Essentially, the ocean is the heart of our climate. The ocean's impact extends beyond the water to the land and atmosphere.

Currents

Your body uses blood vessels and veins to move blood around. **Currents**, the movement of water from one place to another in a definite direction, work in a similar way in Earth's oceans. Ocean currents are affected by many factors including the gravitational pull of the moon and sun (tides), wind, temperature, and **salinity** (the amount of salt dissolved in water). Currents are important because they move moisture, heat, and biological material around the planet. They also help people navigate across the ocean in ships.



This map shows the surface currents around the world. Notice that the currents start from the equator and generally circle towards the poles.

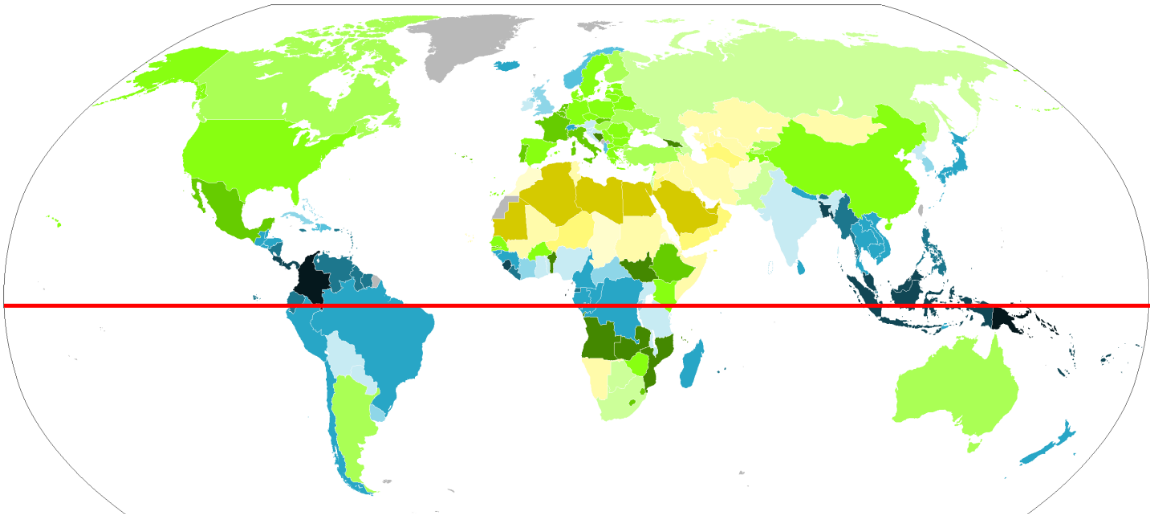
Tides

If you have ever been to the beach, you have probably noticed that the level of the water changes throughout the day. When the waves wash higher on the beach, the tide is coming in. When the waves move further out to sea, the tide is going out. **Tidal currents** are caused by the interaction of the Earth, moon, and sun. The pull of gravity from the moon and sun cause tides to rise and fall in predictable ways, and tidal currents are the only currents we can accurately forecast.

At low tide, these fishing boats rest on the floor of a harbor. Because tides are predictable, fishermen can plan when to move their boats.

