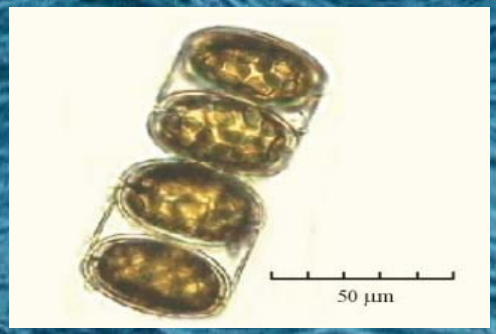
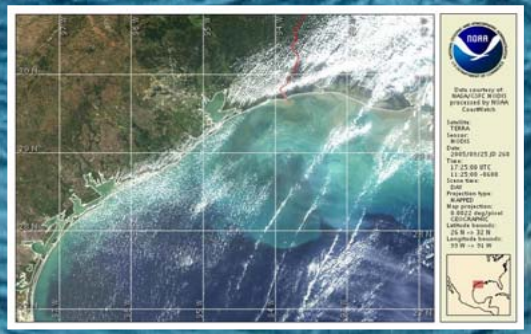
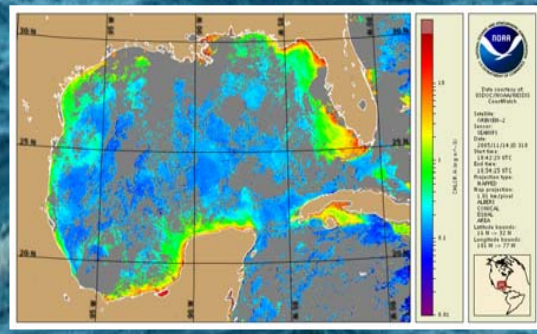
Satellite Ocean Color







NOAA CoastWatch Program
DOC/NOAA/NESDIS/ORA/ORAD
5200 Auth Rd, Room 601
Camp Springs, MD 20746-4303
http://coastwatch.noaa.gov

In this Lesson:

Why do we measure ocean color?

What is ocean color?

Why do you see different colors of ocean water?

How is ocean color measured?

What are some applications of ocean color?

Ocean Color is….

The characteristic hue of the ocean according to the presence and concentration of specific minerals or substances, such as chlorophyll. (Photonics.com dictionary)

Ocean Color

Though we often think of the ocean as being blue, it can be different colors. Tiny particles are found within the water column, including microscopic plant life called *phytoplankton.* Like land plants, these organisms contain a green pigment called *chlorophyll*. When a great number of organisms are concentrated in an area, the pigment changes the color of the ocean surface.

Sediment can also change ocean color, especially near a river mouth. The sediment concentration in the water column determines how cloudy or murky the water appears. This murkiness factor is called *turbidity*. More particles cause an increase in turbidity. Turbidity can be measured by light scattered from suspended sediments.

Phytoplankton (Chlorophyll-a)

Phytoplankton are microscopic plants that live in the ocean. They contain a pigment called chlorophyll, which gives them their green color. Though these organisms are microscopic, they come in various shapes and sizes; and they serve as the basis to the marine food web.

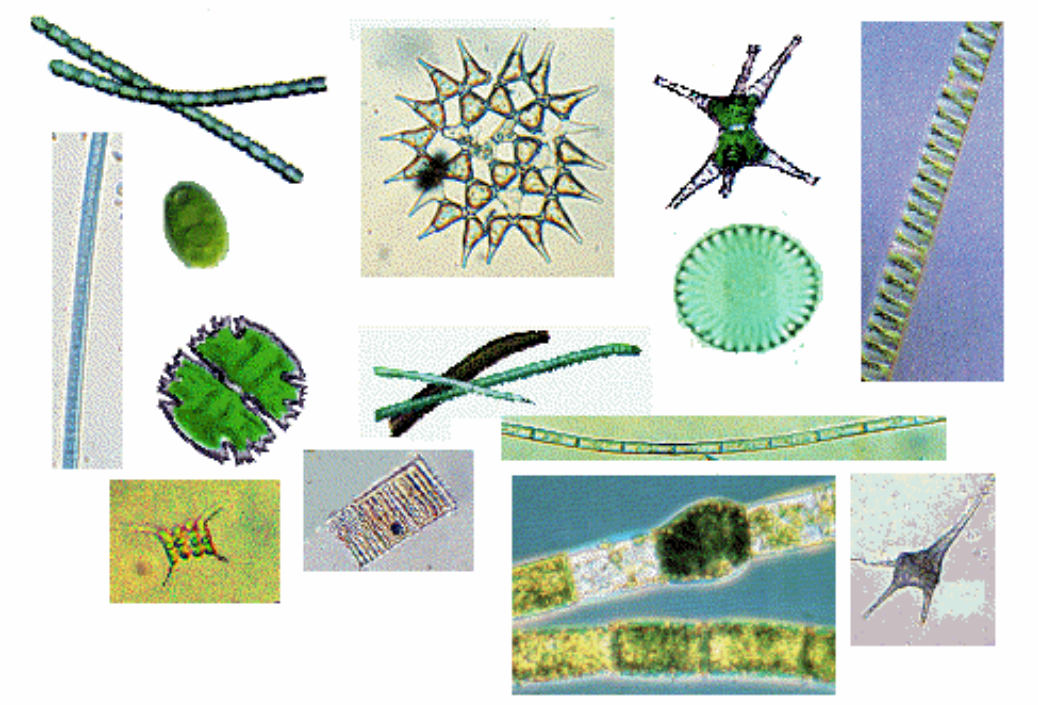
Like terrestrial plants, phytoplankton require sunlight, water, and nutrients for growth. Chlorophyll not only gives the plant its color, but it also plays a major role in photosynthesis; the process of using sunlight to change carbon dioxide and water into carbohydrates (plant food).

