Marine Phytoplankton Blooms

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Note: In PDF format most of the images in this web paper can be enlarged for greater detail.

Introduction

As the base of the marine food chain, phytoplankton—microscopic single cell algae and bacteria that carry on photosynthesis—are important indicators of change in the oceans. These marine flora, in the process of photosynthesis, also extract carbon dioxide from the atmosphere, and, as a result, they play an important role in the balance of greenhouse gases that control global climate. Though incredibly small as individual cells, their vast numbers influence both the primary production of the oceans and the world's climate.

Remote Sensing and the Study of Marine Phytoplankton Blooms

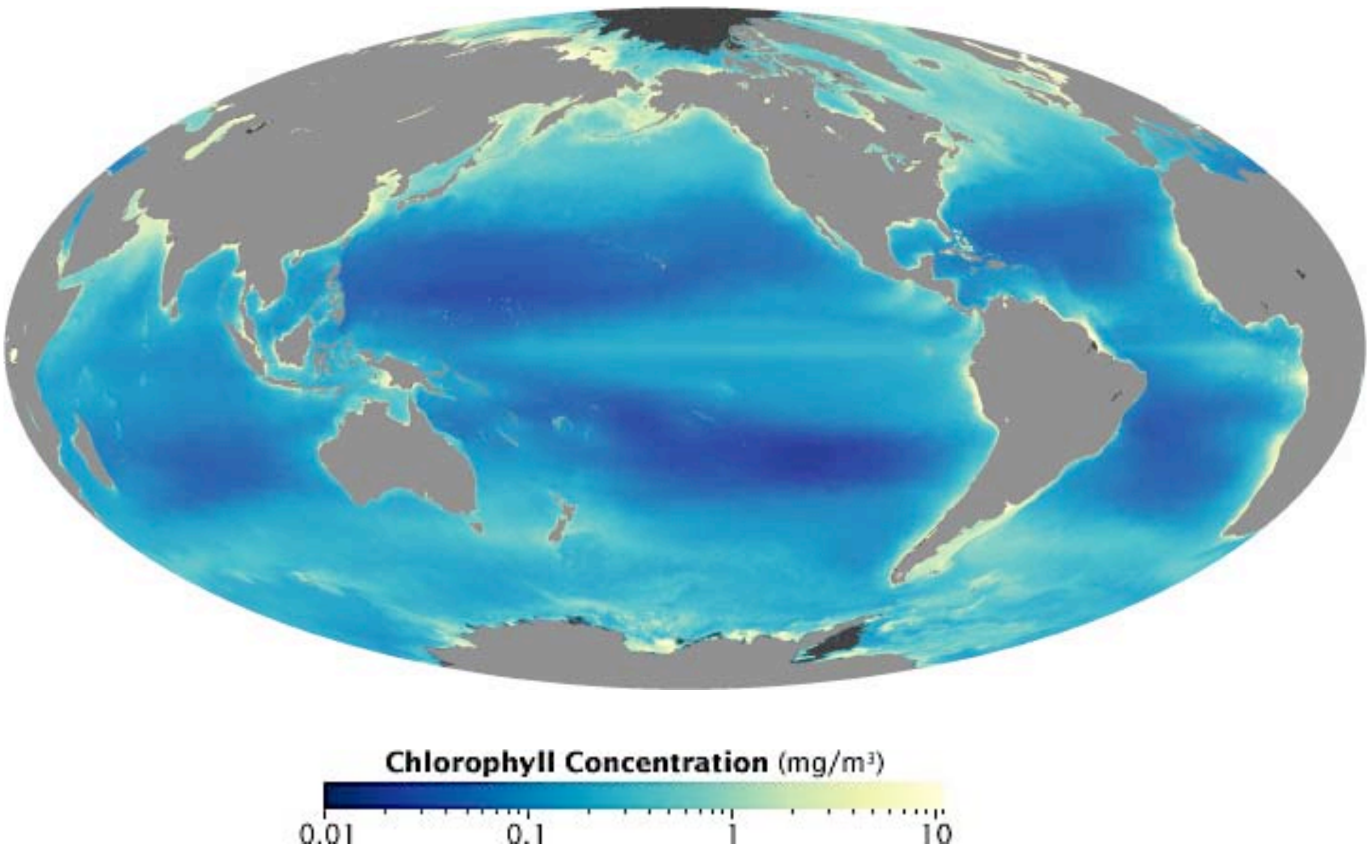
Remote sensing involves the use of instruments or sensors to "capture" the spectral and spatial relations of objects and materials observable at a distance—typically from above. An aerial photograph is a common example of a remotely sensed (by camera and film) product. Phytoplankton blooms that occur near the surface are readily visible from space, enabling a global estimation of the presence of chlorophyll and other pigments using satellite images. The images in this paper were taken by either NASA's Moderate-resolution Imaging Spectroradiometer (MODIS) aboard the Terra or Aqua spacecrafts, or the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) aboard the OrbView-2 satellite. SeaWiFS was launched August 1, 1997, the Terra satellite December 18, 1999, and Aqua May 4, 2002.

Web References

http://earthobservatory.nasa.gov/Features/Phytoplankton/

http://modis.gsfc.nasa.gov/

http://oceancolor.gsfc.nasa.gov/SeaWiFS/TEACHERS/sanctuary_4.html



Eight Year Map of World Wide Chlorophyll Concentration

This map shows the average chlorophyll concentration in the global oceans from **July 2002 to May 2010** acquired by the MODIS instrument aboard NASA's Aqua satellite. Chlorophyll is shown in milligrams per cubic meter of seawater. The greatest concentrations appear in yellow, and the sparsest appear in deep blue. Since this image shows values averaged over eight years, greater amounts of chlorophyll are observed in areas with recurring blooms. Some of the greatest concentrations appear along coastlines.

Web Reference
http://earthobservatory.nasa.gov/Features/Phytoplankton/page4.php

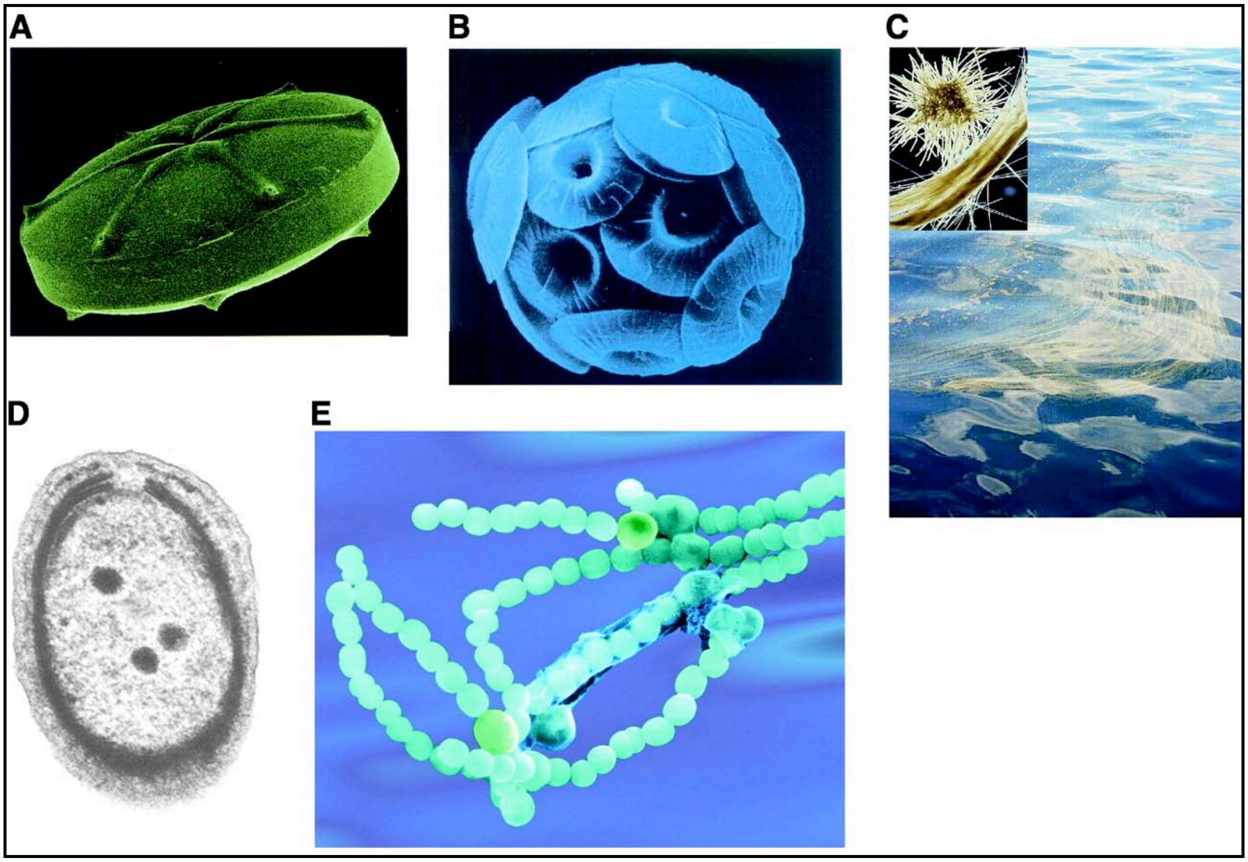
When we think about the Earth's sources of oxygen, we usually think of vast forests such as the Amazon, but almost half of the oxygen we breathe comes from phytoplankton. Phytoplankton also serve as the base of the ocean's food chain. Yet as important as phytoplankton are to life on Earth, their interaction with our planet has only been studied on a global scale starting September of 1997, as the first images from NASA's satellite instrument the Sea-viewing Wide Field-of-View Sensor or SeaWiFS became available.

Consistently high concentrations appear at high latitudes, with medium level concentrations over much of the ocean at mid latitudes and the equator. Marine biologists often refer to the darkest blue areas in the open oceans as "deserts," because the concentration of key nutrients in the water is usually so low that phytoplankton can't grow.

Prior to the launch of SeaWiFS, scientists could only study phytoplankton on a relatively small scale. By measuring chlorophyll on a global scale over time, NASA's satellites have been able to track how phytoplankton thrive and diminish as light and nutrient levels change. Massive phytoplankton blooms spread across the North Atlantic in the Northern Hemisphere each spring, and intense blooms occur in the South Atlantic off the Patagonian Shelf of South America during spring in the Southern Hemisphere. Blooms fostered by changes in nutrient-rich water, though less regular, are also dramatic, especially when El Niño gives way to La Niña, and cold, nutrient-rich waters well up across the Pacific.

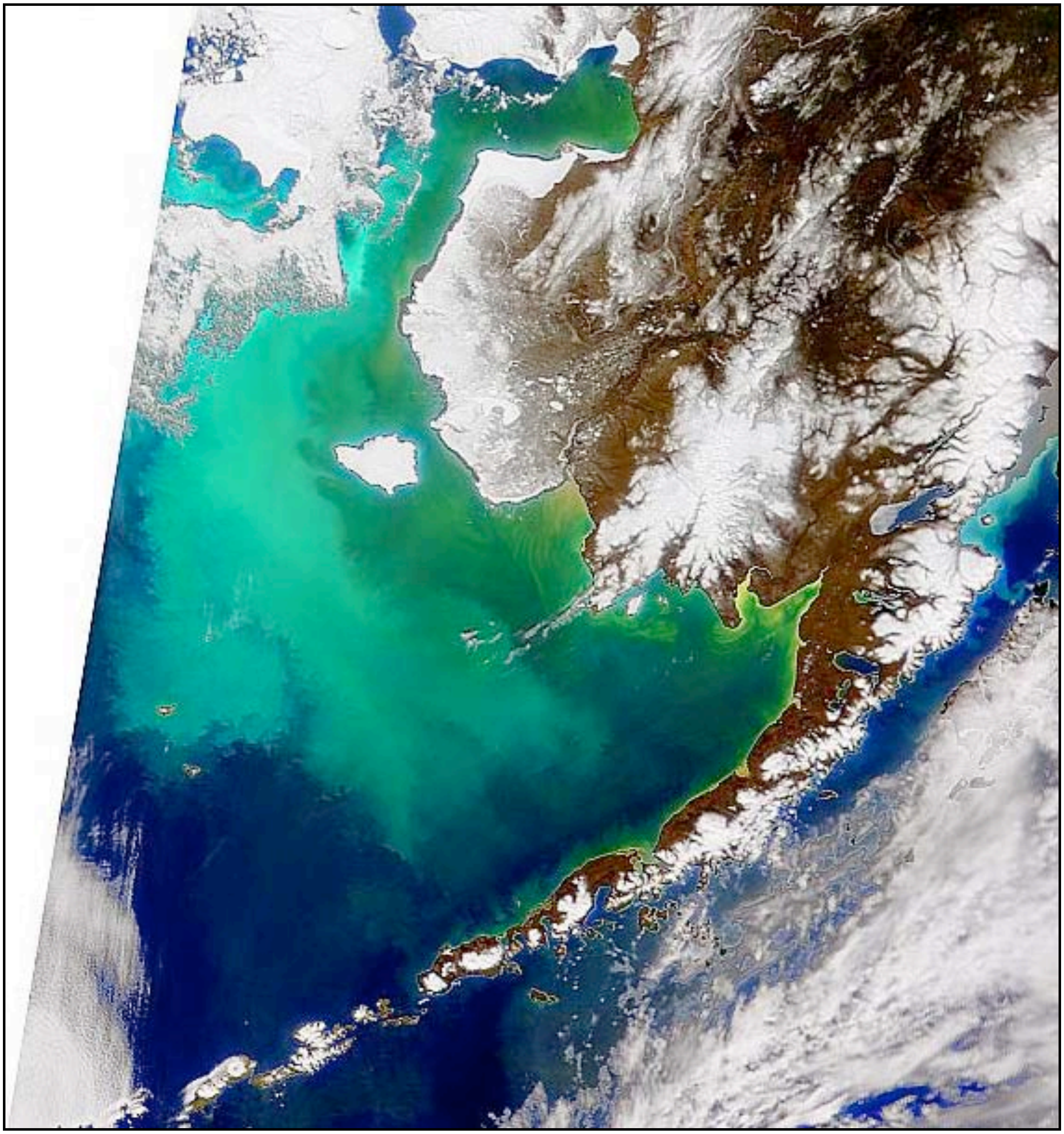
Web Reference
http://earthobservatory.nasa.gov/Features/Phytoplankton/