Surface Currents

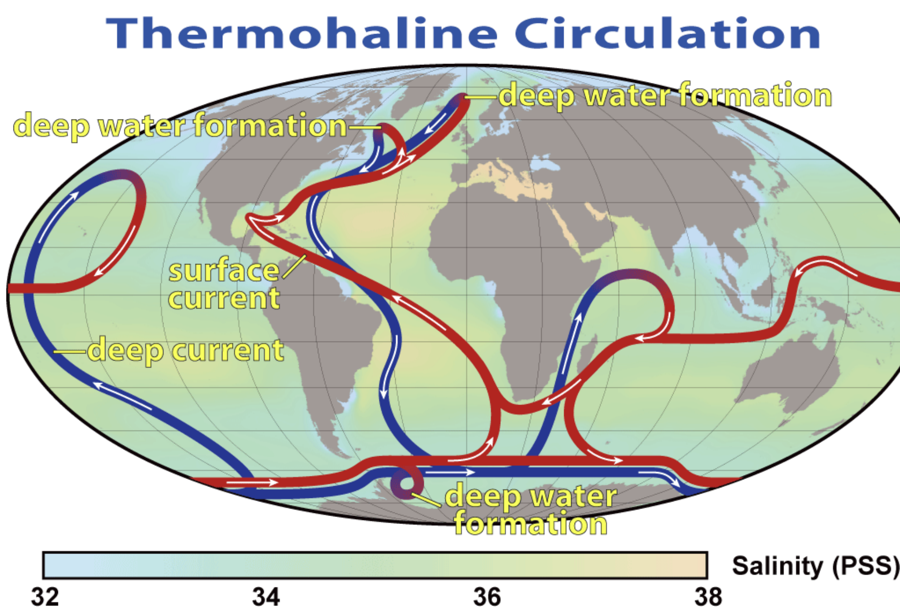
Surface currents are currents that occur at depths of less than 100 meters (300 feet) and are driven by wind. Water is wonderful and trapping and storing heat. The ocean near the equator is absorbing heat from the sun all year round. This water in turn warms the air, causing it to rise and flow towards the poles in the form of wind. This warm, moist air cools as it moves away from the equator and loses its moisture as it does so in the form of rain and snow. As the wind moves north and cools, it begins to descend back towards the equator to begin the process all over again. This interaction between the ocean and the atmosphere is responsible for the weather patterns we experience on land. The wettest places in the world tend to be on or near the equator where the wind carries the most moisture and humidity. The driest places in the world are the ones that make up the "last stops" of the wind before it returns to the equator to replenish the moisture it lost along the way.



The wettest countries (in blue) are those near the equator. The heat trapped in the ocean warms the air and fills it with moisture. As the Earth turns, the moisture-filled air rises and moves towards the poles before circling back towards the equator.

Thermohaline Circulation

There are also currents deep below the ocean's surface. These currents are much slower than surface currents and play an important role balancing temperature around the planet. Deep water currents move due to **thermohaline circulation**. "Thermo" means temperature, and "haline" means salt. When the temperature and density due to salt levels in water interact, they create thermohaline circulation. As water cools near the Earth's poles, the water freezes into sea ice. When sea water freezes, salt is left behind, increasing the salinity and density of the surrounding ocean. This dense water begins to sink, and surface water flows in to replace it. As the cold water moves around the poles, some of it splits off and travels towards the warmer waters of the equator. The salinity of the cold water decreases as it warms and combines with the surrounding ocean, causing the current to rise towards the ocean surface. This process is called **upwelling**. The upwelling water is full of nutrients and plankton from the poles, and upwelling sites often attract many species of marine organisms. As the water leaves the equator and travels back towards the poles, it begins the process all over again.