$$6H_2O + 6CO_2 + \text{ENERGY} \longrightarrow C_6H_{12}O_2 + 6O_2$$

However, phytoplankton still require other nutrients to survive.

How do they get these other nutrients?

Phytoplankton (Chlorophyll-a)



The average phytoplankton is about 3 microns. There are 25,400 microns in one inch. This dot (.) is approximately 1/64 of an inch wide and equals 615 microns.

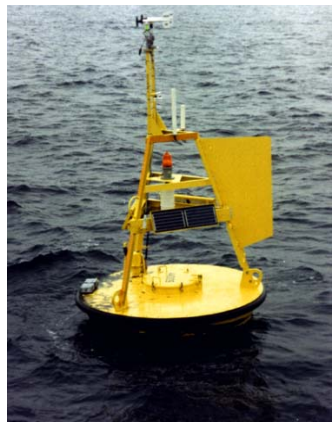
Activity: Make a list of common names of phytoplankton.

How is ocean color measured?

The ocean's color is based on the concentration of chlorophyll, which can be measured by sensors on ships, buoys, aircraft, and satellites. These sensors are called *radiometers* and *spectrometers*. They measure the intensity of light at different wavelengths that is backscattered from the ocean surface.

Measurements by Ships and Buoys

Sensors aboard ships and buoys measure light in a single area. They can measure the light above the surface of the water and they can measure the changes in light with depth underwater.



How is ocean color measured?

Measurements from Aircraft

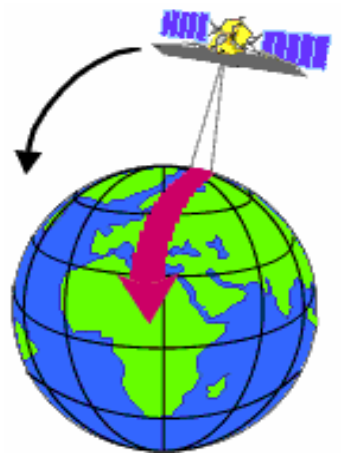
Aircraft can also carry the sensors needed to measure chlorophyll. Although the spatial resolution is better, the image only covers a small area, though larger than an area from ships or buoys. Aircraft are expensive to operate, so they are usually used for special cases, such as a harmful algal blooms.

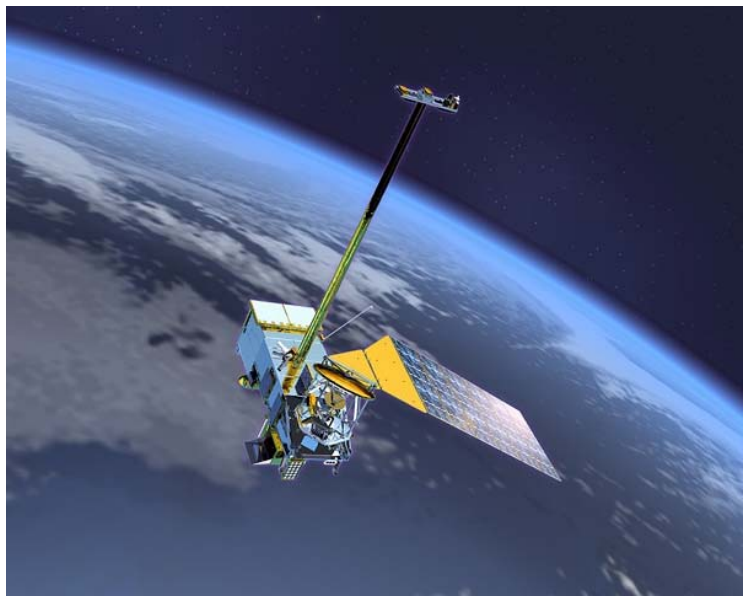
How is ocean color measured?