(Portions of edited text used courtesy of NASA Earth Observatory)

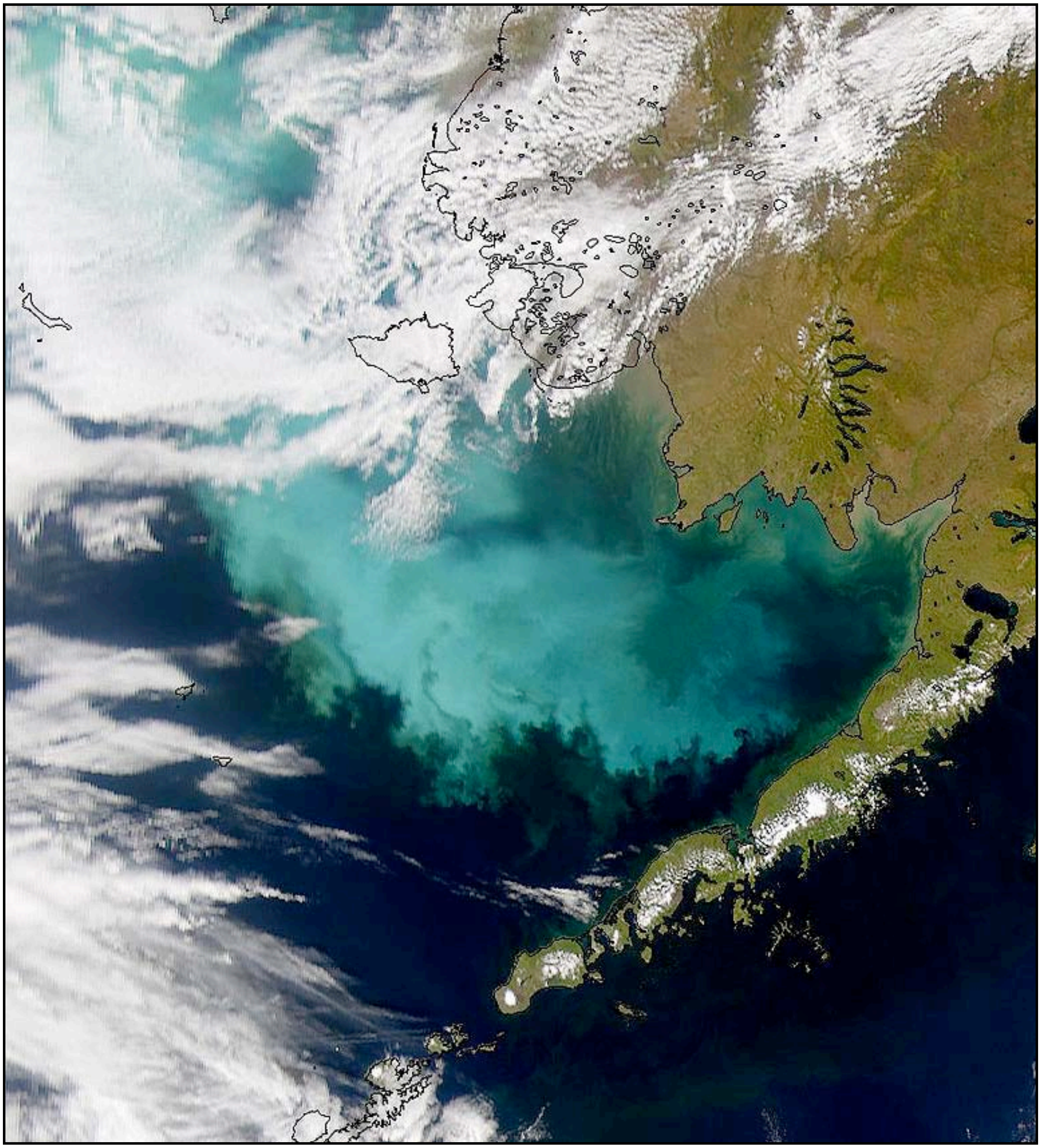


Examples of photosynthesizing single cell marine microorganisms (phytoplankton), including (**A**) diatoms, (**B**) coccolithophores (both of which are algae), and the cyanobacteria species (**C**) *Trichodesmium*, (**D**) *Prochlorococcus*, and (**E**) *Anabaena*.

The following images are of phytoplankton blooms caused by upwelling currents. These currents are, themselves, caused by a variety of factors including water depth and temperature, coastal and tidal currents, winds, and landforms.



The Bering Sea between Alaska and Siberia is noted for some of the most extensive phytoplankton blooms in the world. This SeaWiFS image of the Bering Sea off the southwest coast of Alaska was acquired on **April 25, 1998**. This image shows the Alaskan coast from Norton Sound on the north, to Nunivak Island, down to Bristol Bay with the Aleutian Peninsula and Islands on the south.



This SeaWiFS image acquired on **September 16, 2000**, shows extensive coccolithophore blooms in the area of the Bering Sea south of Nunivak Island into Bristol Bay.

Web Reference
http://earthobservatory.nasa.gov/Study/Coccoliths/

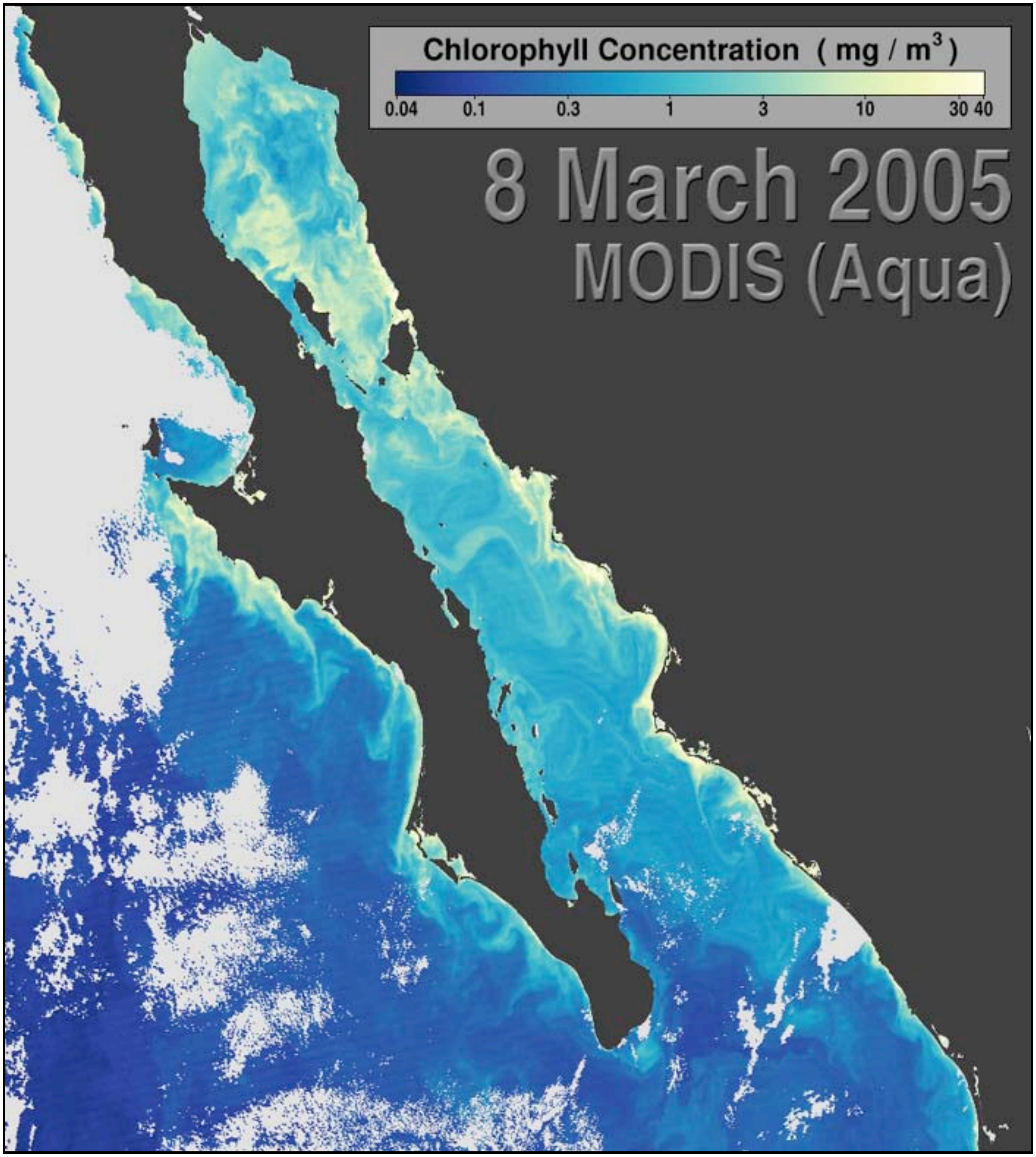
In this **July 3, 1999**, SeaWiFS image of the Gulf of Alaska, eddies of warm water, filled with nutrients from shallow coastal waters, mixing with the cold water off the continental shelf have produced gigantic swirls of phytoplankton blooms. This view of the gulf is to the north with Kodiak Island upper left and Anchorage in the upper right.

Strong upwelling currents along the Olympic Peninsula of Washington State and Vancouver Island, British Columbia, provide the nutrients for extensive phytoplankton blooms as shown in this SeaWiFS image from **August 9, 2001**.

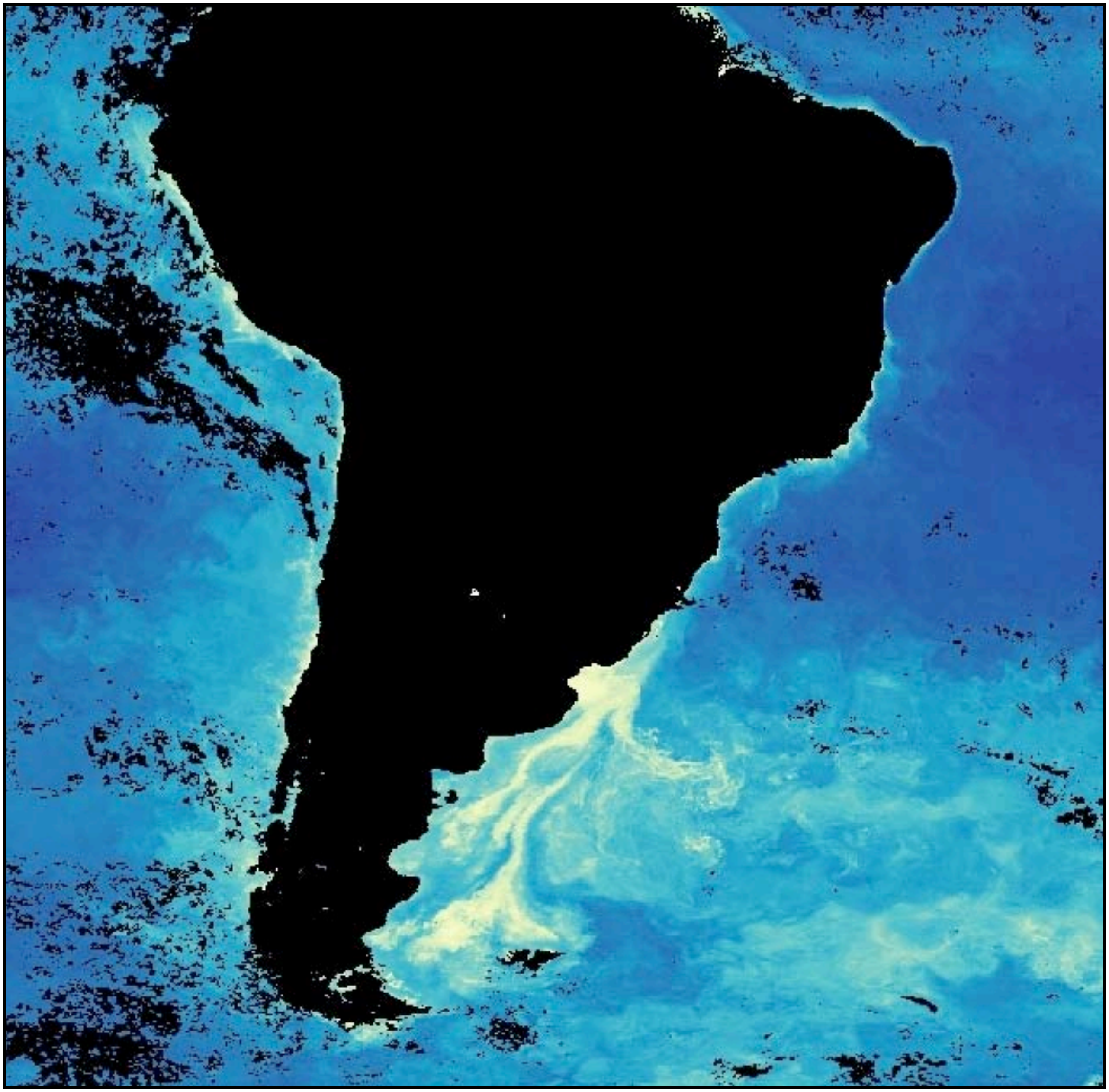
Off the coast of Vancouver Island and Washington State, phytoplankton blooms tend to occur when winds blow from the land, as they do in the summer. The winds push the ocean's surface water west, out to sea. Deep water rises up to replace the wind-blown surface water, and carries the nutrients needed to support extensive phytoplankton blooms. The MODIS instrument aboard NASA's Aqua satellite captured this image on **June 25, 2006**.