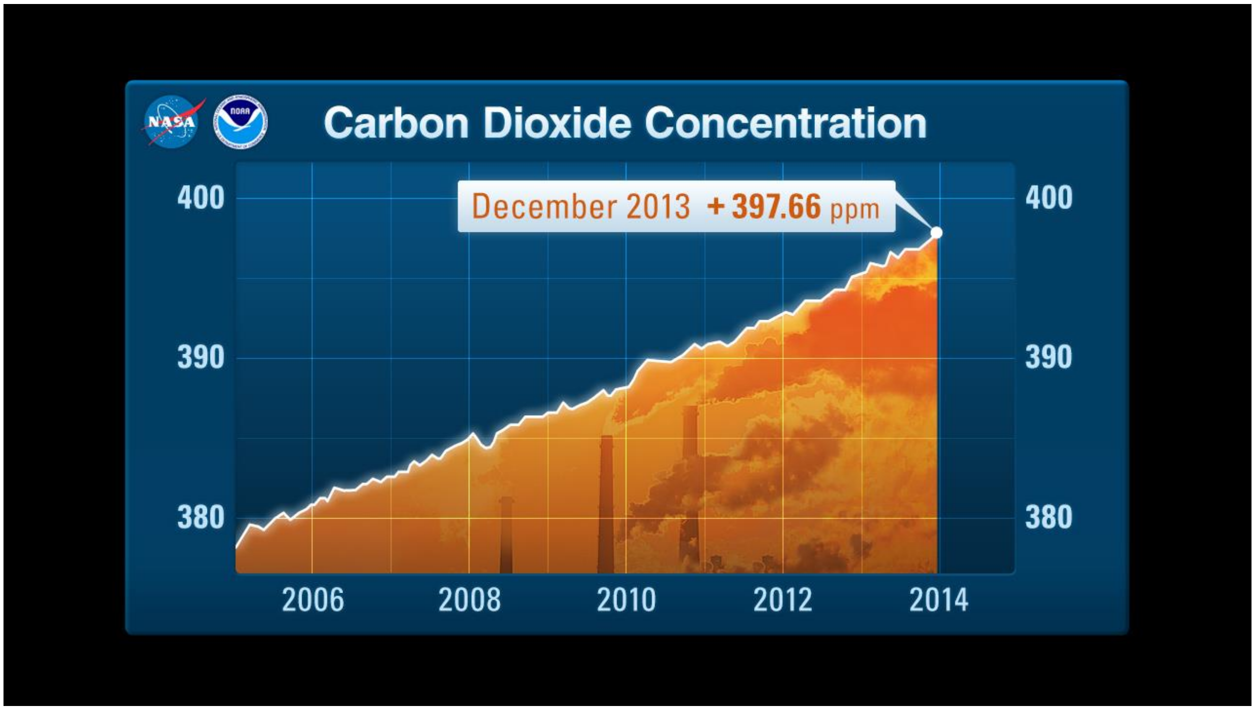
Without this "global conveyer belt" transferring nutrients and regulating temperature, life on Earth as we know it could not exist. Many marine ecosystems, including most coal reefs, rely on the thermohaline circulation to provide food. Some scientists estimate that it would take a single cubic meter of water 1000 years to travel on one thermohaline circuit around the world. This slow, predictable movement of nutrients and temperature is what allows different marine ecosystems to survive despite more dramatic and unpredictable changes to surface ocean currents.

Climate Change

The Earth's climate has changed dramatically many times. Ice ages and periods of extensive global warming are natural occurrences throughout Earth's history. Usually, **climate change**, or a change in global or regional climate patterns, happens very slowly over hundreds or thousands of years. When climate change happens at this rate, living organisms have time to adapt to new conditions. Some species do not survive natural climate changes (dinosaurs) while others (mammals) actually do better because of them.

The vast majority of scientists agree that Earth's climate is currently changing rapidly due to an increase in the overall temperature of the Earth's atmosphere called **global warming.** Our planet is becoming warmer and warmer each decade, leading to changes in weather patterns, ocean chemistry, and geography. While climate change has happened naturally many times in the past, the current rate of climate change is much faster than any other climate event in Earth's history.

Our current climate change is due to high amounts of carbon dioxide in the Earth's atmosphere. Carbon dioxide is produced by burning **fossil fuels** like coal, oil, and natural gas. All the carbon dioxide in the atmosphere works like a heat-trapping blanket, and the more carbon dioxide humans produce, the thicker the blanket becomes.



This graph shows the increase in carbon dioxide in the air from 2006 to 2014. "PPM" stands for "parts per million." Just like 1 percent means 1 part out of a hundred, 1 part per million means 1 part out of a million.