Measurements from Satellites

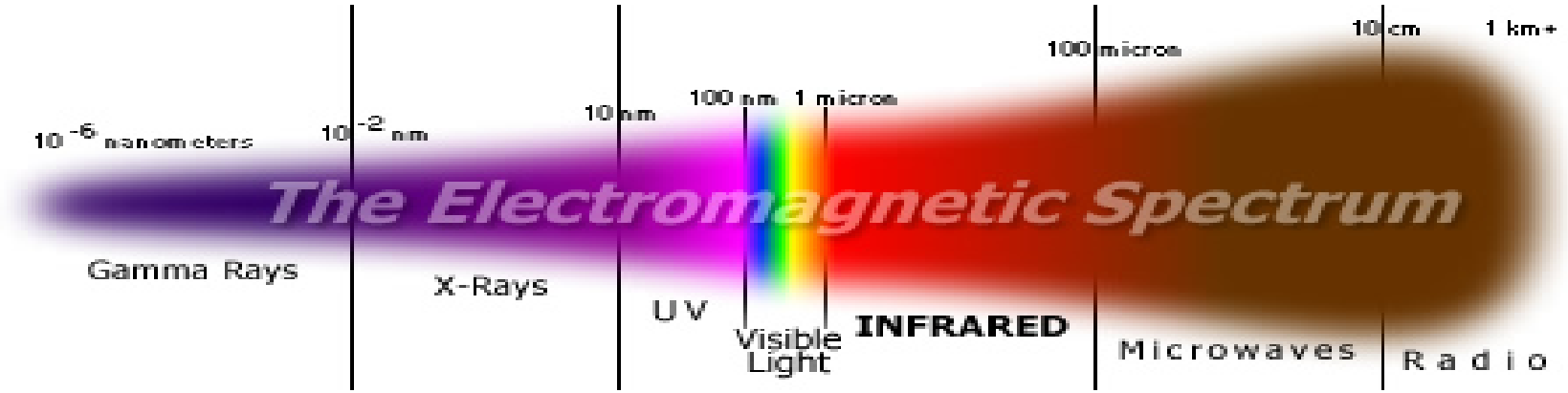
Many satellites carry the necessary sensors to measure chlorophyll. From space, these satellites can see large regions of the entire globe in a short time, thus providing daily ocean color images all over the world. However, the spatial resolution is coarser than sensors onboard an aircraft.

The path a satellite follows is called its "*orbit*", while the area on the earth's surface that the satellite flies over is referred to as the satellite *"swath".*





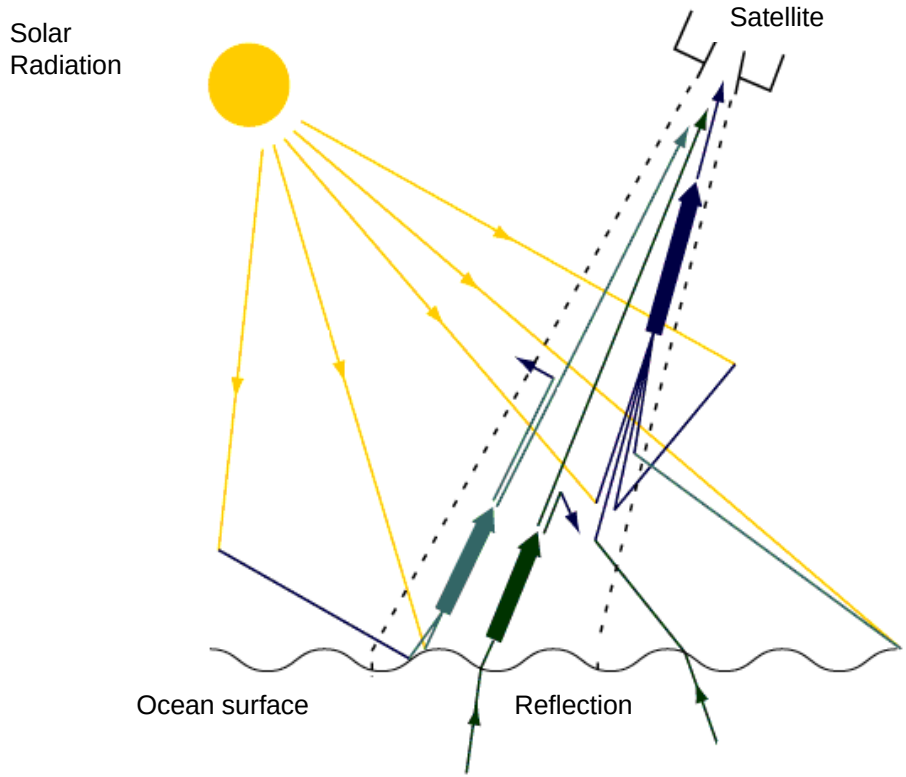
Ocean Optics



The satellite spectrometers don't measure the chlorophyll concentrations directly, but rather the visible light that is backscattered from the surface ocean.

