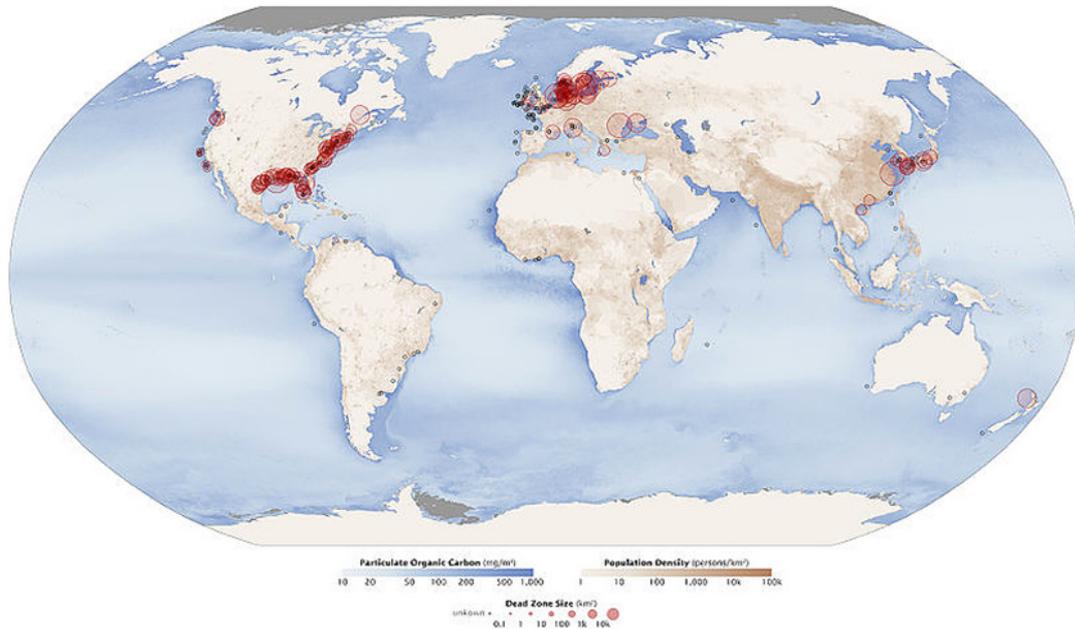


# Dead zone

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This article is about the oceanic phenomenon. For other uses, see [Dead Zone \(disambiguation\)](#).



*Red circles show the location and size of many dead zones.  
Black dots show dead zones of unknown size.*

The size and number of marine dead zones—areas where the deep water is so low in dissolved oxygen that sea creatures can't survive—have grown explosively in the past half-century.

Dead zones are hypoxic (low-oxygen) areas in the world's oceans, the observed incidences of which have been increasing since oceanographers began noting them in the 1970s. These occur near inhabited coastlines, where aquatic life is most concentrated. (The vast middle portions of the oceans, which naturally have little life, are not considered "dead zones".) The term can also be applied to the identical phenomenon in large lakes.

In March 2004, when the recently established UN Environment Programme published its first Global Environment Outlook Year Book (GEO Year Book 2003), it reported 146 dead zones in the world's oceans where marine life could not be supported due to depleted oxygen levels. Some of these were as small as a square kilometre (0.4 mi<sup>2</sup>), but the largest dead zone covered 70,000 square kilometres (27,000 mi<sup>2</sup>). A 2008 study counted 405 dead zones

## Causes

Aquatic and marine dead zones can be caused by an increase in chemical nutrients (particularly nitrogen and phosphorus) in the water, known as eutrophication. These chemicals are the fundamental building blocks of single-celled, plant-like organisms that live in the water column, and whose growth is limited in part by the availability of these materials. Eutrophication can lead to rapid increases in the density of certain types of these phytoplankton, a phenomenon known as an algal bloom. Although these algae produce oxygen in the daytime via photosynthesis, during the night hours they continue to undergo cellular respiration and can therefore deplete the water column of available oxygen. In addition, when algal blooms die off, oxygen is used up further during bacterial decomposition of the dead algal cells. Both of these processes can result in a significant depletion of dissolved oxygen in the water, creating hypoxic conditions. Dead zones can be caused by natural and by anthropogenic factors. Use of chemical fertilizers is considered the major human-related cause of dead zones around the world. Natural causes include coastal upwelling and changes in wind and water circulation patterns. Runoff from sewage, urban land use, and fertilizers can also contribute to eutrophication.