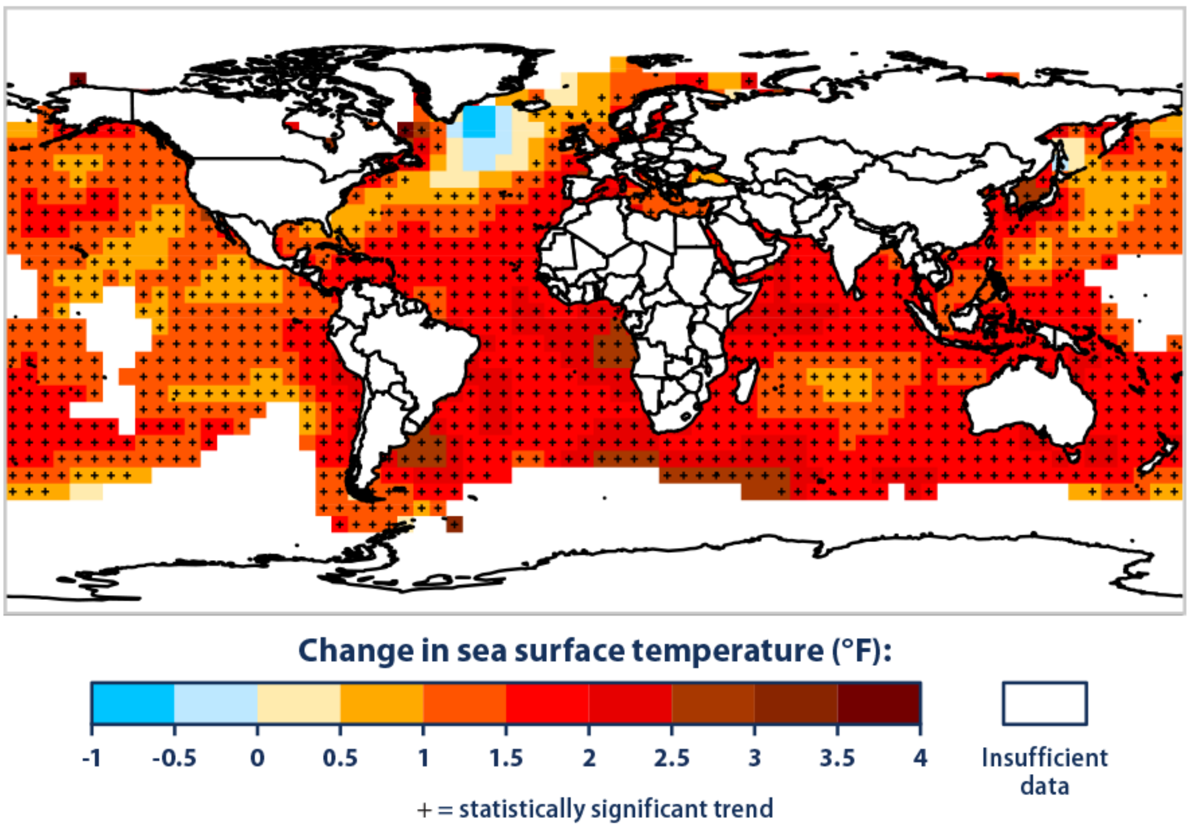
Normally, the ocean is great at regulating the temperature of the planet, but as the climate warms at a very fast pace, the ocean is absorbing too much heat too quickly, and living organisms don't have enough time to adapt to the changes in their environment.

Ocean Indicators of Climate Change

Scientists have found many different indications of a rapidly changing climate in the ocean. Many of these changes have increased dramatically in the last hundred years.

Ocean Heat

Ocean water can hold much more heat than the air in the atmosphere. In fact, the ocean has absorbed about 90% of the additional heat caused by the carbon dioxide blanket since 1955. Without the ocean absorbing extra heat, climate change would be much more extreme and unpredictable. When the ocean absorbs more heat, it affects the flow of thermohaline circulation, sea level rise, and weather patterns.