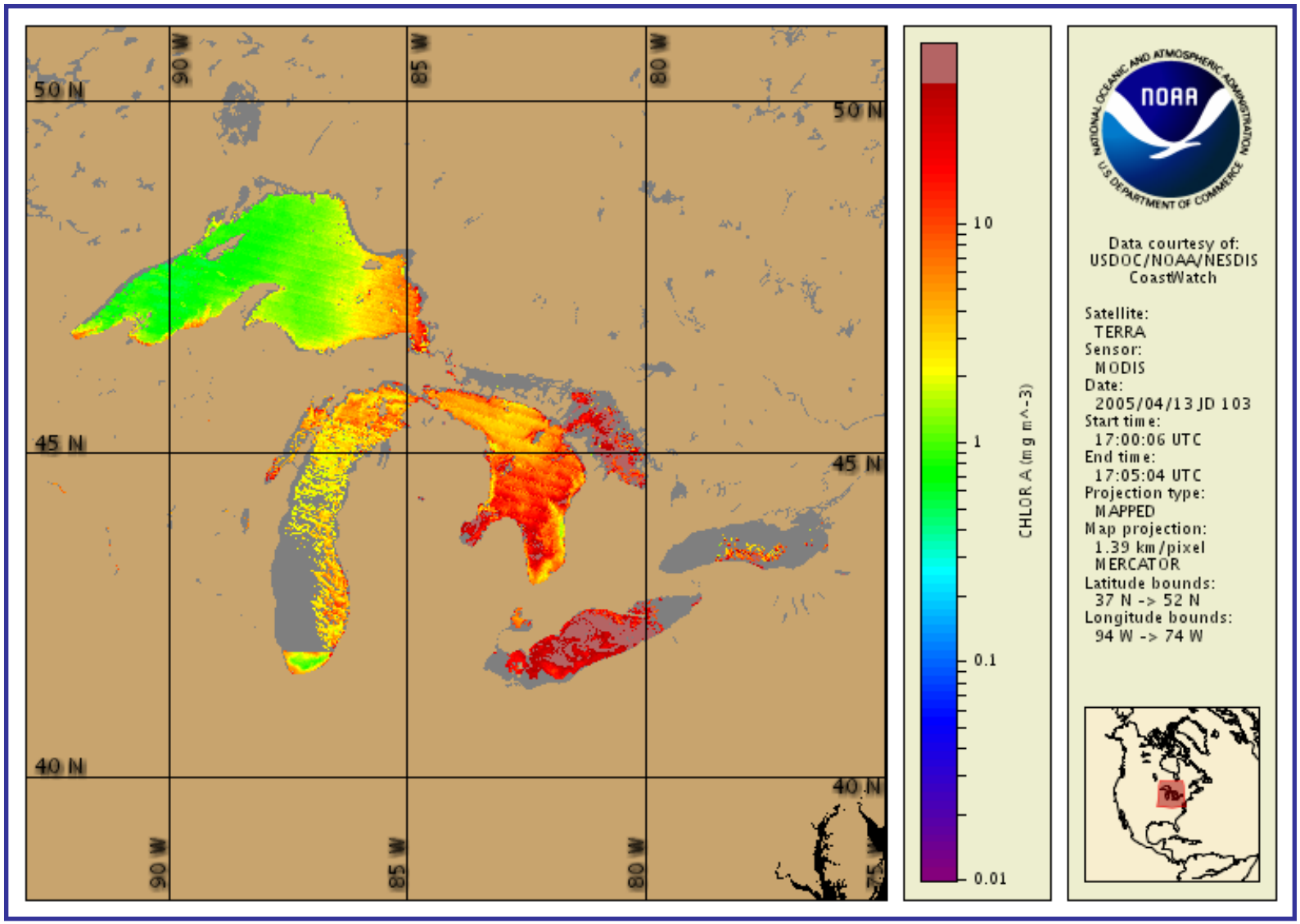
Have you ever held a glass prism for the sun to shine through? What do you see? The colors of the rainbow? This rainbow is the separation of visible light within the electromagnetic spectrum. Each color has an associated wavelength: the longer wavelength is closer to red, while the shorter wavelength is closer to violet.
The ocean is “blue” because water absorbs the wavelengths in the spectrum longer than blue.

Ocean Optics



As the sun's light (solar radiation) is transmitted through the earth's atmosphere to the ocean, the light rays will be scattered and some will be absorbed by the atmosphere. The visible light that reaches the earth's surface is reflected back into space. These reflected wavelengths are then measured by the satellite sensors.

How is Ocean Color Used?



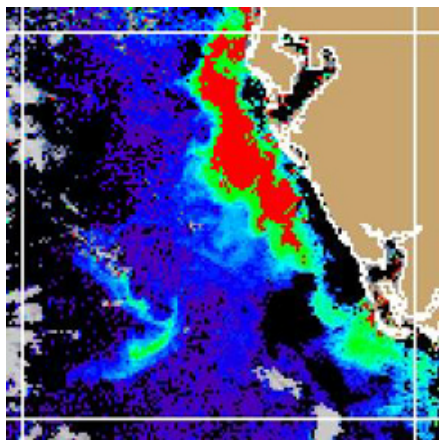
Example of CoastWatch Chlorophyll –a image

Harmful Algal Blooms

Phytoplankton are also referred to as algae. Certain types of algae can be toxic, and with the right environmental conditions, they can significantly increase in population, yielding a harmful algal bloom (HAB) or a red tide.