Notable dead zones in the United States include the northern Gulf of Mexico region, surrounding the outfall of the Mississippi River, and the coastal regions of the Pacific Northwest, and the Elizabeth River in Virginia Beach, all of which have been shown to be recurring events over the last several years. Additionally, natural oceanographic phenomena can cause deoxygenation of parts of the water column. For example, enclosed bodies of water, such as fjords or the Black Sea, have shallow sills at their entrances, causing water to be stagnant there for a long time. The eastern tropical Pacific Ocean and northern Indian Ocean have lowered oxygen concentrations which are thought to be in regions where there is minimal circulation to replace the oxygen that is consumed (e.g. Pickard & Emery 1982, p 47). These areas are also known as oxygen minimum zones (OMZ). In many cases, OMZs are permanent or semipermanent areas.

Remains of organisms found within sediment layers near the mouth of the Mississippi River indicate four hypoxic events before the advent of artificial fertilizer. In these sediment layers, anoxia-tolerant species are the most prevalent remains found. The periods indicated by the sediment record correspond to historic records of high river flow recorded by instruments at Vicksburg, Mississippi.

## Effects

Low oxygen levels recorded along the Gulf Coast of North America have led to reproductive problems in fish involving decreased size of reproductive organs, low egg counts and lack of spawning.

In a study of the Gulf killifish by the Southeastern Louisiana University done in three bays along the Gulf Coast, fish living in bays where the oxygen levels in the water dropped to 1 to 2 parts per million (ppm) for three or more hours per day were found to have smaller reproductive organs. The male gonads were 34% to 50% as large as males of similar size in bays where the oxygen levels were normal (6 to 8 ppm). Females were found to have ovaries that were half as large as those in normal oxygen levels.

The number of eggs in females living in hypoxic waters were only one-seventh the number of eggs in fish living in normal oxygen levels.

(Landry, et al., 2004) Fish raised in laboratory-created hypoxic conditions showed extremely low sex hormone concentrations and increased elevation of activity in two genes triggered by the hypoxia-inductile factor (HIF) protein. Under hypoxic conditions, HIF pairs with another protein, ARNT. The two then bind to DNA in cells, activating genes in those cells.

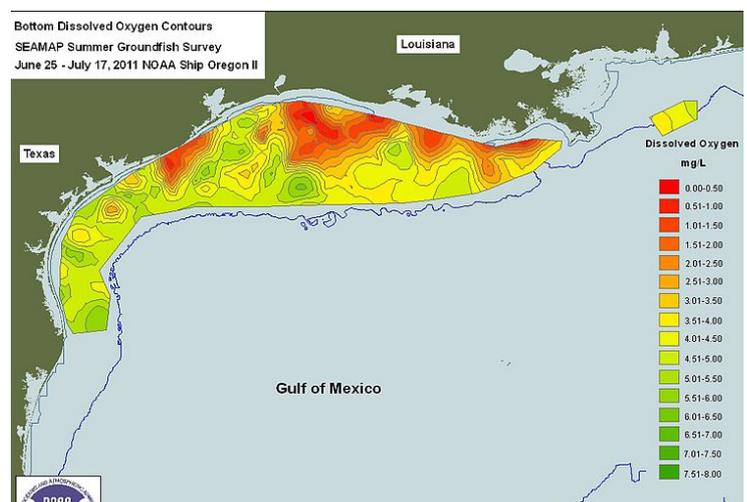
Under normal oxygen conditions, ARNT combines with estrogen to activate genes. Hypoxic cells in vitro did not react to estrogen placed in the tube. HIF appears to render ARNT unavailable to interact with estrogen, providing a mechanism by which hypoxic conditions alter reproduction in fish.