Massive tidal surges in the Gulf of California cause extensive upwelling which provides the nutrients for large phytoplankton blooms such as seen in this SeaWiFS image taken **April 16, 2001**. Shown above is the southern end of the Gulf of California with the Baja Peninsula on its left and the mainland of Mexico on the right.

Web Reference
http://fire.biol.wwu.edu/trent/alles/Sea_of_Cortez.pdf

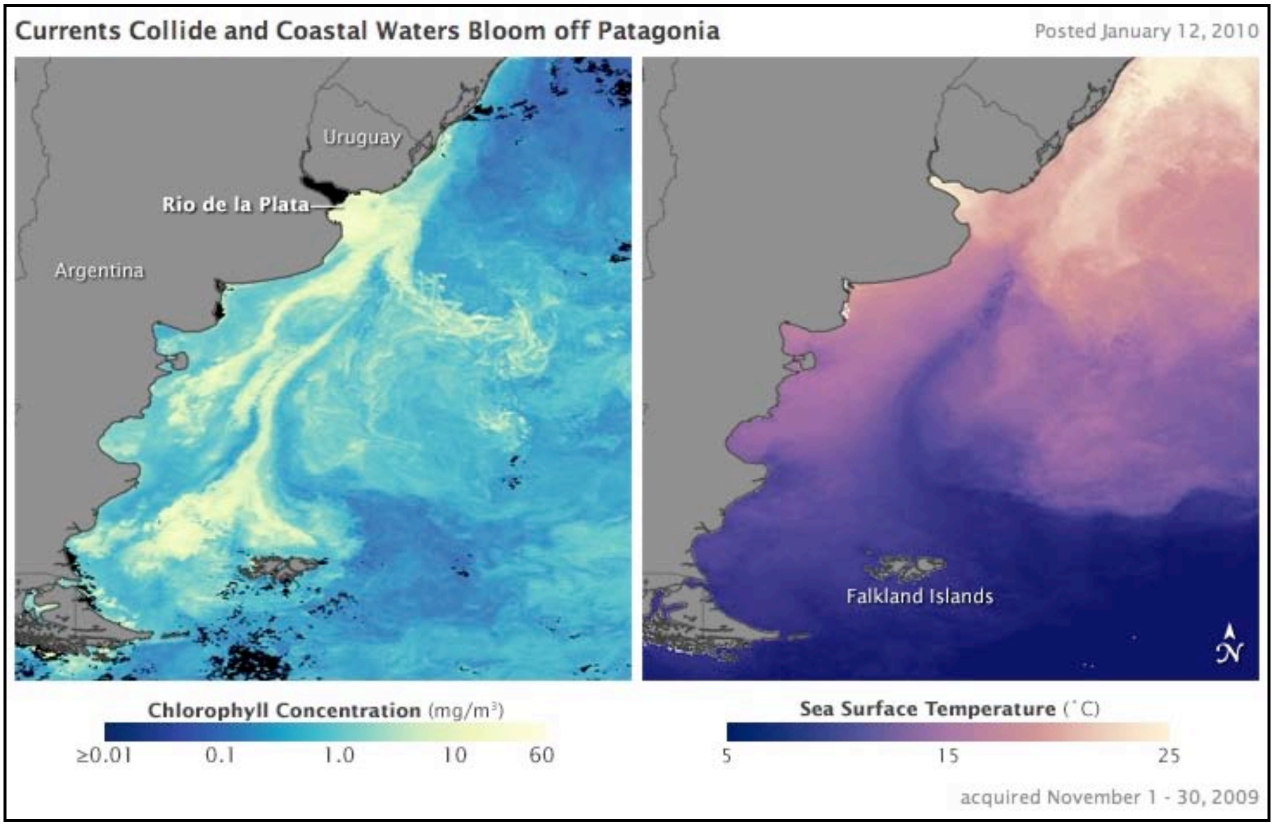


The entire length of the Gulf of California is shown in this image. Although waters in the northern portion of the gulf are seldom deeper than 600 feet (180 meters), the southern part can reach depths of 10,000 feet (3,000 meters). Upwelling of water from these depths stirs the sea into a mix of nutrients sustaining immense concentrations of phytoplankton.



Located over the continental shelf of southeastern South America is one of the world’s most productive and complex marine ecosystems. Covering about 1.2 million square kilometers (4.6 million square miles) of coastal waters, the Patagonia Large Marine Ecosystem stretches from the Rio de le Plata (a wide estuary at the mouth of the Paraná River) to the southern tip of the continent. The brighter colors show the location of phytoplankton blooms in the Patagonia Large Marine Ecosystem.

This image of South America and the ocean waters surrounding it was cropped from Global Maps of the Earth Observatory data collected by the (MODIS) on NASA’s Aqua satellite in **November 2009**. Monthly maps of chlorophyll and sea surface temperature from Aqua are available in Global Maps on NASA's Earth Observatory.



In **November 2009**, as summer approached the foundation of the ecosystem's food web, phytoplankton bloomed expansively brightening the waters with living ribbons of color. The image on the left shows the monthly average chlorophyll concentration. High chlorophyll concentrations (yellow) mean large populations of phytoplankton, which use chlorophyll and other pigments to capture sunlight for photosynthesis.

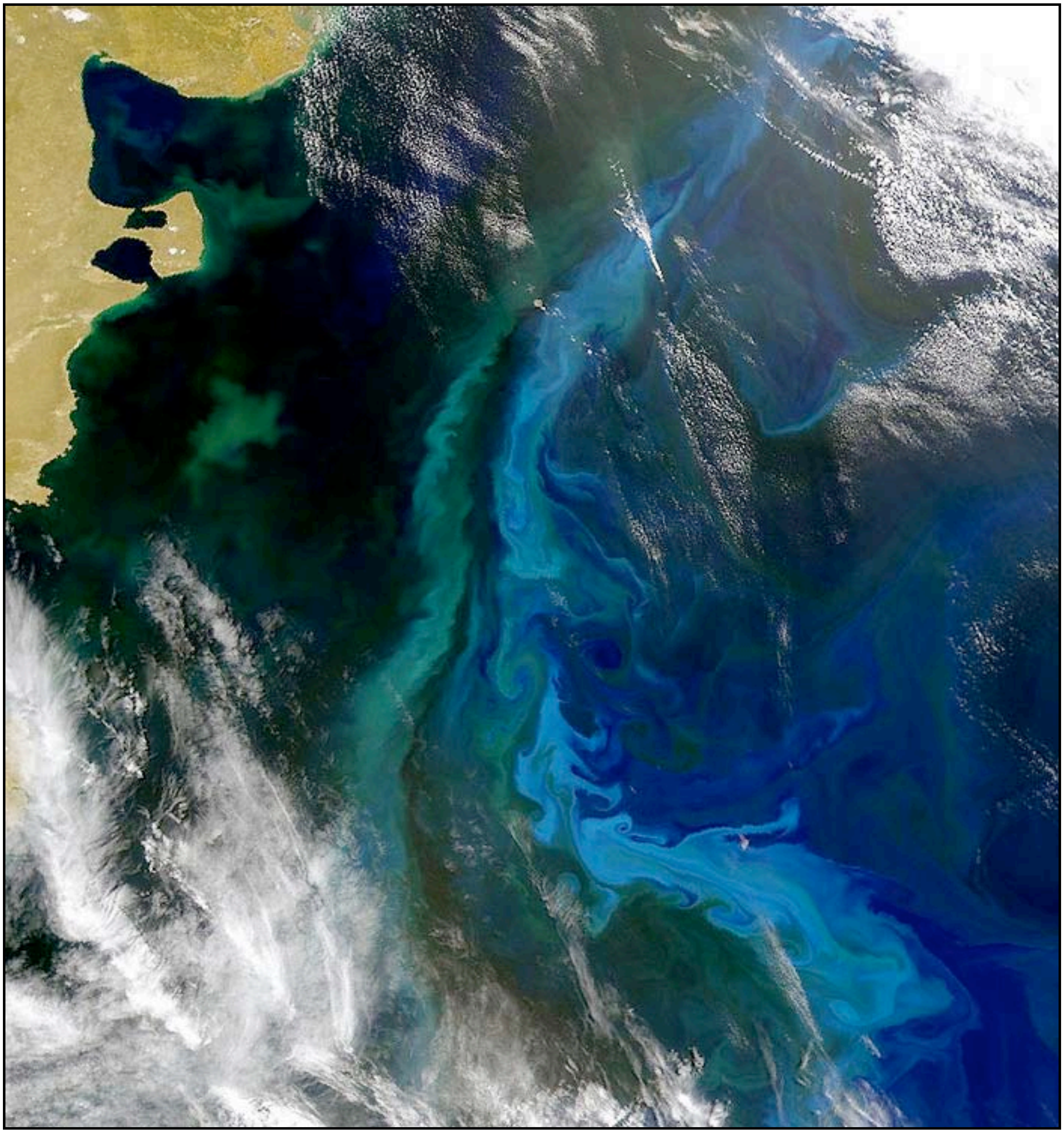
The sea surface temperature image (right) reveals one of the reasons for the region's productivity: the convergence of two wind-driven ocean currents. The warm, salty Brazil Current meanders south over the continental shelf, where it meets the cold, less-salty Falklands/Malvinas Current, a north-flowing branch off the Antarctic Circumpolar Current.

In the spring and summer, the convergence zone occurs at about the latitude of the Rio de la Plata, which is where it seems to be based on the water temperatures shown in the sea surface temperature image. Blues and purples (cooler water) dominate the image south of the estuary, while pinks and yellows (warmer water) dominate the image north of there. The convergence of two water masses of different temperatures and saltiness enhances mixing of the water, both vertically and horizontally. Vertical mixing brings nutrient-rich water up from deeper in the ocean, restocking surface waters.

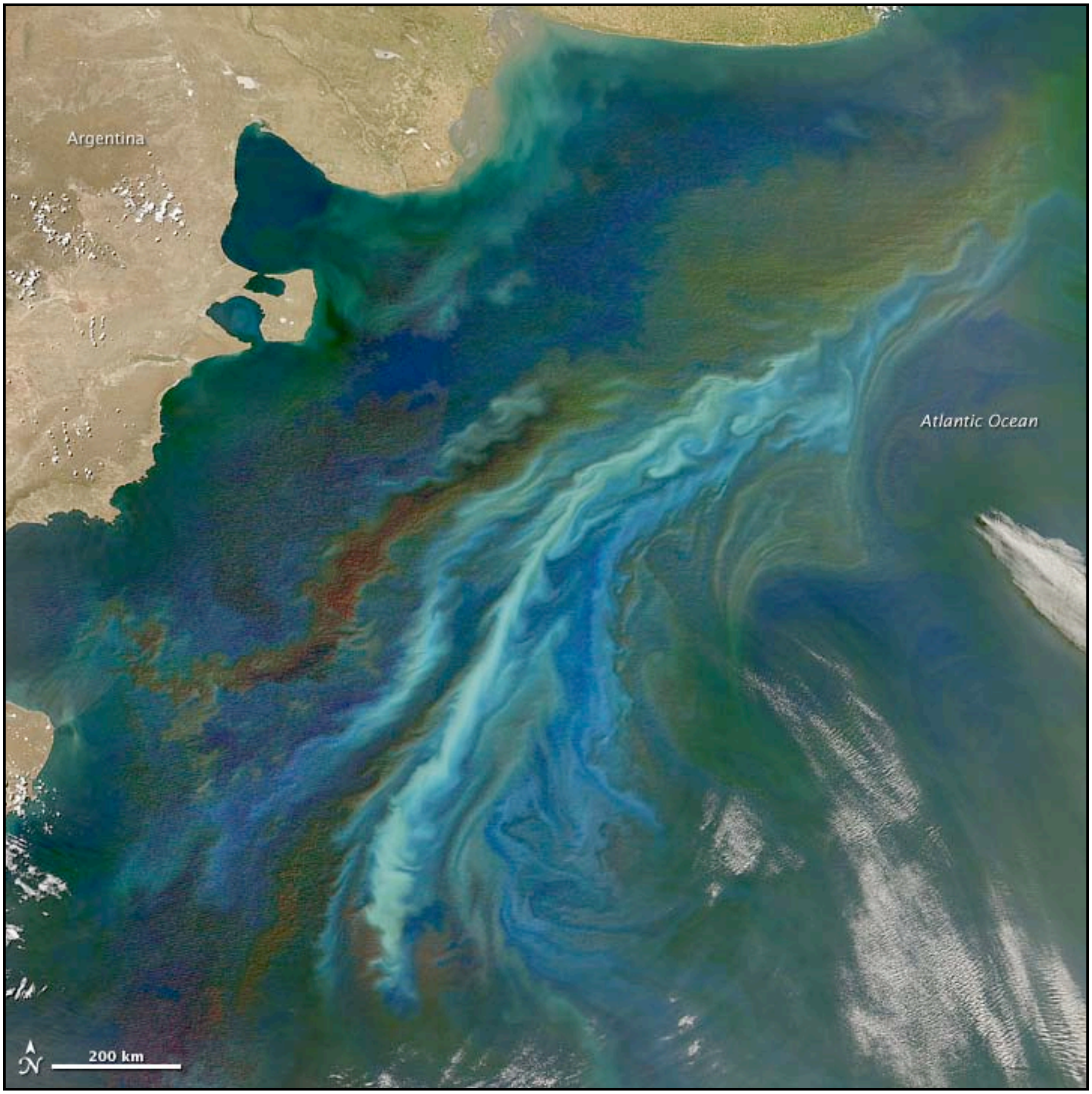
Web References

http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MY1DMM_CHLORA

http://earthobservatory.nasa.gov/GlobalMaps/



This SeaWiFS image from **November 29, 2001**, shows the bright waters of the Patagonian Shelf off the coast of Argentina that mark the convergence of the Malvinas and Brazil Currents. Along the Atlantic coast of the southern tip of South America, a jet of cold water branches off the Antarctic Circumpolar Current, which loops in a continuous eastward-flowing cycle in the Southern Ocean around Antarctica. This north-flowing offshoot is the Malvinas Current. The current flows northward along the coast of South America until it meets the warm, south-flowing Brazil current, usually within a few degrees latitude of the Rio de la Plata.



Phytoplankton Bloom in the Malvinas Current December 21, 2010

Off the coast of Argentina, two strong ocean currents stirred up a colorful brew of floating nutrients and microscopic plant life just in time for the summer solstice. The MODIS instrument on NASA's Aqua satellite captured this image of a massive phytoplankton bloom off the Atlantic coast of Patagonia on December 21, 2010. Scientists used seven separate different spectral bands to highlight the differences in the plankton communities across this swath of ocean.

This milky green and blue bloom developed on the continental shelf off of Patagonia, where warmer, saltier coastal waters and currents from the subtropics meet the colder, fresher waters flowing up from the south. Where these currents collide—known to oceanographers as a shelf-break front—turbulent eddies and swirls form, pulling nutrients up from the deep ocean. Also, the nearby Rio de la Plata runs off the land and deposits nitrogen and iron-laden sediment in the sea just north of the area shown in the image. Add in some strong summer sun, and you have a bountiful feast for the phytoplankton that forms the base of the ocean food web. Phytoplankton become food for everything from microscopic animals (zooplankton) to fish to whales.

Though it is impossible to say for sure without direct sampling of the water, most of the phytoplankton blooming in this image are coccolithophores, single-celled algae that form calcite scales. (Calcite is a carbonate mineral often found in limestone chalk.) Blooms of coccolithophores are common in these waters in southern hemisphere's spring and summer. Diatoms also form part of the mix of phytoplankton during this period.

References

Garcia, V.M.T., et al (2008). Environmental factors controlling the phytoplankton blooms at the Patagonia shelf-break in spring. Deep-Sea Research I, 55, (9), 1150-1166.

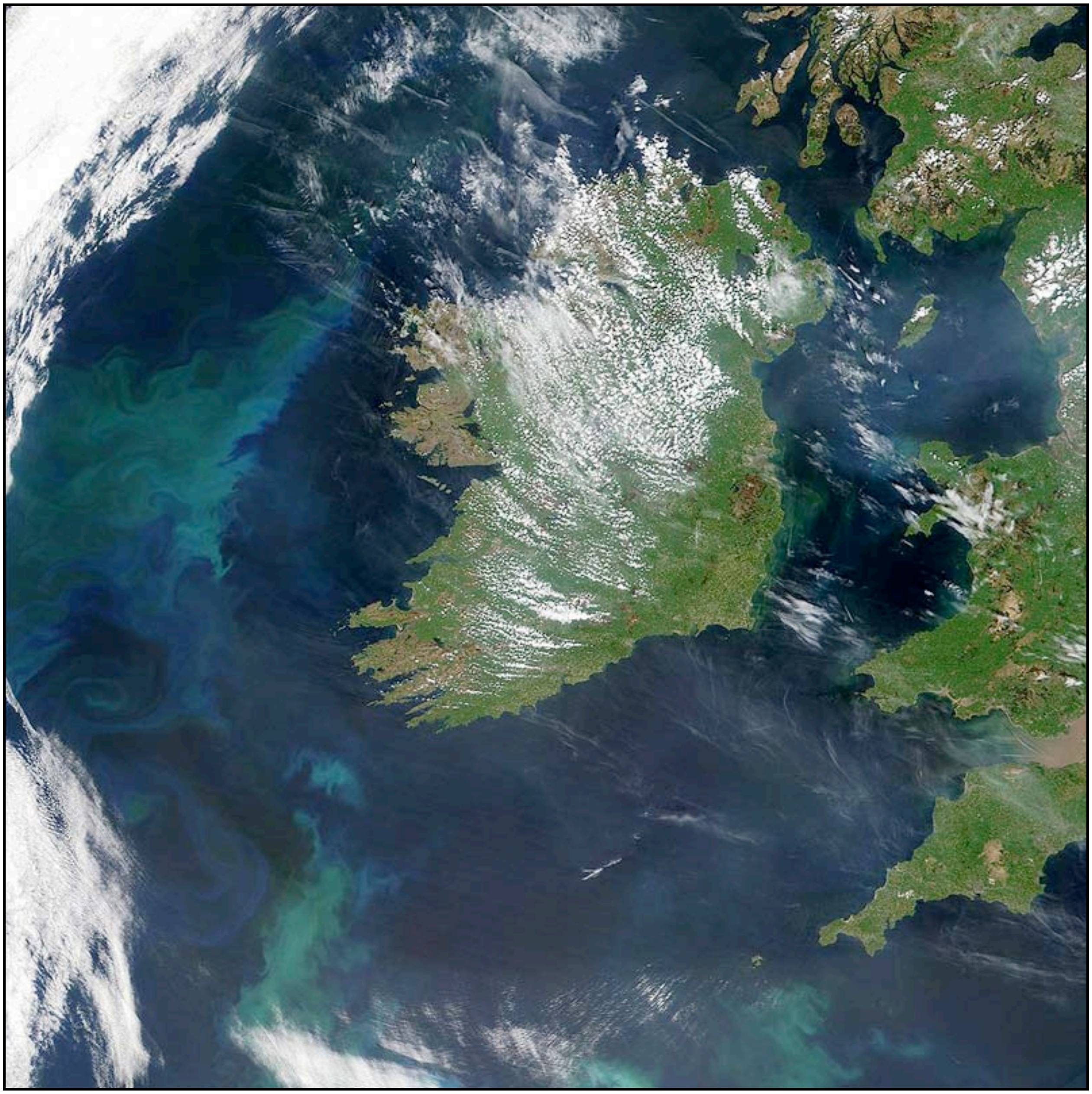
Painter, S.C., et al (2010). The COPAS'08 expedition to the Patagonian Shelf: Physical and environmental conditions during the 2008 coccolithophore bloom. Continental Shelf Research, 30 (18), 1907-1923.

Web References

http://earthobservatory.nasa.gov/IOTD/view.php?id=48244

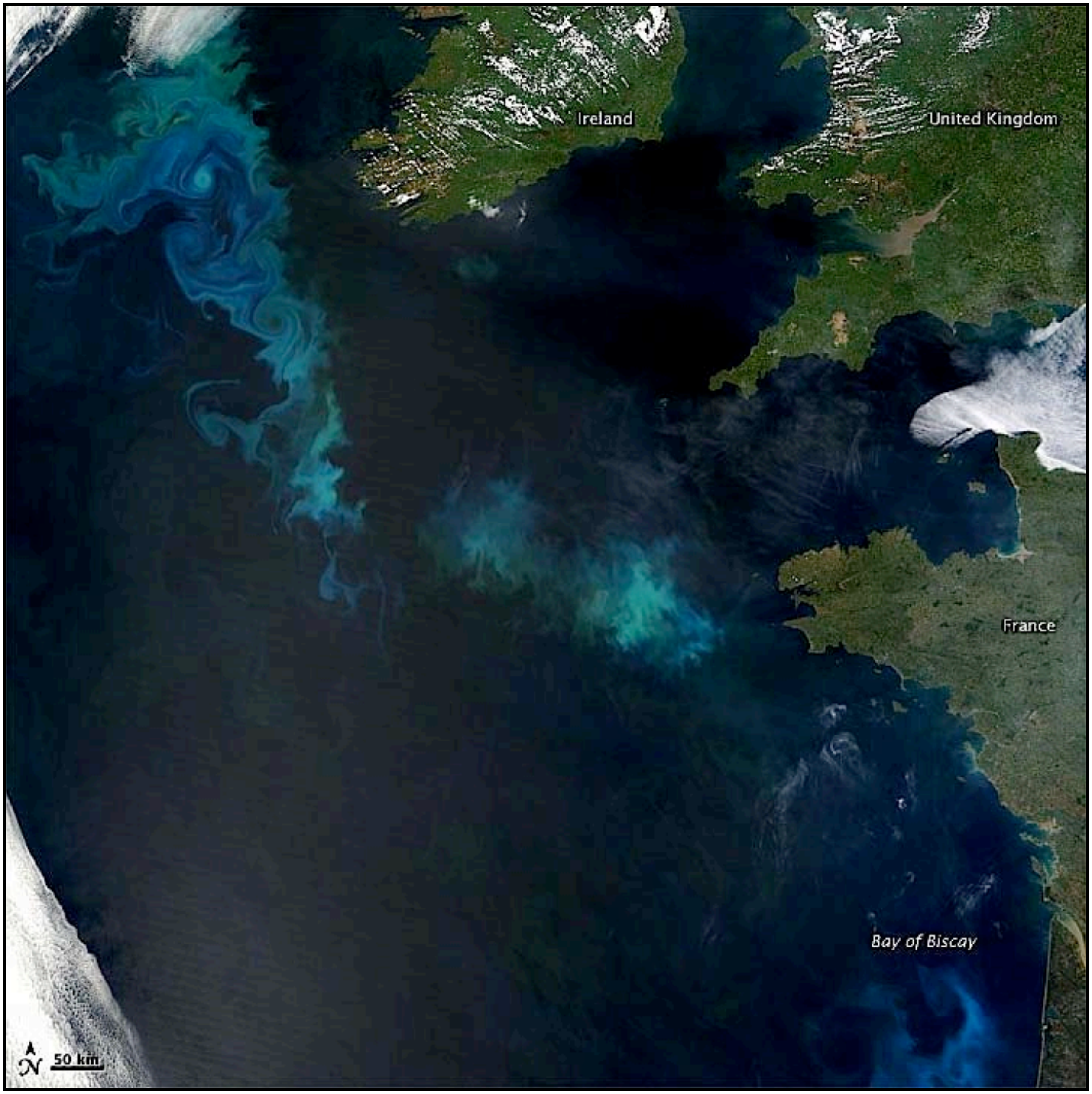
http://earthobservatory.nasa.gov/Features/Phytoplankton/

http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=171&Itemid=74



Phytoplankton blooms often occur over continental shelves when prevailing winds from the land draw cold water from the depths to the surface. This upwelling carries nutrients from the ocean floor that can sustain large blooms. The ocean is normally black in true-color satellite images such as this one acquired **May 22, 2001**, by the MODIS/Terra instrument. But a large phytoplankton bloom has colored the waters off the west coast of Ireland (center) brilliant hues of blue and green.