When physical ocean conditions, such as the temperature, types of nutrients, and light availability are right, phytoplankton reproduce quickly, yielding millions of organisms. These toxic blooms are monitored for several reasons, as they can be dangerous to the environment and harmful to other marine organisms and humans. In coastal areas, these blooms can reduce the amount of dissolved oxygen in the water available for fish, submerged aquatic vegetation, and shellfish. Direct contact with the toxin can cause respiratory problems in humans and marine mammals.

Satellite view of chlorophyll (in red)

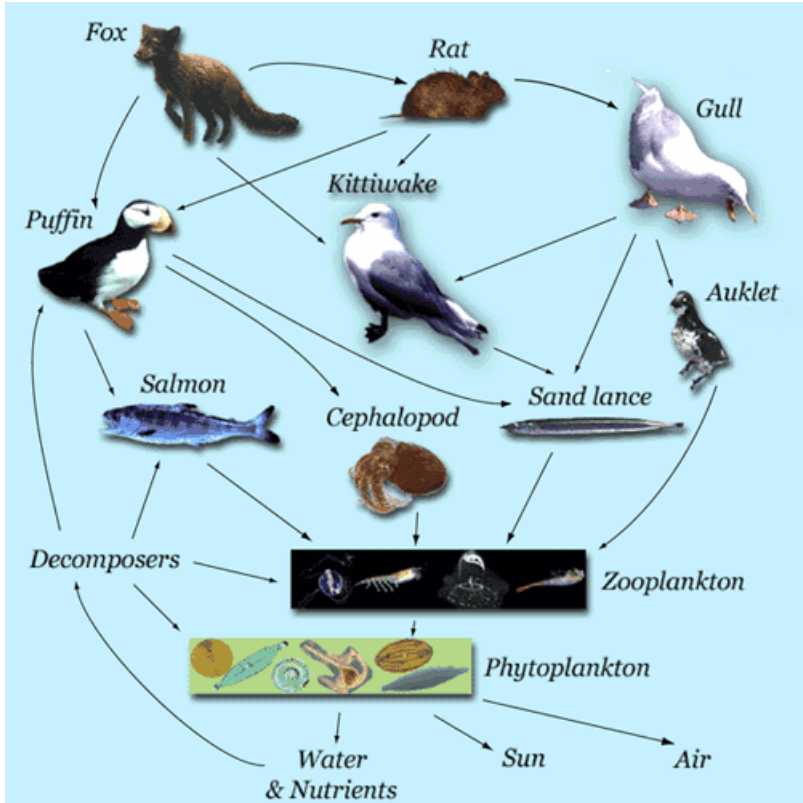


Aerial view of a “red tide”

Base of the Food Web

Phytoplankton play an important role in the marine food web. These microscopic organisms are at the bottom, and are essential to the overall feeding process. Phytoplankton are food to organisms called zooplankton, which are eaten by small fish, which are food to larger fish and animals like penguins and seals, on up to whales and humans.

Therefore, all of these animals receive their nourishment one way or another from phytoplankton. If phytoplankton numbers decline, so will the organisms that depend on them.



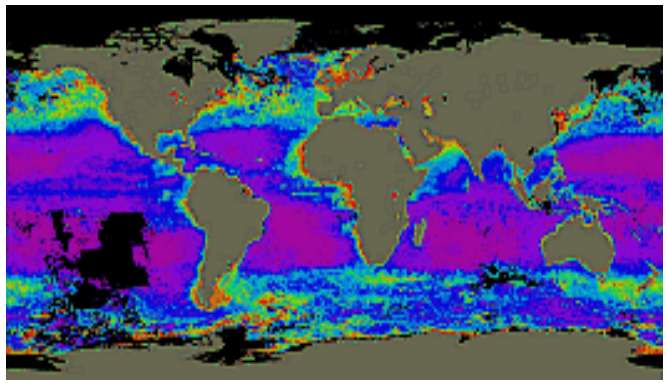
Environmental Change

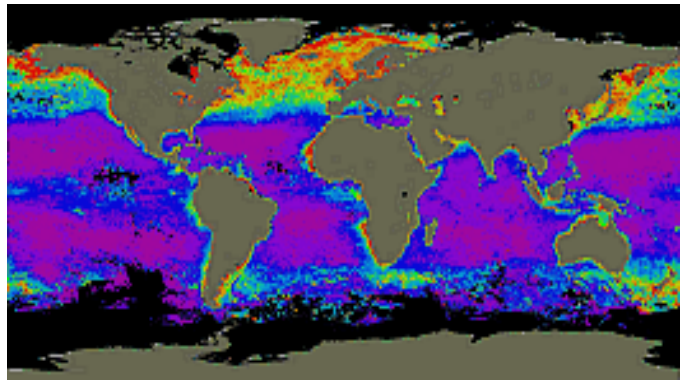
Do you remember what phytoplankton use in the photosynthetic process? The carbon dioxide in seawater comes from the atmosphere. Because carbon dioxide is a 'greenhouse gas', over an extended period of time, large populations of phytoplankton could make a significant change to the amount of carbon dioxide in the atmosphere, and make an impact on the average global temperature.