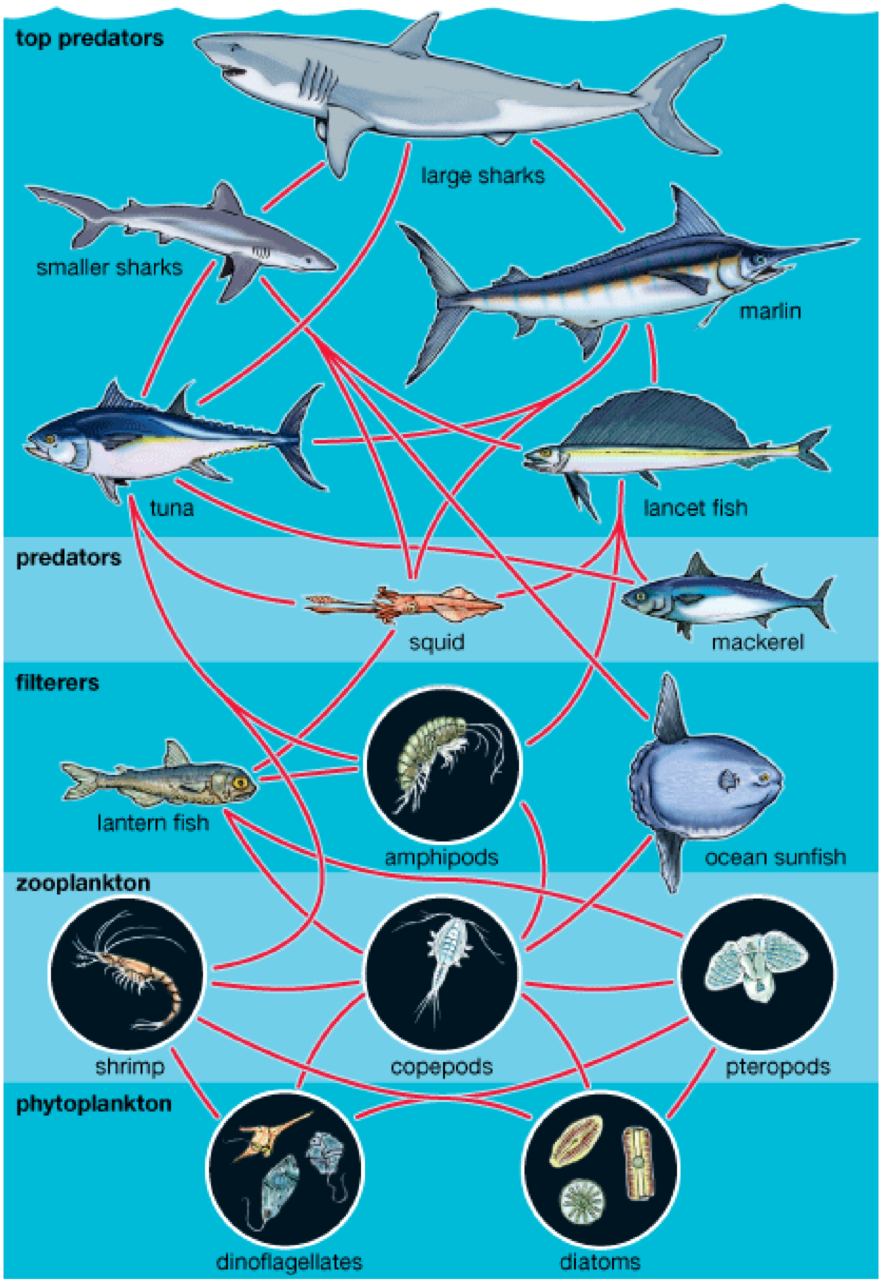
This map shows the increase in ocean surface temperature from 1901-2015. Even a change of .5 degrees can have a dramatic impact on ocean ecosystems and global weather patterns.

Sea Level Rise

As the climate warms, **sea level**, or the depth of ocean in a given area, rises where the ocean meets land. Higher water levels are caused by an increase in water from melting sea ice and polar ice caps and by the fact that warmer water expands and takes up more space. When sea levels raise, people, animals, and plants that live along coasts are threatened by flooding and changes in water chemistry. Higher sea levels increase salinity in rivers, lakes, and ground water and makes cities near the ocean more vulnerable to extreme weather events.

Ocean Acidity

Not all carbon dioxide from burning fossil fuels joins the heat-trapping blanket in the atmosphere. Over the past 250 years, the ocean has absorbed about 28% of the carbon dioxide produced by human activity. The dissolved carbon dioxide changes the chemistry of the ocean in a process called **ocean acidification**, making the water more acidic and preventing shelled organisms from developing properly. Since shelled organisms like krill and plankton make up the base of the ocean's **food web**, or system of interacting food chains, a continuing increase in the acidity of the ocean could result in the loss of entire marine ecosystems.



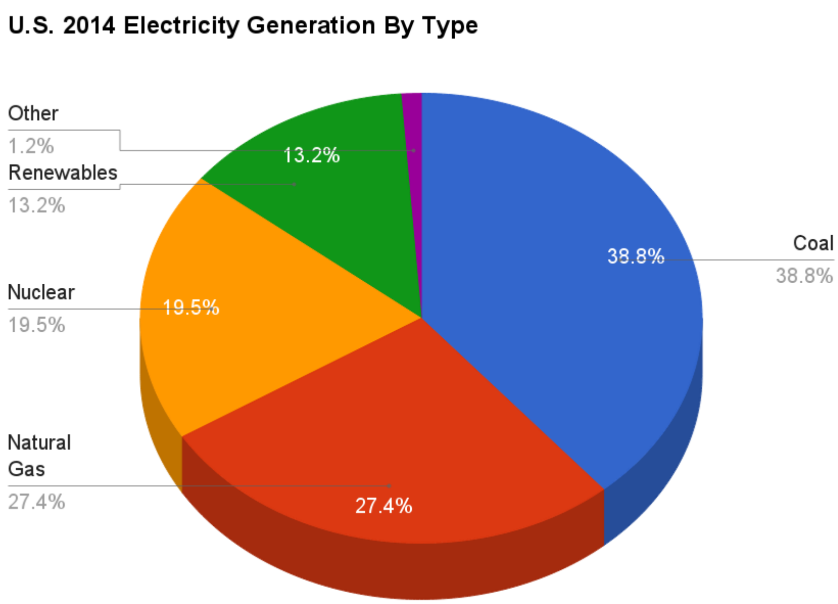
The black circles in this food web show shelled animals that make up the base of every ocean food chain. Without these animals, larger fish, birds, and marine mammals would struggle to survive.