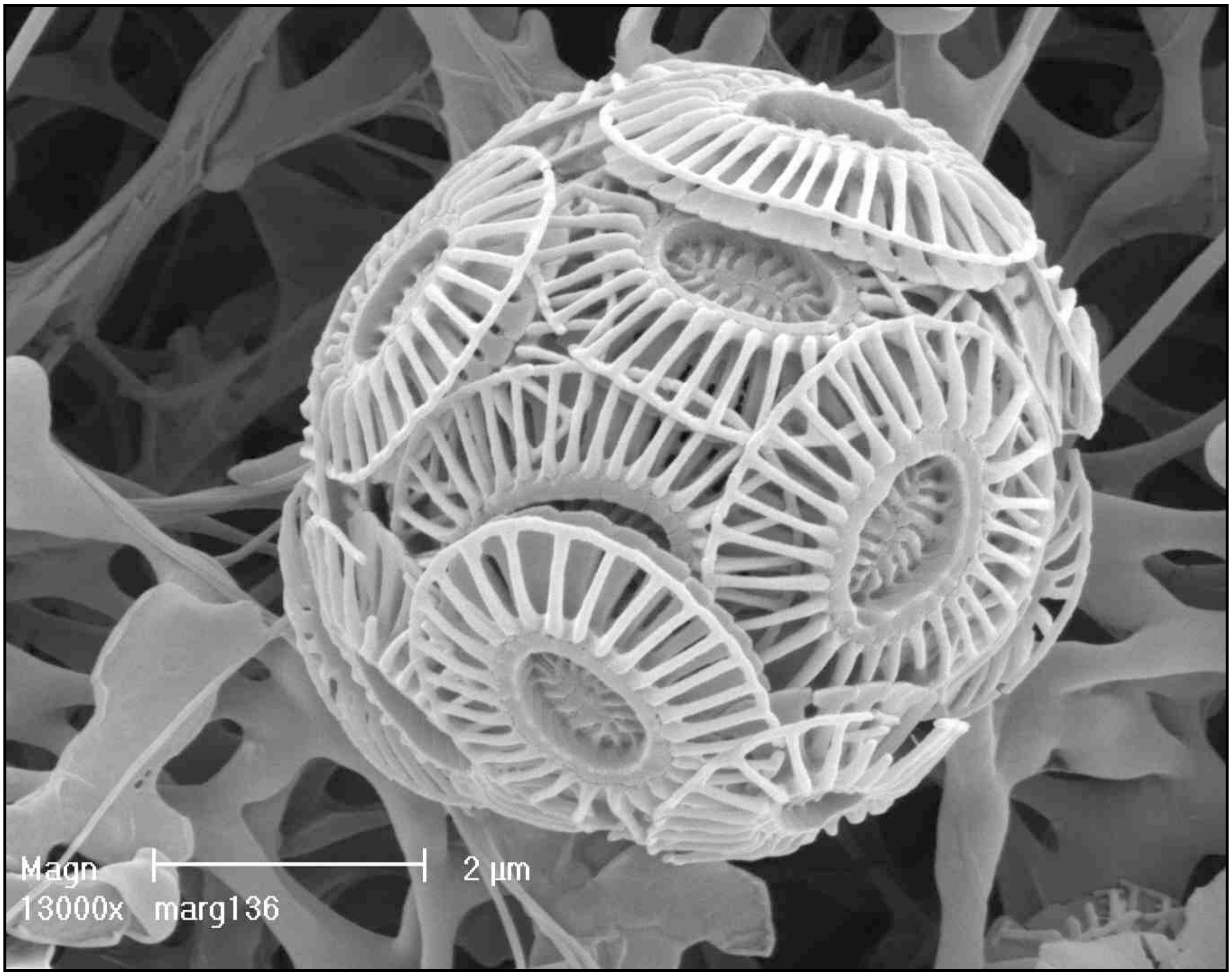
This MODIS/Aqua image shows a similar phytoplankton bloom west of Ireland on **June 2, 2006**. Steady winds from the east have pushed the surface waters west causing deeper, nutrient rich waters to well up and produce plankton blooms off shore from Scotland to well south of Ireland.



Atlantic Bloom from Ireland to France

Late May 2010 brought peacock-hued swirls of blue and green to the North Atlantic. The iridescent waters formed a giant arc hundreds of kilometers across, extending from west of Ireland to the Bay of Biscay. The MODIS instrument on NASA's Aqua satellite captured this natural-color image on **May 22, 2010**. The vibrant colors are phytoplankton, that grow explosively in the North Atlantic in the spring and summer.

Peacock in color, but more reminiscent of a mighty dragon's head, the swirls of blue and green iridescent phytoplankton in this image make it hard to imagines they are formed by countless tiny organisms that grow explosively from Iceland to the shores of France.



It is not always possible to identify the type of phytoplankton present using space-based remote sensing. Coccolithophores, however, are a group of phytoplankton that are identifiable from space. These microscopic algae armor themselves with external plates of calcium carbonate. Called coccoliths (a ball of which is shown above magnified 13,000 times), these plates can give the ocean a milky white or turquoise appearance during intense blooms. A ball of coccolith plates surrounds each coccolithophore algae cell. Typically there is a single layer of about 10 coccoliths around the cell, but some cells accumulate multi-layered coccospheres with hundreds of coccoliths. The long-term flux of coccoliths to the ocean floor is the main process responsible for the formation of chalk and limestone.

(Electron microscope photograph by Jeremy Young)

Web References
http://en.wikipedia.org/wiki/Coccolithophore

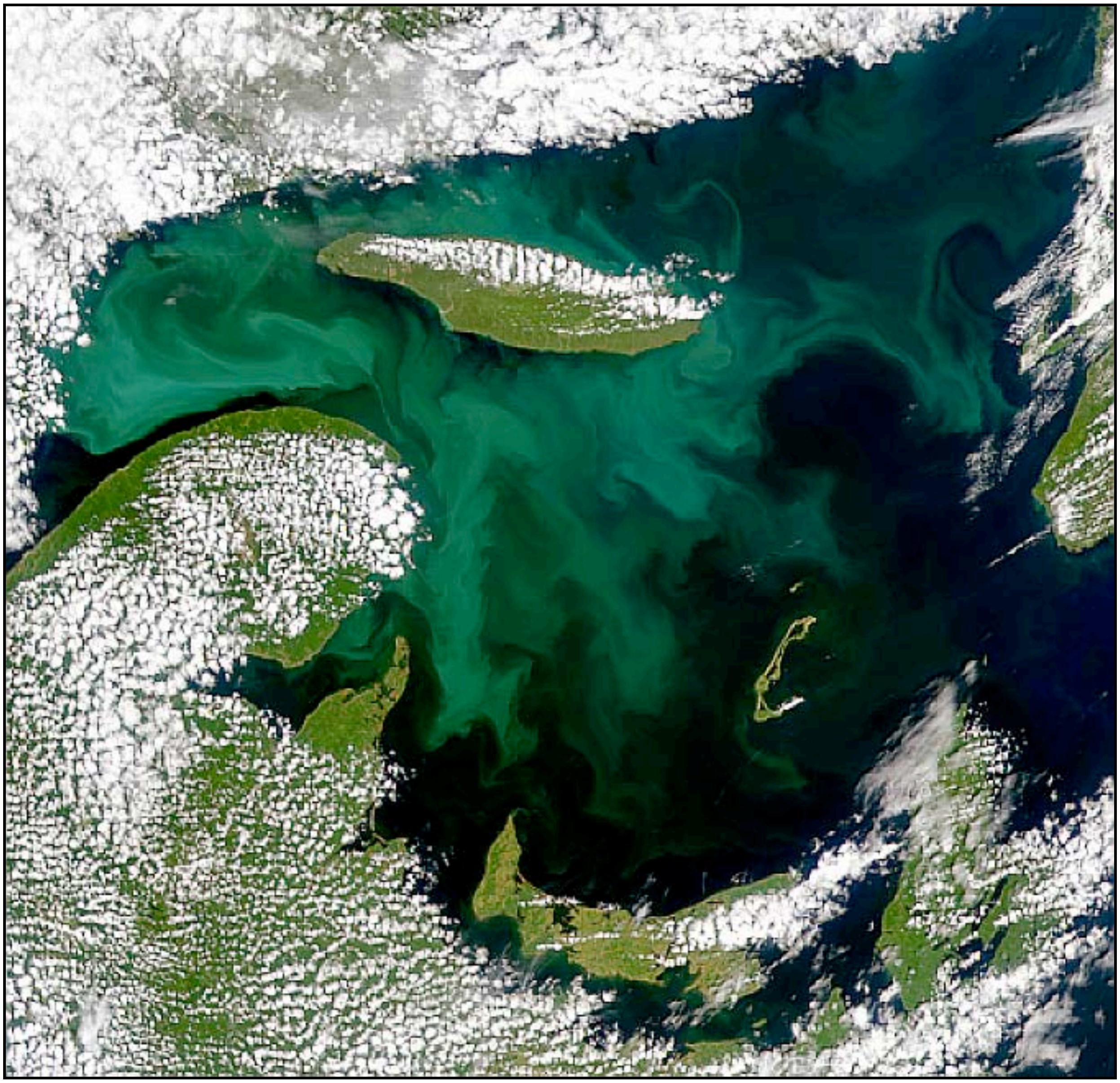
http://www.soes.soton.ac.uk/staff/tt/eh/index.html

Lake Ontario August 20, 2008

Phytoplankton blooms are not restricted to oceans or seas as seen in this image of a bloom in Lake Ontario. Although great strides in controlling nutrient pollution have been made, the problem of eutrophication in the Great Lakes has not been solved as shown in this MODIS/Aqua image.

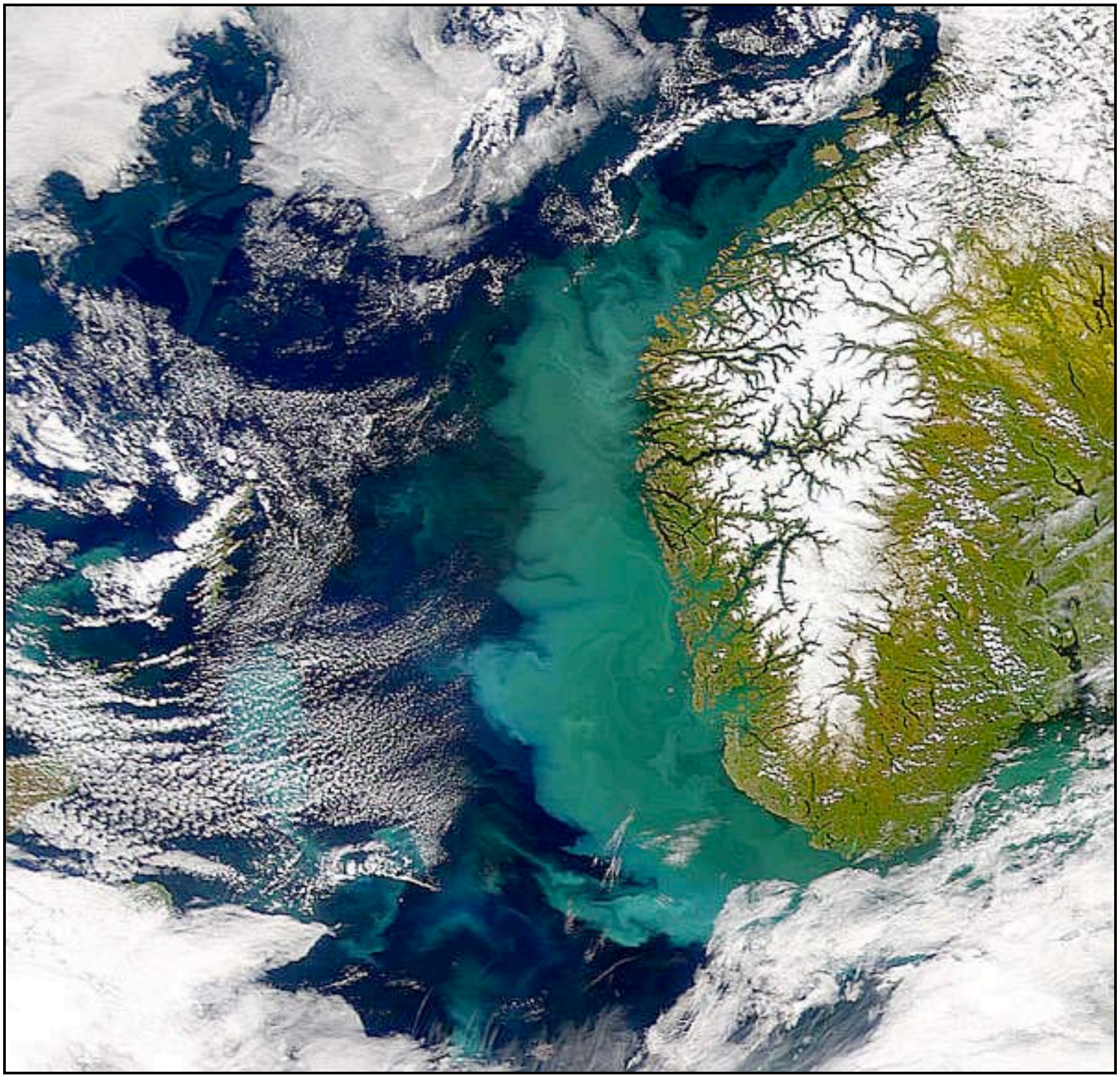
Eutrophication, the excessive influx of nutrients into waterways and wetlands, was first extensively studied in the Great Lakes. Nitrogen and phosphorous pollution from agricultural and urban runoff are major contributing factors to eutrophication (Anderson, et al., 2002). This image and the ones on the following pages are examples of phytoplankton blooms caused or intensified by nutrient pollution from human activities.

Web Reference
http://fire.biol.wwu.edu/trent/alles/WaterPollution.pdf



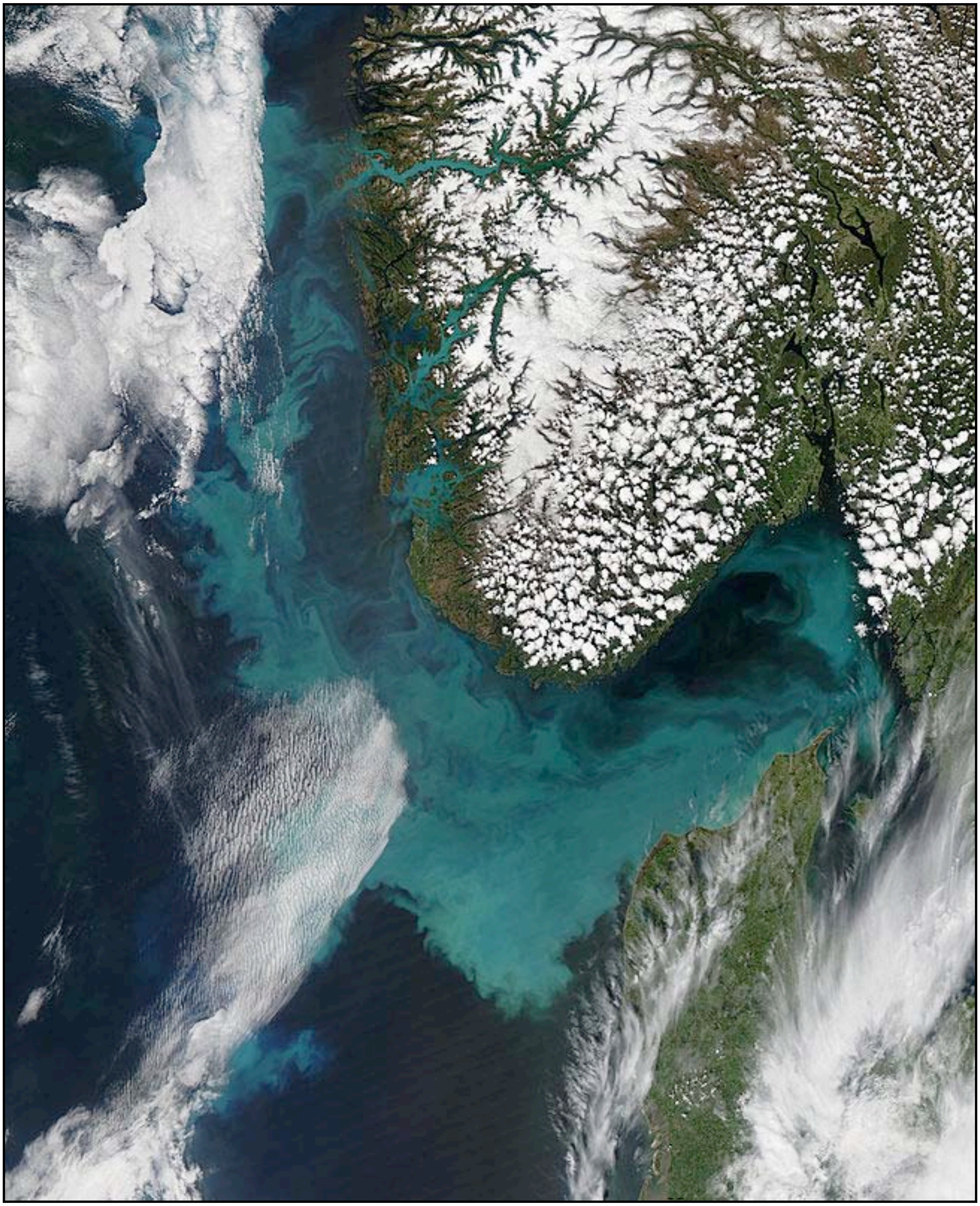
In August of 1999, this massive phytoplankton bloom lasted for three weeks in and around the Gulf of St. Lawrence, Canada. The bloom may have resulted from nutrient run-off flowing from the Great Lakes, via the St. Lawrence Seaway, to the sea.

(**August 11, 1999**, SeaWiFS image courtesy of NASA)

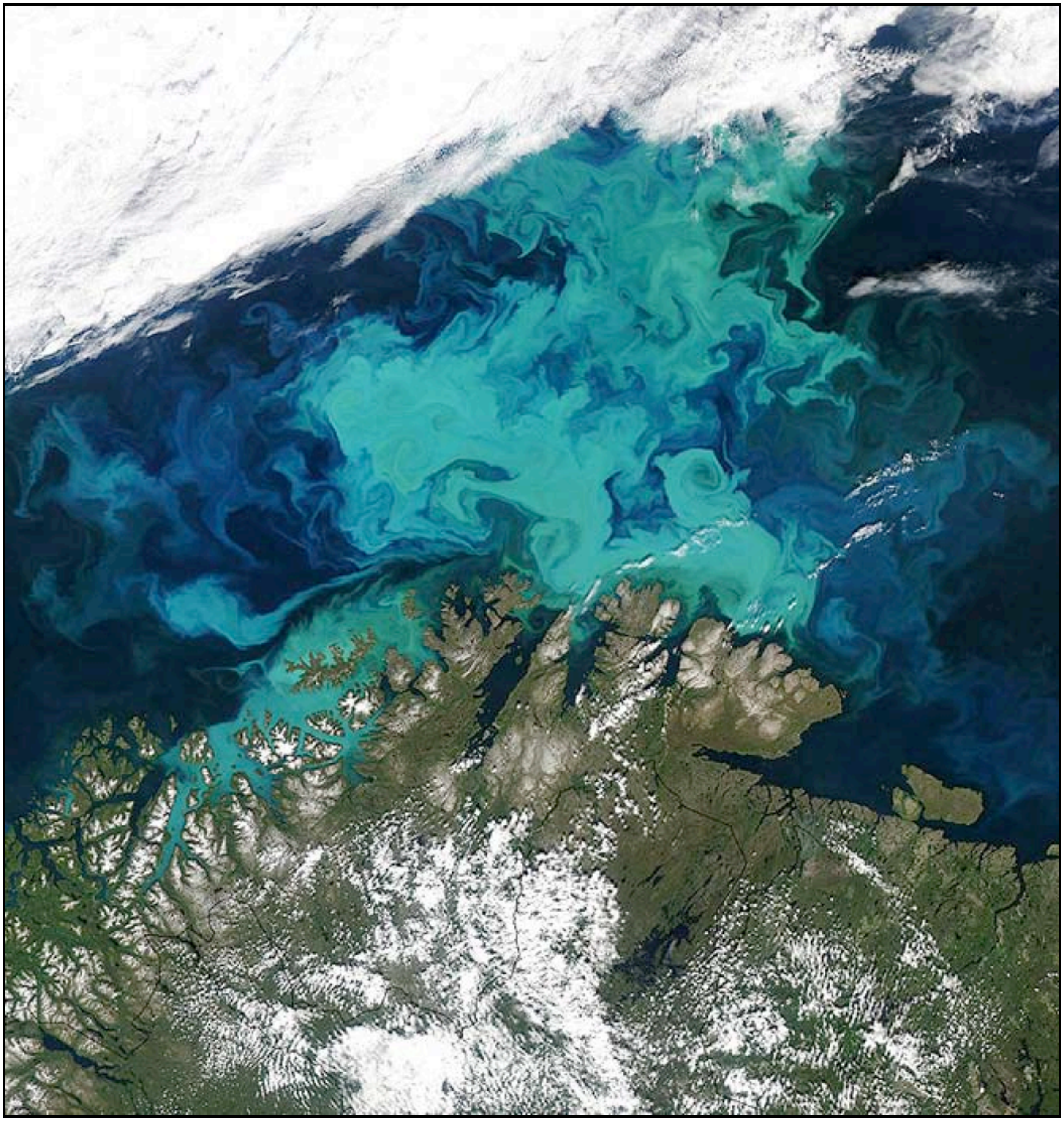


An intense phytoplankton bloom surrounds the coast of Norway in this **June 5, 2000**, SeaWiFS image. Pollution from the Baltic Sea flowing into the North Sea may contribute to the intensity of these blooms in a situation similar to the Great Lakes and the St. Lawrence Seaway in North America.

Green clouds of phytoplankton swirl in the North Sea, the Skagerrak, and Kattegat straits in this **May 23, 2004**, image acquired by the MODIS/Aqua instrument. The Skagerrak strait is a rectangular arm of the North Sea, trending southwest to northeast between Norway on the north and Denmark on the south. About 150 miles (240 km) long and 80–90 miles (130–145 km) wide, the Skagerrak narrows between Cape Skagen, Denmark, and the Swedish coast before turning south into the Kattegat toward the Danish sounds and the Baltic Sea.



In this MODIS/Aqua image acquired **May 31, 2010,** and taken of southern Norway and the Skagerrak strait, note the similarities to the bloom in the same location from the **June 5, 2000, SeaWiFS image**.



Phytoplankton Blooms in the Barents Sea

The Barents Sea is awash in colorful swirls of blue and green in this **July 19, 2003**, MODIS/Aqua satellite image. In contrast to the previous images, this bloom located in the Barents Sea just off Norway's rugged northern coast, is not influenced by human activity.

The Barents Sea north of Norway is again awash in swirls of blue and green in this **July 27, 2004**, MODIS/Aqua satellite image taken almost exactly a year later than the previous image. These spectacular displays of color reveal the natural biological richness of these cold, nutrient-rich waters. The colors can be produced by a variety of pigments, including chlorophyll, but the brightest blue color is the result of coccolithophores. Their covering of coccoliths is bright white, but mixes with the blue reflection of the water to produce brilliant hues of blue and green.

Barents Sea Phytoplankton Bloom

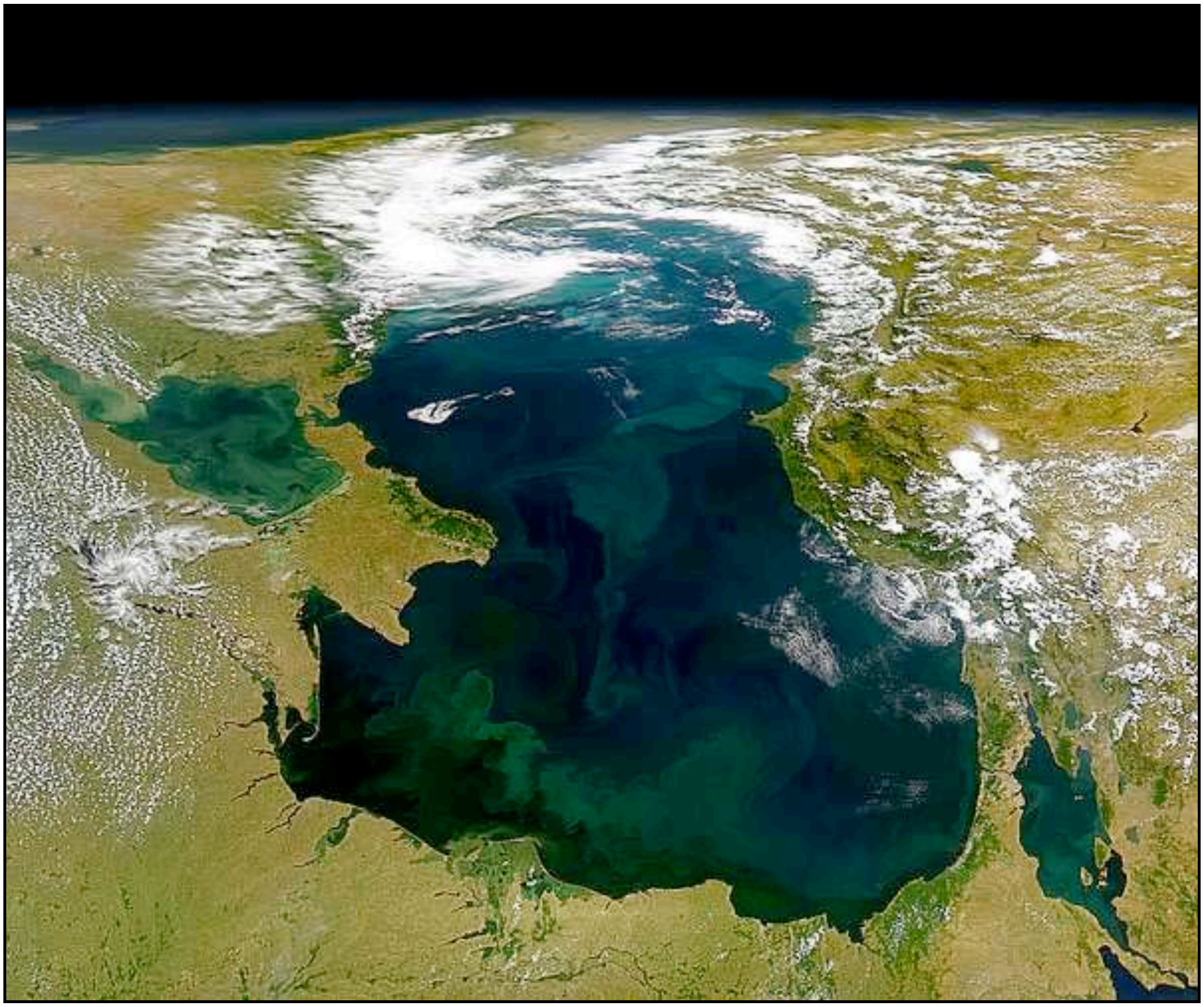
(MODIS/Aqua image acquired **2010-8-31** courtesy of NASA)

During the **late summer of 2011**, the Barents Sea experienced a massive phytoplankton bloom in the southern reaches of the sea along the adjoining coasts of Norway and Russia. The size and duration of the blooms warrants greater attention than is available in this paper. To solve this problem I have produced a second web paper covering 2011 and 2012 blooms in the Barents Sea as well.

Marine Phytoplankton Blooms in the Barents Sea 2011 and 2012

Which is available as a part of my series on **Global Ecology and Remote Sensing** and can be accessed from this paper at:

Web Reference
http://fire.biol.wwu.edu/trent/alles/BarentsSea2011_2012.pdf



The Black Sea

This image of the Black Sea, looking east toward Asia, was taken by the SeaWiFS instrument aboard NASA's OrbView-2 satellite on **June 17, 1999**. It gives some idea of the extent of phytoplankton blooms that have occurred in the Black Sea over the last forty years (Kideys, 2002; Borysova, et al., 2005). The delta of the Danube River is near the bottom just left of center. The Sea of Azov is on the left. On the lower right are the Bosporus Strait, the Sea of Marmara, and the Dardanelles which connect the Black Sea to the Aegean Sea and the Mediterranean.

Note the dark green algae phytoplankton blooms off the delta of the Danube River in the Black Sea, in the Sea of Azov, and the Sea of Marmara. While the eastern end of the Black Sea shows the light blue of coccolithophore blooms.

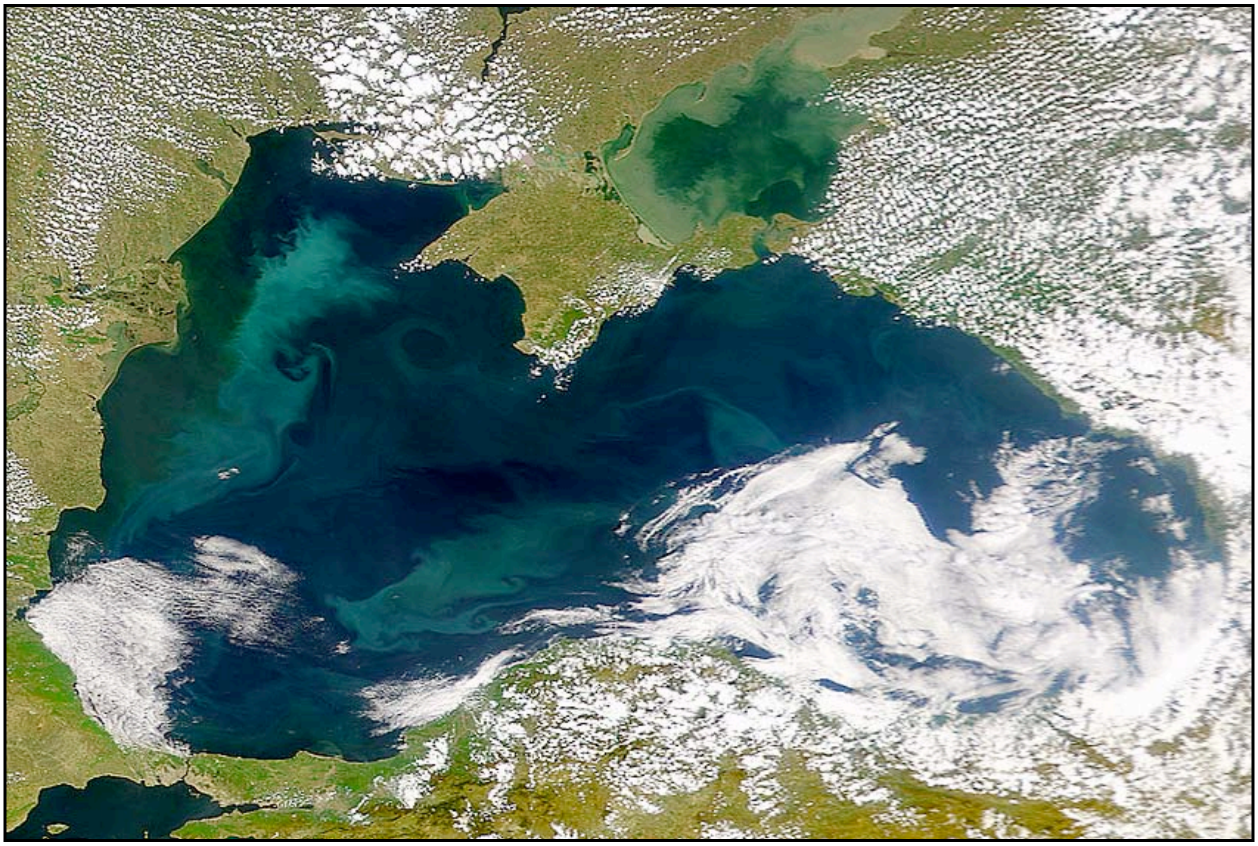
Like many bodies of water throughout the world the Black Sea has had problems related to eutrophication over the past four decades. Eutrophication is the excessive influx of nutrients into waterways and wetlands most often caused by run-off polluted with fertilizers and other chemicals that spur the rapid growth of algae and cyanobacteria, which die off and decompose, robbing oxygen from the water in the process. Often these blooms of phytoplankton kill fish and other aquatic animals by suffocation or the release of toxins into the water.

Starting in the 1960s the environment of the Black Sea and Danube Basin became seriously degraded. Pollution of the Black Sea and its tributaries, notably the Danube, caused significant losses to the countries involved through reduced revenues from tourism and fisheries, loss of biodiversity, and increased water-borne diseases. Extensive studies conducted during the 1990s showed that pollution by agricultural fertilizer runoff, and nitrogen and phosphorus discharges from municipal and industrial sources were the most significant causes of the ecological degradation of the Black Sea and Danube River (Borysova, et al., 2005). Phytoplankton blooms are one of the visible results of nitrogen and phosphorus nutrient loading in these waters.

According to the Black Sea Environment Program's Marine Hydrophysical Institute, the Black Sea is one of the world's marine environments most damaged by human activity. The coastal zone around this Eastern European inland water body is densely populated with a permanent population of roughly 16 million people and another 4 million tourists each year. Six countries border on the Black Sea, including Ukraine to the north, Russia and Georgia to the east, Turkey to the south, and Bulgaria and Romania to the west.

Web Reference
http://www.grid.unep.ch/bsein/publish/about.htm

This MODIS/Terra image from **June 5, 2000**, shows extensive blooms in the western portion of the Black Sea. The dark plume of phytoplankton left of center is off the delta of the Danube River. The Dnieper River empties into the Black Sea above and to the right of the Danube. Spring run-off from these rivers may have caused or intensified this bloom.



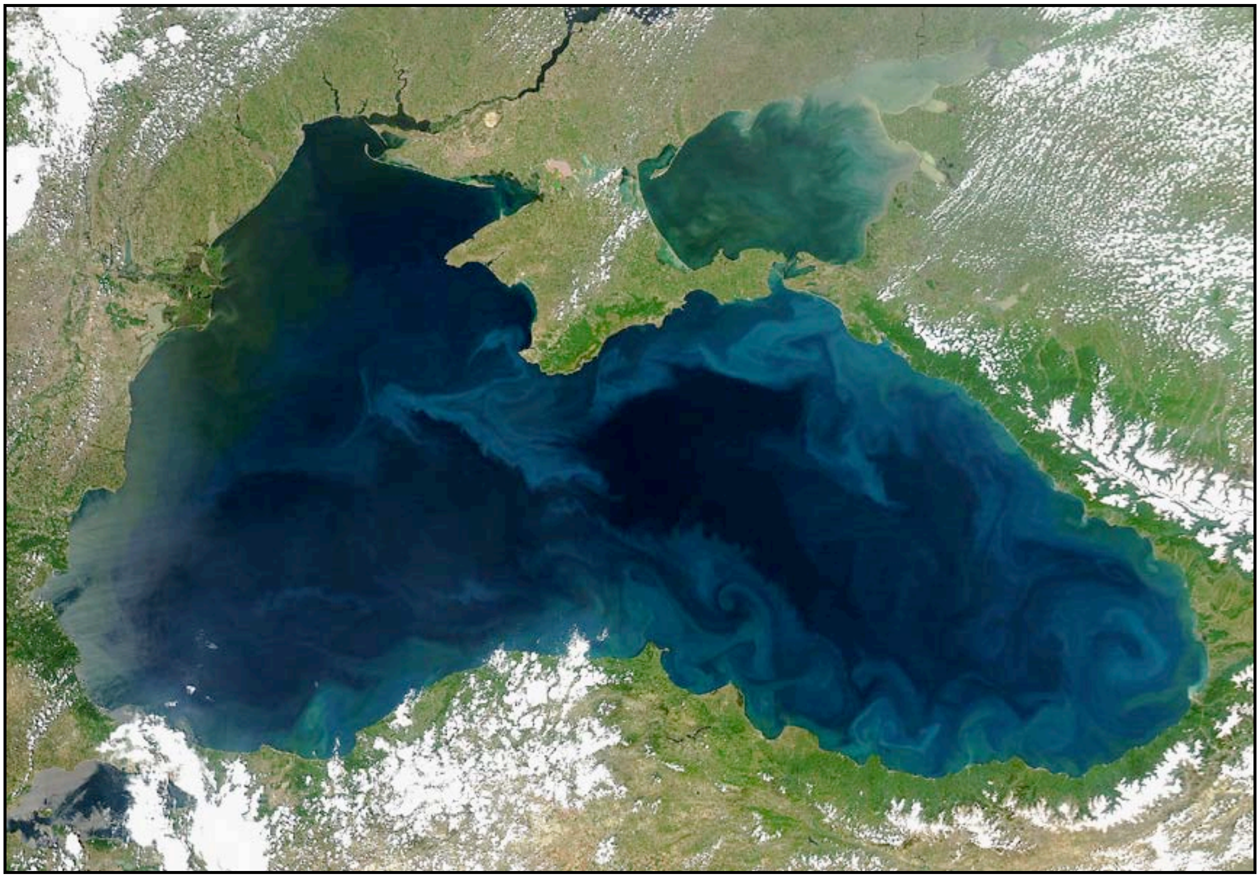
Shown above is a SeaWiFS image of the Black Sea on **May 4, 2002**. Although the year 2002 saw a heavy spring run-off on the Danube River, it was not until August that heavy rains produced record flooding.

One of the fundamental limitations on remote sensing is visibility. If an area of interest is covered by clouds, little useful imaging can be done. The Black Sea suffers from this problem as there are relatively few cloud free days over the sea in any given year.

Web Reference
http://en.wikipedia.org/wiki/2002_European_floods

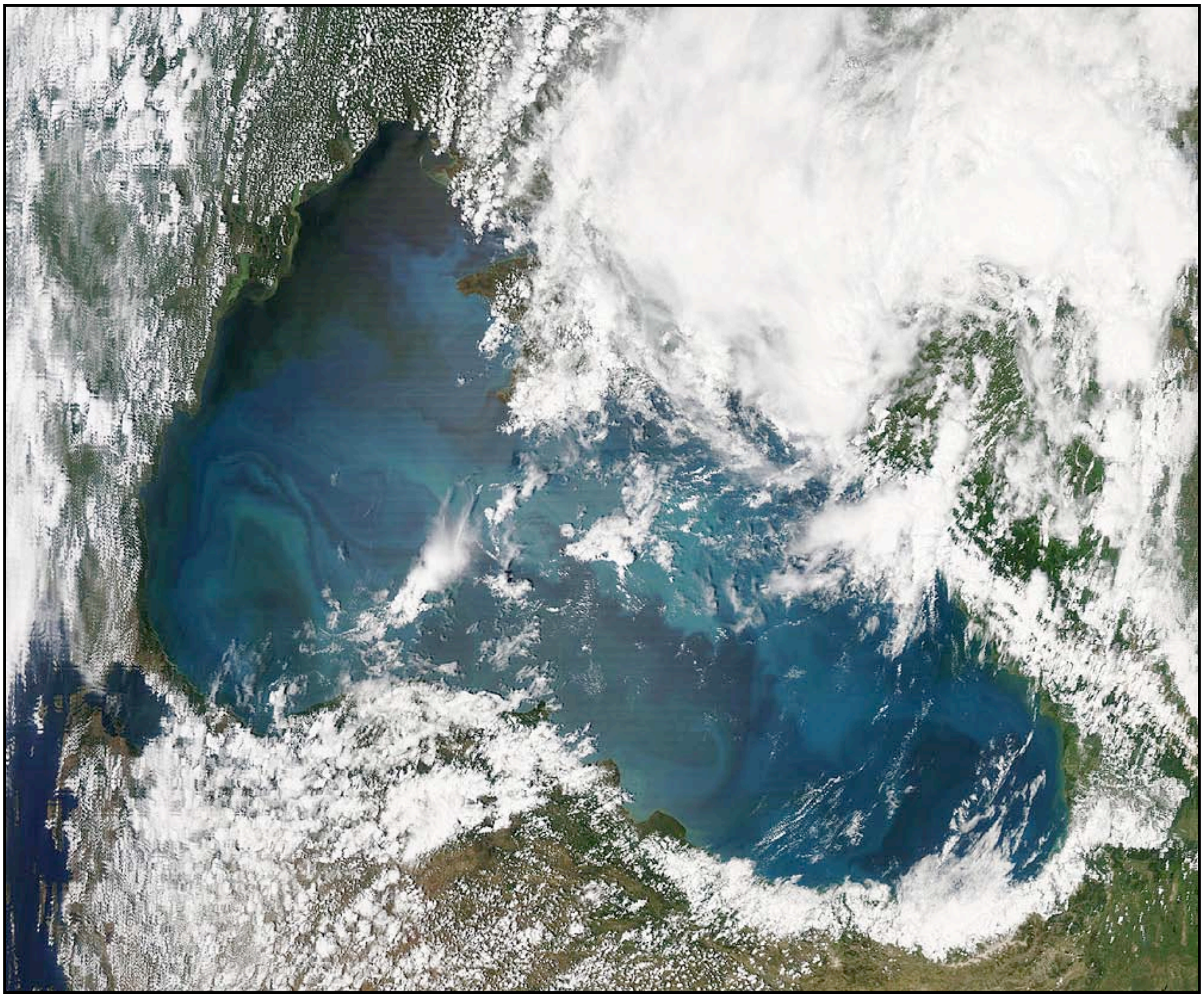
This MODIS/Terra image of the delta of the Danube River was acquired **May 10, 2002**. A phytoplankton bloom progresses outward from the delta and coastline, with waters close to shore being dark, then farther from shore lightening to a bright blue. This may reflect the species of phytoplankton present with coccolithophores further from shore. The Danube is a major source of the nutrient pollution that drives phytoplankton blooms in the Black Sea.

Web Reference
http://en.wikipedia.org/wiki/Danube



This MODIS/Aqua Gallery image shows the Black Sea on **May 22, 2004**. The year 2004 can be used as a baseline "normal" year for phytoplankton blooms in the Black Sea.

Web Reference
http://rapidfire.sci.gsfc.nasa.gov/cgi-bin/imagery/gallery.cgi



During the 1990s the water quality of the Black Sea did see some improvement related to the improving economic status of the adjoining countries and consequent reduction of eutrophication (Velikova, 2004). In spite of this, record spring run-off in the Danube River basin in 2006 produced massive phytoplankton blooms that spread across the Black Sea for months.

On April 15, 2006, after weeks of snowmelt and rain the Danube River reached its highest level in 111 years flooding parts of Romania, Bulgaria, Hungary and Serbia. This **June 10, 2006,** MODIS/Aqua image shows the entire Black Sea covered with intense phytoplankton blooms following almost two months of heavy run-off.

Web Reference
http://en.wikipedia.org/wiki/2006_European_floods

This **June 20, 2006**, MODIS/Aqua image shows that massive phytoplankton blooms continued across the Black Sea through the month of June, before finally subsiding in July.

Web Reference
http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=16739

What follows is a snapshot of a phytoplankton bloom in the Black Sea during the **summer of 2012**. The images and edited text are from NASA's Earth Observatory website of a Black Sea Phytoplankton Bloom on **July 15, 2012**. The quality and information that NASA provides on its Earth Observatory website has improved steadily over the last ten years as demonstrated in the following images. The title of the piece "Carbon Eaters on the Black Sea" July 15, 2012 refers to the central role that phytoplankton play in the Earth's balance of carbon dioxide in the atmosphere. One of the main groups of phytoplankton in maintaining this crucial balance are Coccolithophores.

It is unfortunate then that the essay does not provide information on the context of this phytoplankton bloom. Central questions such as *How frequent are blooms of this magnitude in the Black Sea?*, and *What other issues such as eutrophication and hypoxia are involved?* are not addressed in this piece.

There are very significant features of this particular phytoplankton bloom that are not addressed. The bloom was, for example, extremely long lasting — running approximately for three months from early May to the first week in August. The NASA essay also does not discuss the impact of spring flooding of the Danube River on phytoplankton blooms during the summer of 2012.

Based on available data for the last six years, an emerging inference is that flooding of the rivers that feed into the Black Sea flushes nutrients into the sea that, normally, would have been prevented by existing conservation measures, such as wastewater treatment. If true, this makes cleaning the waters of the Black Sea over the long term more difficult and complicated than previously thought. And may require design parameters that account for 100 year flood levels to be a part of all new cleanup and conservation measures for the rivers of the Black Sea basin.

References for Danube flooding in 2002, 2006, and 2012

2002 Reference:
Black Sea in Bloom May 8, 2002
http://earthobservatory.nasa.gov/IOTD/view.php?id=2424

2006 References:
Danube bursts its banks — Published online: 28 April 2006; | doi:10.1038/news060424-13 by News@ Nature.com, by the journal *Nature*.

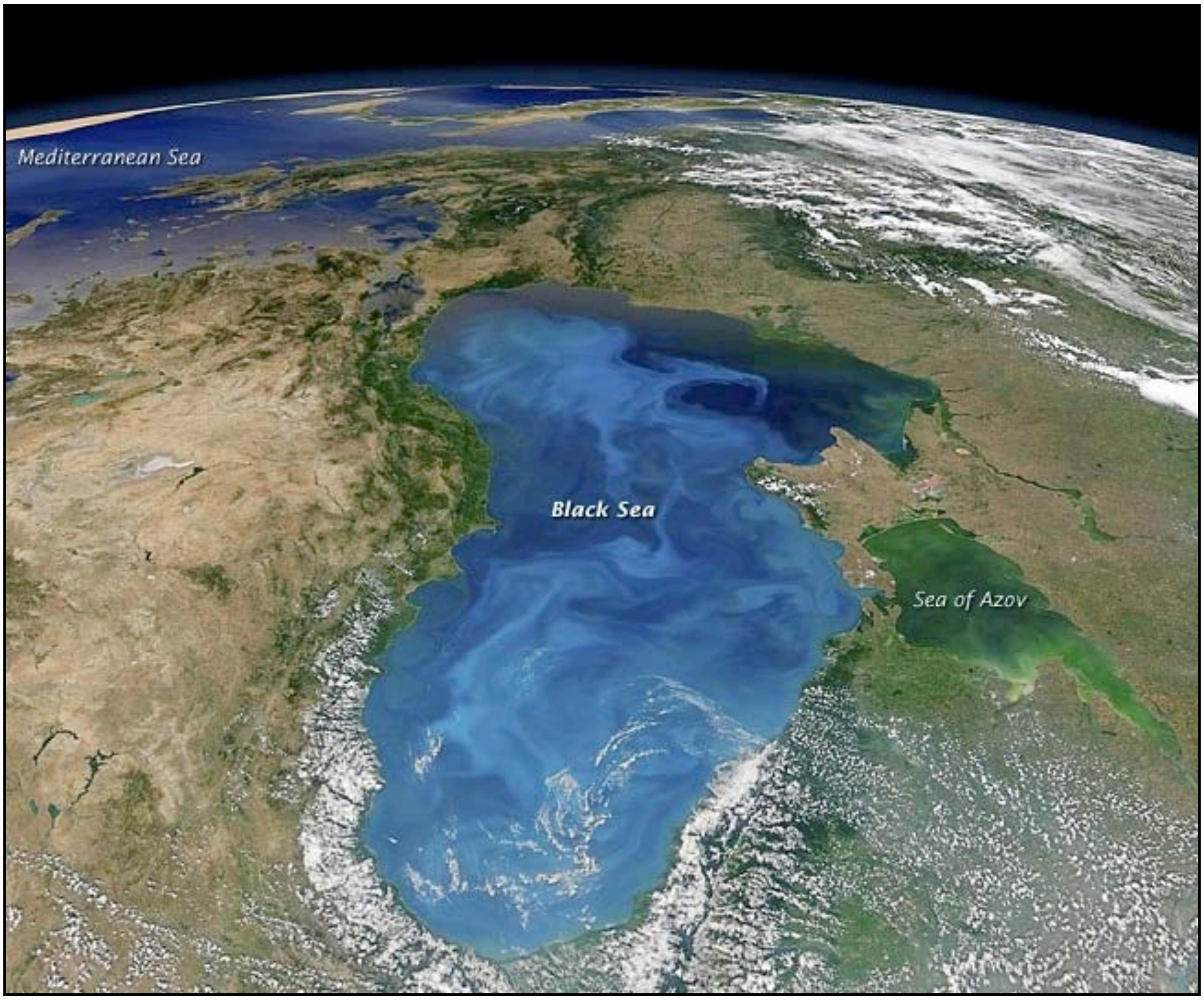
June 10, 2006, MODIS/Aqua image
http://en.wikipedia.org/wiki/2006_European_floods

Warning of destructive floods as Danube thaw sets in, UN urges better response.
Published online: http://www.un.org/apps/news/printnewsAr.asp?nid=41310

2012 References:
UN news of spring flooding of the Danube
http://www.un.org/apps/news/story.asp?NewsID=41310&Cr=disaster+risk&Cr1 -.UK658Y7CF5g

NASA Earth Observatory, Bloomin' Black Sea, May 19, 2012:
http://earthobservatory.nasa.gov/IOTD/view.php?id=77984

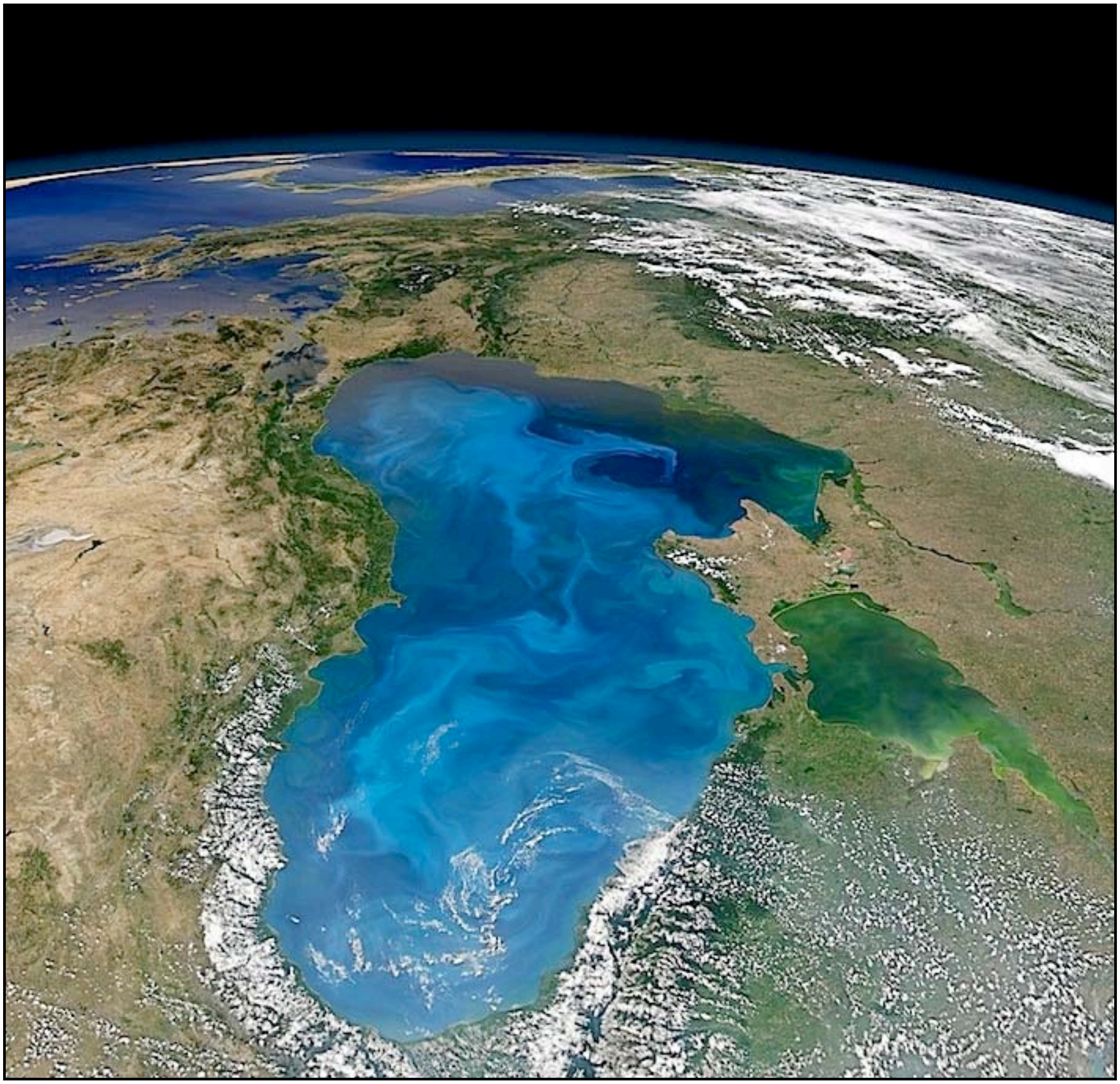
Definition of a 100 Year Flood: http://en.wikipedia.org/wiki/100-year_flood



NASA Earth Observatory view of a Black Sea Phytoplankton Bloom July 15, 2012

The brilliant blue pattern scattered across the surface of the Black Sea is a bloom of microscopic phytoplankton. Because of the light-blue color of the water the majority of organisms in the image are likely to be coccolithophores. Coccolithophores, single-celled photosynthetic eukaryotes, constantly remove carbon dioxide from the atmosphere as they grow and produce calcium carbonate plates to protect their cell body. Therefore during their lifespan, coccolithophores remove carbon dioxide from the air and integrate it into what is destined to become limestone when they die and sink. This acts to help stabilize the Earth's climate by sequestering carbon on the sea floor.

Web Reference
http://earthobservatory.nasa.gov/IOTD/view.php?id=78705



In this essay all three variations of the same image of the swirling light-blue bloom was captured by the MODIS instrument aboard NASA's Aqua satellite. Note that the image has been rotated so that north is to the right.

Ocean scientist Norman Kuring of NASA's Goddard Space Flight Center suggested the bloom was most likely the coccolithophore *Emiliania huxleyi*, although a phytoplankton bloom can be a complex mixture of many different species of cyanobacteria, single-celled photosynthetic eukaryotes, and algae depending on the concentration and mixture of nutriants available. Green algae are normally associated with high concentrations of nutriants. Whereas coccolithophores are associated with low concentrations.

Web References

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

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

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