In order to make necessary food through photosynthesis, phytoplankton depend on nutrients found in seawater. To get these nutrients, phytoplankton depend on the ocean's circulation patters of currents to carry cooler, nutrient rich water to the surface in a process called upwelling. Scientists can track the currents and other physical conditions that phytoplankton require to give an indication of environmental change.

Environmental Change

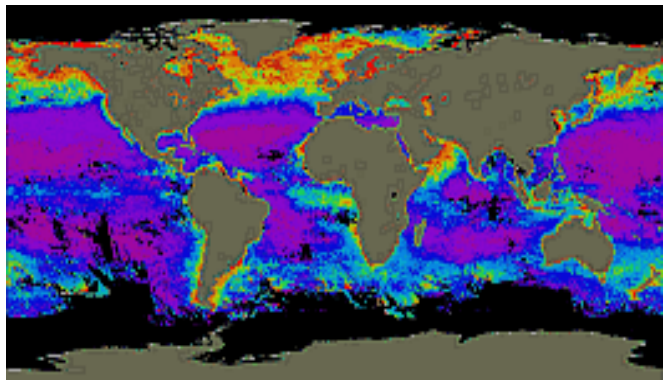
Jan - March

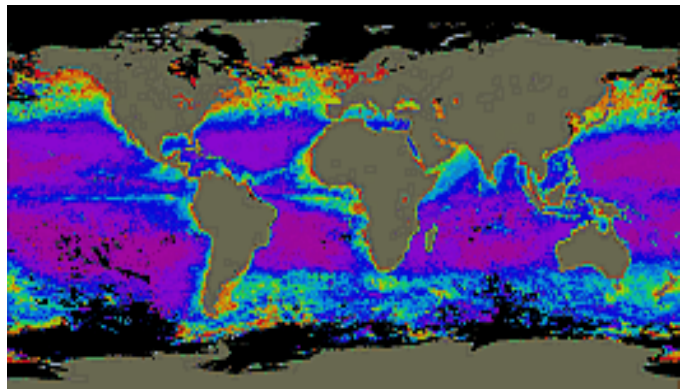




April - June

July - Sept.