(Johanning, et al., 2004)

It might be expected that fish would flee this potential suffocation, but they are often quickly rendered unconscious and doomed. Slow moving bottom-dwelling creatures like clams, lobsters and oysters are unable to escape. All colonial animals are extinguished. The normal re-mineralization and recycling that occurs among benthic life-forms is stifled.

## Locations

In the 1970s, marine dead zones were first noted in areas where intensive economic use stimulated "first-world" scientific scrutiny: in the U.S. East Coast's Chesapeake Bay, in Scandinavia's strait called the Kattegat, which is the mouth of the Baltic Sea and in other important Baltic Sea fishing grounds, in the Black Sea, (which may have been anoxic in its deepest levels for millennia, however) and in the northern Adriatic. Other marine dead zones have apparently appeared in coastal waters of South America, China, Japan, and New Zealand. A 2008 study counted 405 dead zones worldwide.



## Oregon

Off the coast of Cape Perpetua, Oregon, there is also a dead zone with a 2006 reported size of 300 square miles (780 km<sup>2</sup>).<sup>[7]</sup> This dead zone only exists during the summer, perhaps due to wind patterns.

## Gulf of Mexico

Currently, the most notorious dead zone is a 22,126 square kilometre (8,543 mi<sup>2</sup>) region in the Gulf of Mexico, where the Mississippi River dumps high-nutrient runoff from its vast drainage basin, which includes the heart of U.S. agribusiness, the Midwest. The drainage of these nutrients are affecting important shrimp fishing grounds.

This is equivalent to a dead zone the size of New Jersey. There is some concern that the Deepwater Horizon oil spill from April to July 2010 may have significantly affected the dead zone. However, Terry Hazen, a microbial ecologist with the Lawrence Berkeley National Laboratory, has suggested that the oil released from the spill did not travel far enough west in appreciable quantities to affect the current size of the dead zone.

A dead zone off the coast of Texas where the Brazos River empties into the Gulf was also discovered in July 2007.



## The Energy Independence and Security Act of 2007

The Energy Independence and Security Act of 2007 calls for the production of 36 billion US gallons (140,000,000 m<sup>3</sup>) of renewable fuels by 2022, including 15 billion US gallons (57,000,000 m<sup>3</sup>) of corn-based ethanol, a tripling of current production that would require a similar increase in corn production. Unfortunately, the plan poses a new problem; the increase in demand for corn production results in a proportional increase in nitrogen runoff. Although nitrogen, which makes up 78% of the Earth's atmosphere, is an inert gas, it has more reactive forms, one of which is used to make fertilizer.

According to Fred Below, a professor of crop physiology at the University of Illinois at Urbana-Champaign, corn requires more nitrogen-based fertilizer because it produces a higher grain per unit area than other crops and, unlike other crops, corn is completely dependent on available nitrogen in soil. The results, reported 18 March 2008 in Proceedings of the National Academy of Sciences, showed that scaling up corn production to meet the 15-billion-US-gallon (57,000,000 m<sup>3</sup>) goal would increase nitrogen loading in the Dead Zone by 10–18%. This would boost nitrogen levels to twice the level recommended by the Mississippi Basin/Gulf of Mexico Water Nutrient Task Force (Mississippi River Watershed Conservation Programs), a coalition of federal, state, and tribal agencies that has monitored the dead zone since 1997. The task force says a 30% reduction of nitrogen runoff is needed if the dead zone is to shrink.

## Reversal

Dead zones are reversible. The Black Sea dead zone, previously the largest in the world, largely disappeared between 1991 and 2001 after fertilizers became too costly to use following the collapse of the Soviet Union and the demise of centrally planned economies in Eastern and Central Europe. Fishing has again become a major economic activity in the region.

While the Black Sea “cleanup” was largely unintentional and involved a drop in hard-to-control fertilizer usage, the U.N. has advocated other cleanups by reducing large industrial emissions. From 1985 to 2000, the North Sea dead zone had nitrogen reduced by 37% when policy efforts by countries on the Rhine River reduced sewage and industrial emissions of nitrogen into the water. Other cleanups have taken place along the Hudson River and San Francisco Bay

The chemical aluminium sulfate can be used to reduce phosphates in water.