



Earth Gauge

A National Environmental Education Foundation Program

## Climate Facts: Changes in Ocean Food Webs

Recent climate changes are affecting the World's ocean food webs. Here, we highlight two distinct, but often interrelated phenomena that are changing ocean life. The first is changes in where and how plankton live as a result in a general increase in sea surface temperatures. The second is how changes in ocean currents are impacting food web compositions and how these webs function.

### ***Warming Waters and Plankton***

In the oceans, tiny creatures known as plankton ultimately feed all other ocean life. These plankton are classified as one of the following: phytoplankton, which are tiny, single celled creatures that rely on the sun's light for energy; zooplankton, which are the microscopic "grazers" that feed on these phytoplankton; and bacterioplankton, which are single celled bacteria that play an important role in cycling nutrients throughout the ecosystems.

- In the heavily studied North Sea, which lies between Britain and Scandinavia, water temperatures have increased by about two degrees Fahrenheit in the last fifty years. Here, zooplankton begin their life cycle when the waters reach a certain temperature. Phytoplankton, on the other hand, begin to bloom when the days become long enough. Because the water is reaching the critical hatching temperature earlier in the year, zooplankton are often starting their lifecycles before their food, phytoplankton, have bloomed.<sup>i</sup>
- In the Narragansett Bay, which is off the Rhode Island Coast, the water temperatures have warmed about three degrees Fahrenheit in just the last thirty years. These warming temperatures have allowed zooplankton to remain active during parts of the year when they previously could not. Traditionally, a late winter phytoplankton bloom would result in a "snow" of nutrients (the phytoplankton bodies) falling to the ocean bottom and feeding the creatures living there. With the zooplankton more active in the winter than they used to be, however, the phytoplankton are being consumed before their bodies fall to the ocean floor. The lack of this phytoplankton "snow" is impacting fish populations, particularly winter flounder.<sup>ii</sup>
- With the waters of the Arctic Ocean warming, light is now able to penetrate waters that were covered by ice just a few decades ago. This has resulted in more productive ecosystems, but it has also encouraged the invasion of Atlantic zooplankton, which are becoming more common as Arctic zooplankton become more rare. For the same reason, Atlantic Cod are replacing Arctic Cod.<sup>iii</sup>
- As the Atlantic Ocean has warmed, plankton abundance has increased in some areas of the Atlantic and decreased in others. Plankton do best when the water is not too warm, not too cold, and has just the right amount of turbulence and nutrient mixing. Thus, areas of the Atlantic that were already relatively warm before recent climate changes have generally experienced a decline in plankton abundance, whereas areas that were relatively cool just a few decades ago and have warmed have generally experienced a rise in plankton abundance.<sup>iv</sup>



A magnified Diatom: Photo  
courtesy of USGS

USGS



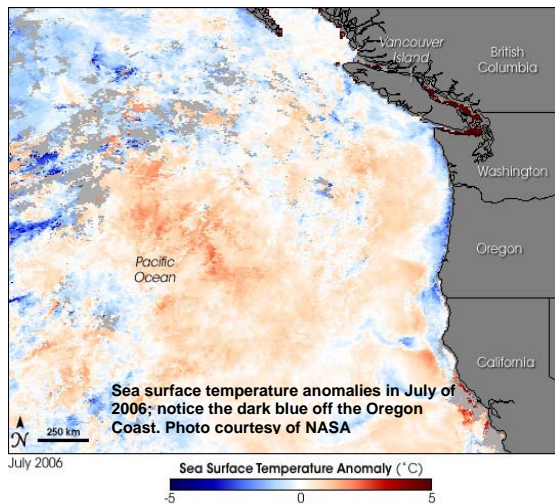
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## Ocean Current Changes

While the Planet's general warming trend has caused an increase in water temperatures, it has also altered the behavior of ocean currents, which move heat and nutrients from one part of the ocean to another. Here are several examples of changes in ocean food webs that can be attributed to changes in ocean currents.

- In the Western North Atlantic Shelf, a stream of water travels from the Arctic Ocean all the way down to Cape Hatteras, NC. Since the 1970's, this stream has become less salty. This "freshening" has set off several changes in the behavior of this water stream including the timing of the annual (autumn) mixing of the deep and shallow water layers, which has corresponded to an increase in snow crab and shrimp populations. Although over-fishing is at least partially responsible for a simultaneous collapse in cod populations, the cod's lack of recovery in Canada's Maritime Provinces despite a decade-long fishing moratorium can be explained by this shift in currents.<sup>v</sup>
- Dead zones off the Oregon Coast occur when strong northerly winds produce an upwelling of nutrient rich water. This water feeds the phytoplankton, which bloom near the surface. Dead phytoplankton sink to the ocean bottom, where they are decomposed by bacteria. As the phytoplankton decompose, oxygen is consumed and hypoxic, or low-oxygen, zones form near the ocean bottom. In recent years, upwellings off the Oregon Coast have been particularly strong and have not been balanced by periods when the winds switch. Although hypoxic zones are considered to be a regular part of the Oregon Coast's circulation system, such zones had not been documented in the shallower waters of Oregon's productive inner-shelf prior to 2002. The 2006 dead zone set records for size, duration, and lack of oxygen.<sup>vi</sup>
- Changes in the California Current System over the past 30 years, specifically a weakening of the upwelling that brings cool and nutrient rich water to the surface, have resulted in widespread and unprecedented declines of plankton, fish, and bull kelp populations. When compared to the early 1970's, zooplankton populations are lower and their annual population peaks are now occurring an average of two months earlier in the year. The fish that eat these plankton have generally declined in population; the populations of some species have fallen by 50 percent during this period. Perhaps the most profound change in the California Current System has been the loss of the productive kelp forests, which provide habitat for over 800 species. These forests only cover 25 percent of the area that they did thirty years ago.<sup>vii</sup>



<sup>i</sup> Edwards, Martin and Richardson, Anthony J. "Impact of climate change on marine pelagic phenology and trophic mismatch." *Nature*, 430, 881-884: 2004.

<sup>ii</sup> Fulweiler, R.W. et al. "Reversal of the net dinitrogen gas flux in coastal marine sediments." *Nature*: Volume 448, pp. 180-182 and Oviatt, C. et al. "Annual Primary Production in Narragansett Bay with no Bay-Wide Winter-Spring Phytoplankton Bloom." *Estuarine, Coastal and Shelf Science* (2002) 54, 1013-1026 and Daley, Beth. "Rising Temperatures Throw Nature a Curve." *Boston Globe*, 13 November 2007. Accessed Online 19 November 2007

<sup>iii</sup> Schiermeier, Quirin. "Polar research: The new face of the Arctic." *News@Nature* 7 March 2007. Accessed Online 17 March 2007  
<http://www.nature.com/news/2007/070305/full/446133a.html>

<sup>iv</sup> Beaugrand, G et al. "Reorganization of North Atlantic Marine Copepod Biodiversity and Climate." *Science* 296, 1692 (2002) and Richardson, AJ et al. "Climate Impact on Plankton Ecosystems in the Northeast Atlantic." *Science* 305, 1609 (2004)

<sup>v</sup> Greene, Charles and Pershing, Andrew. "Climate Drives Sea Change." *Science* 315 (2007) 1084-1085.

<sup>vi</sup> Partnership for Interdisciplinary Studies of Coastal Oceans and Oregon State University. Frequently Asked Questions About Hypoxia and the Central Oregon Coast "Dead Zone." Corvallis, Oregon. October 30, 2006. Accessed online 13 August 2007 <<http://www.piscoweb.org/research/oceanography/hypoxia>> and "OSU Scientists Detect Low-Oxygen Zones Forming Off Coast for Sixth Straight Year." Oregon State University: News and Communication Services. July 27, 2007. Accessed Online 13 August 2007 <<http://oregonstate.edu/dept/ncs/newsarch/2007/Jul07/hypoxia2007.html>>

<sup>vii</sup> Ballard, G. et al. "Long Term Declines and Decadal Patterns in Population Trends of Songbirds in Western North America." *The Condor* (2003) 105: 737-755 and McGowan, JA et al. "The biological response to the 1977 regime shift in the California Current." *Deep-Sea Research II*: 50 (2003) 2567-2582 and Chavez, FF et al. "From Anchovies to Sardines and Back: Multidecadal Change in the Pacific Ocean." *Science* 299, 217 (2003) and Richardson, TW et al. "The Occurrence and Seasonal Distribution of Migratory Birds on Southeast Farallon Island, 1968-1999." *Western Birds*: Volume 34, Number 2, 2003>