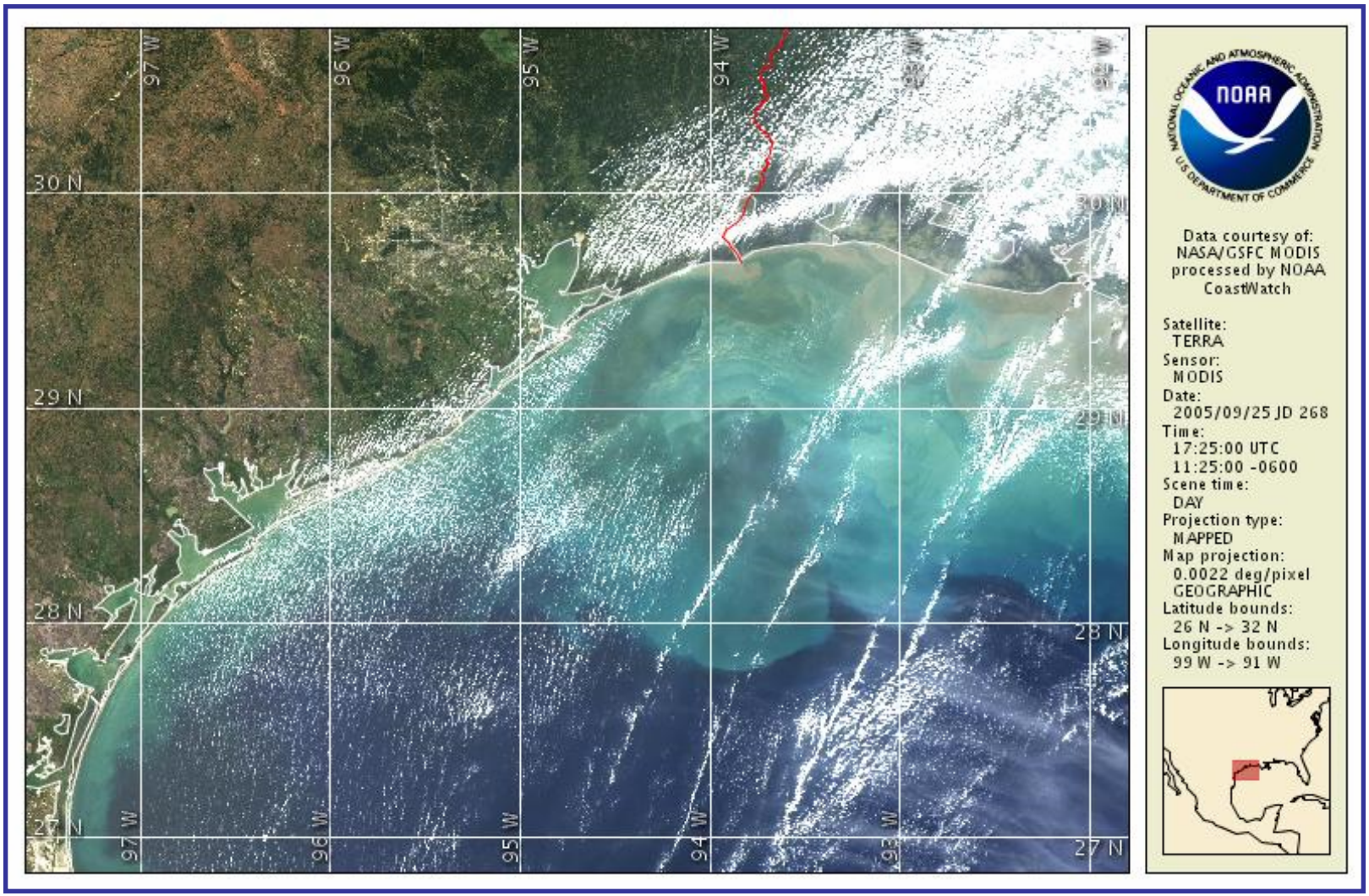




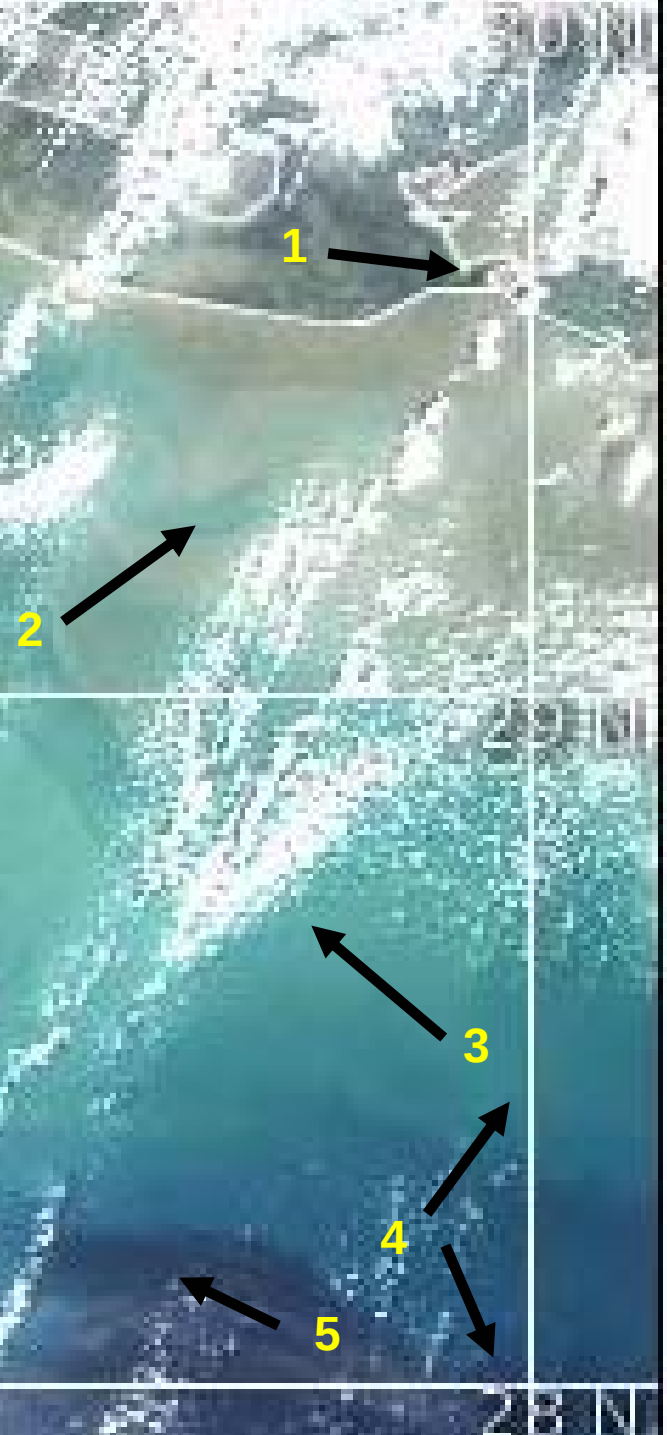
Oct. - Dec.

Three-month "climatological" composites for all months between November 1978-June 1986. The red indicates a bloom of phytoplankton over the North Atlantic during northern hemisphere spring. Also present are seasonal increases in phytoplankton concentrations near the equator in both Atlantic and Pacific Oceans, and off the western coasts of Africa and Peru.

Satellite True Color Image



True color images differ from ocean color images, in that they are showing exactly what is being seen. They show the “true” picture.



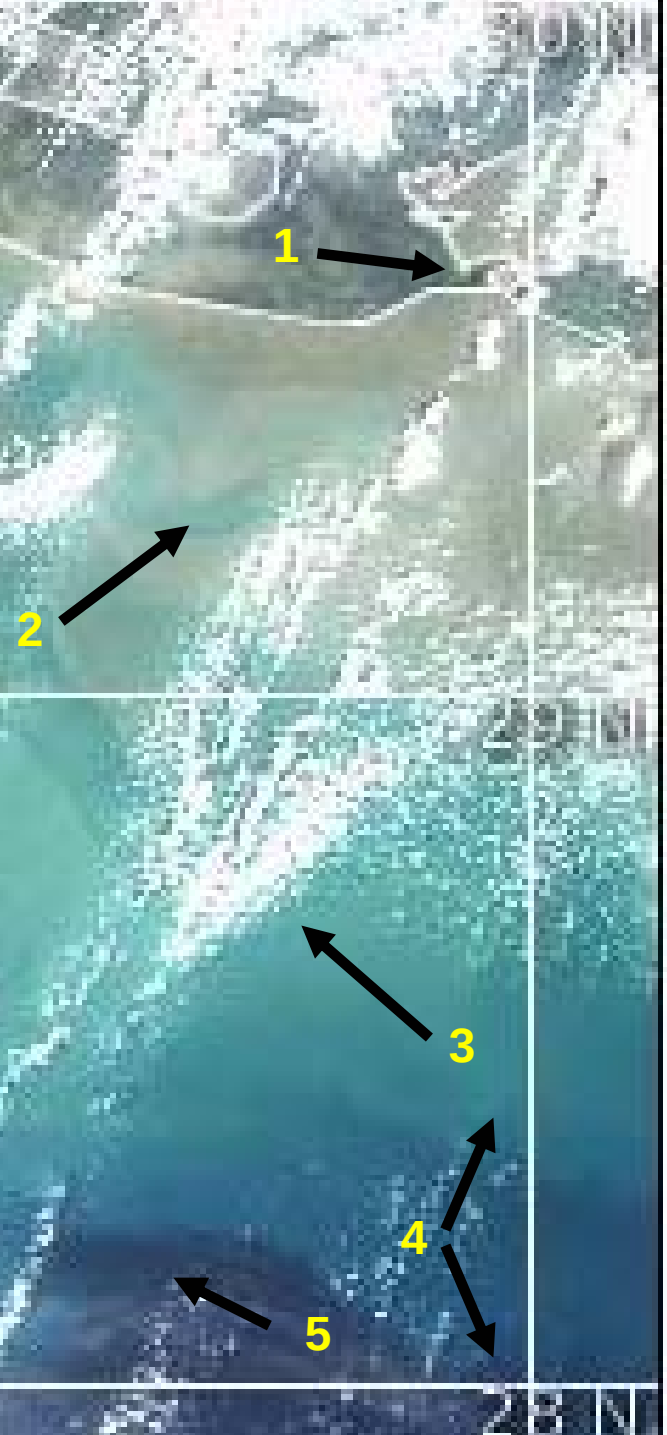
In addition to phytoplankton, there are other tiny particles in the water, including various sizes of sediments, that scatter and absorb light in different ways. The more particles that are in the water, the less "blue" it will appear.

Away from the coast, sediments settle to the ocean bottom and the water gradually becomes more blue the farther you go from shore.

Can you identify what the arrows are pointing to?

Hints:

1. A geographic feature
2. The color and feature
3. The white areas
4. Vertical and horizontal lines
5. The color



1. Points to the river mouth. Can you see how the water is very brown? The water is transporting a lot of sediment.
2. Points to greenish-brown swirls. You can see the currents produced by the river by following the swirls of sediment.
3. The white areas are clouds. Remember that satellites look down on the earth from space.
4. The white lines mark latitude and longitude. Notice the markers “28N”, “29N”, and “30N”. These tell you what latitude the image was collected at.
5. At this point, notice the water has gotten much bluer. A lot of the sediment has fallen out of the water column to the ocean bottom, giving it a bluer color.

Questions

How do scientists measure ocean color?

Why is the water blue?

How are humans poisoned by harmful algal blooms, if a fish eats the toxic algae?

Name a few applications for ocean color. Can you think of any not specified in this lesson?

What is meant by “true color”?

Additional Resources/Lesson Plans:
http://landsat.gsfc.nasa.gov/education/ocean_color/Lessons.html
http://www.oceanservice.noaa.gov/education/classroom/07_algal.html

Thank you for taking the time to review this tutorial.

Please forward any comments and suggestions to Shawna.Karlson@noaa.gov

For more information on CoastWatch, please visit the website at http://coastwatch.noaa.gov