Climate Change and You

Scientists agree that climate change is already happening. Even if we stopped burning fossil fuels today, we would still see irreversible changes to Earth's ocean. However, it's not too late to help the ocean adapt by reducing the impact of climate change as much as possible. The wonderful thing about humans is that we are great at solving problems, especially when we know what is causing them.

Since we know that burning coal, oil, and natural gas causes the heat-trapping blanket, we can begin by reducing the amount of fossil fuels we use. Try the following tips to reduce your "**carbon footprint**," the amount of carbon dioxide you add to the heat-trapping blanket through your daily activities.

- Carpool, use public busses or trains, ride your bike, or walk whenever possible. If we use cars more efficiently, we'll keep a lot of carbon dioxide out of the air.
- Reuse everything. Most goods manufactured around the world are produced by burning fossil fuels. Stick with a reusable water bottle. Shop at thrift stores. Swap toys and games with your friends instead of buying new ones. Every time you reuse something, you keep carbon dioxide out of the atmosphere.
- Use energy wisely. All of the electricity in Utah comes from burning coal, so reducing the amount of electricity you use will automatically reduce your carbon footprint. Turn off lights, computers, televisions, and other electronics when you aren't using them and switch to more energy efficient appliances and light bulbs.
- Support businesses that have a low carbon footprint. Look for stores that recycle, conserve energy, and support local products (local products produce less carbon because they don't have to be transported over long distances by truck, plane, or train).
- Spread the word. Not everyone understands what climate change is or why it is happening. Tell people about the "heat-trapping blanket" and how it is damaging the ocean heart of our climate. The more people that understand the issues, the more likely we'll be able to make the right changes in time.



Most energy in the United States comes from fossil fuels like coal, oil, and natural gas. These fuels contribute to the heat-trapping blanket in the atmosphere. The less fossil fuel energy we consume, the lower our carbon footprints.

Vocabulary

Use the article to define the words below.

Weather:

Climate:

Extreme Weather Events:

Dendrochronology:

Sediment:

Sediment Core:

Paleoceanography:

Currents:

Salinity:

Tidal Current:

Surface Current:

Thermohaline Circulation:

Upwelling:

Climate Change:

Global Warming:

Fossil Fuels:

Sea Level:

Ocean Acidification:

Food Web:

Carbon Footprint:

Short Answer

After reading the article, answer each question with a short paragraph.

Explain the difference between climate and weather.

Describe one way scientists can study ancient climates.

In your own words, explain how thermohaline circulation works.

How does the ocean impact the climate in Utah?

Use two examples from the ocean that indicate Earth is experiencing climate change.

Carbon Footprint Action Plan

It's time to take action for a healthier ocean. Think about the ways you can help keep Earth's ocean clean, cool, and contaminant free. A great place to start is by looking at your own carbon footprint. Ask yourself the following questions.

Do I carpool?

Do I turn off the lights and other electronics when I leave a room?

Do I turn off my computer at night?

Do I wash my clothes in cold water?

Do I recycle?

Do I pack my lunch in reusable containers?

Do I shower for 5 minutes or less?

Do I use energy efficient light bulbs?

Do I use all the food I buy?

Do I have a garden?

If you can answer yes to most of these questions, you're doing great! If you answered no to one or more, now you know what you need to work on. Make 3 goals that will help you reduce your carbon footprint and write them below.

I will reduce my carbon foot print by: