Partnership for Interdisciplinary Studies of
Coastal Oceans (PISCO)
www.piscoweb.org

Frequently Asked Questions about Hypoxia and the Pacific Northwest 'Dead Zone'

1) What is hypoxia?

Most marine animals breathe by extracting oxygen that is dissolved in seawater. Ocean water at the surface generally has oxygen levels of 5-7 milliliters of oxygen per liter (ml/l) of seawater.

If the amount of oxygen is less than 1.4 ml/l, it is defined as 'hypoxic" which simply means 'low oxygen'. At levels lower than 1.4 ml/l, organisms such as fishes and crabs may either show symptoms of low-oxygen stress or may suffocate from lack of oxygen. The lower the level of oxygen, the greater the impact. Scientists call levels lower than 0.5 ml/l 'severe hypoxia' because at those levels, serious biological and ecological effects occur.

2) Is hypoxia typical off the coasts of Oregon and Washington?

It is normal for low-oxygen water to appear occasionally on the sea floor along the outer and middle portions of the continental shelf, many miles from the coast. These areas are sometimes naturally hypoxic, with levels of dissolved oxygen generally in the range of 1-3ml/l. Many of the animals that live there are tolerant of occasional low-oxygen conditions. The ocean bottom on the outer shelf is invaded by low-oxygen water from the deep sea during summertime upwelling (typically from late spring to early fall). As surface waters are pushed offshore by the combined action of winds and the earth's rotation, deep, nutrient-rich yet oxygen-poor waters are pulled up onto the continental shelf. Hypoxia at the edge of the continental shelf has been known by scientists and fishermen for a long time and is not usually termed a 'dead zone.' Its occurrence is not unusual and not new.

3) What is new or unusual about hypoxia on the Pacific Northwest coast?

Three aspects of the recent hypoxia are new: (a) The occurrence of low-oxygen water close to shore (the inner shelf, less than 50 m (165') of water) is highly unusual and not reported prior to 2002. (b) During each summer since 2002, the levels of oxygen in this inner-shelf water have been even lower than those in the low-oxygen water at the edge of the continental shelf. (c) Significant numbers of dead organisms have been documented along the Pacific Northwest coast in 2002, 2004 and 2006, hence the popular term 'dead zone.'

The inner shelf and hypoxia have been studied more intensively off the Oregon coast than off the Washington coast. More is known about the development of hypoxia in Oregon due to the collaborative efforts of researchers at Oregon State University, the Oregon Department of Fish and Wildlife and the National Oceanic and Atmospheric Administration (NOAA) Fisheries. OSU scientists include those from PISCO, the Partnership for Interdisciplinary Studies of Coastal Oceans in the Department of Zoology and the College of Oceanic and Atmospheric Sciences (COAS).

4) What is a dead zone?

A dead zone is an area of the ocean that does not have enough oxygen to support most marine life. Hypoxic waters can kill animals if the oxygen levels are low enough and for a long enough period of time. Species vary in their tolerance of low-oxygen conditions.

5) Does everything die in a dead zone?

No. It depends on the behavior and physiology of the animals and the rate of movement, oxygen content, and persistence of the mass of low-oxygen water. Some animals such as fishes or crabs are able to swim or scuttle away from an incoming mass of low-oxygen water and thus escape suffocation. Most animals that do not escape will die if the low-oxygen water persists or if the levels of oxygen drop low enough. Those animals that escape may survive and either find new homes or return, or as they flee the hypoxic waters, they may be eaten by predators or caught by fishermen. Severe hypoxia often results in the accumulation of fishes at the edges of the mass of hypoxic waters.

6) Why is the dead zone occurring off the Pacific Northwest coast?

Scientists are not sure why this dead zone has appeared in recent years. They suspect that there have been fundamental changes in ocean and wind conditions off the Oregon and Washington coasts. These changes may include either oceanic or atmospheric changes or both. This is an active area of investigation.

7) Is the dead zone caused by climate change?

It is not possible to say definitively that the dead zone is or is not caused by climate change[1]. Scientists can say that the changes in oceanic and atmospheric conditions that are causing the dead zone are consistent with predictions of climate change. That is not the same, however, as saying that climate change is definitely causing the dead zone. At present, there is no other viable hypothesis to explain why oceanic

[1] [1]Scientists prefer the term 'climate change' to 'global warming' for multiple reasons: (a) there are a broad array of changes underway in addition to temperature (for example, increases in extreme precipitation events, changes in ocean circulation, changes in atmospheric circulation, etc.); (b) although the average global temperature is increasing, some places are warming much faster than others and some are cooling; (c) the changes are not gradual through time, but often abrupt; (d) many changes involve increases in variability not just the average.

and atmospheric conditions are changing. The appearance of hypoxia and severe hypoxia in nearshore waters is not correlated with El Niño cycles or known decadal oscillations.

8) How is the Pacific Northwest dead zone formed?

The dead zone results from a perturbation of a normal event called 'upwelling'. The next few paragraphs describe normal upwelling off the Pacific Northwest, then indicate the unusual events that result in the dead zone.

Normal conditions: Intermittent upwelling and downwelling. Every summer off Oregon and Washington, northerly winds (winds blowing from the north to the south, which are sometimes referred to as southward winds) drive surface waters offshore. This causes deep, cold, nutrient-rich and naturally low-oxygen waters to rise to the surface near the coast. When the nutrient-rich, upwelled water reaches the lighted zone near the ocean surface, the microscopic plants called 'phytoplankton' bloom and contribute to Oregon's and Washington's productive ocean ecosystem. Those phytoplankton that are not eaten by microscopic animals sink to the sea floor where microbes decompose them, consuming oxygen in the process. This further lowers oxygen levels near the sea floor. Oxygen levels tend to stay high near the sea surface and in the shallowest waters right near the shore, where breaking waves efficiently mix oxygen into the water.

If coastal winds cease or become southerly, the earth's rotation causes surface waters to move back toward the shore, driving bottom waters away from the coast -- a process called downwelling. If upwelling periods alternate with strong downwelling periods, low-oxygen waters do not accumulate at the bottom across the continental shelf.

Abnormal conditions: If, however, downwelling-favorable winds do not blow, or blow only rarely, then low-oxygen waters can accumulate. When that happens, each successive strong upwelling brings the low-oxygen waters closer to shore. Each strong upwelling also brings more nutrients to the lighted zone, causing more phytoplankton to bloom, sink and decay, resulting in even lower levels of oxygen. Repetitions of these events cause the mass of low-oxygen water to become thicker as well as lower in oxygen.

In some recent years, the pattern of coastal winds has been abnormal. For example, in 2006, stronger northerly winds and fewer southerly winds resulted in conditions that favored the formation and accumulation of low-oxygen waters close to shore.

The normal upwelling period runs from about April to October. October to April is generally dominated by downwelling-favorable coastal winds. Even during years in which hypoxia develops in the summertime, normal conditions have reappeared in October, with the appearance of downwelling that pushes low-oxygen waters away from the coast.

9) How can we tell if there is a dead zone off the coast?

PISCO scientists say that a dead zone is happening if there is low-oxygen water (<1.4 ml/l) in waters inshore of the 50-m (165-feet) depth contour.

Scientists detect the presence of a dead zone by measuring the amount of oxygen in the water. PISCO scientists measure oxygen content along transect lines running from close to the shore out across the continental shelf at five locations: Cascade Head, Lincoln Beach, Newport, Seal Rock, Waldport and Strawberry Hill (north of Florence). Measurements are taken at the same location every year at stations with depths of 15 meters (= 50 feet), 30m, 40m, 50m, 60m, 70m, 80m, 90, and 100m (=330 feet). The shallowest stations are approximately 6/10 of a mile from the shore; the deepest stations are from 8 to 13 miles from the shore, depending on the site. At each station, scientists measure oxygen content and other features from the surface to the seafloor. NOAA Fisheries scientists use similar methodologies, and focus on the mid and outer shelf waters along Oregon and Washington. Researchers from the University of Washington and Olympic Coast National Marine Sanctuaries also monitor and research oxygen levels along the Washington coast.

Since 2006, OSU scientists have deployed new oceanographic sensors that are also instrumental for detecting the return of low oxygen conditions to our coast. Off Newport, scientists have deployed a sophisticated new buoy that provides data on ocean currents, oxygen levels, ocean productivity, temperature and salinity in near-real time to the public (www.orcoos.org). In addition, physical oceanographers from OSU have started to operate a fleet of robotic "gliders" that can patrol parts of Oregon's coastal oceans where they can detect and report on changes in ocean conditions including hypoxia. With these data in-hand, scientists will be better able to track the ocean environment and detect the return of hypoxia to our coast. Still needed are better instruments to track ecosystem changes.

Severely hypoxic waters that persist for weeks will generally kill many marine animals. Dead animals attached to the seafloor (such as anemones) will decay in place; dead mobile animals (like crabs or fishes) will be moved by currents, often to deeper waters. Sometimes, coastal residents or visitors will find dead crabs and fishes washed up on the shore, occasionally in large numbers. (Care must be taken to ensure that crab molts -- found naturally on beaches-- are not mistaken for dead crabs. Molts can be identified by a protruding abdomen, a split at the back of the top shell, and loose legs.) It is difficult to tell just from dead animals washed up on beaches how extensive a dead zone is. Many species that suffocate from lack of oxygen may remain on the ocean floor or be transported to deeper waters.

Other indicators of low oxygen may be reports from divers and fishermen of live fish found in unusual places, e.g., bottom fish found high up in the water column, deep-water fish found close to shore, or schools of fishes accumulating at the margins of the mass of low-oxygen water. Crabbers might find dead crabs in their pots.

10) Have there been dead zones off the Oregon coast before?

Prior to 2002, dead zone events had not been reported in the near-shore waters off the Oregon and Washington coasts. It is important to note that low-oxygen water occasionally appears at depth over the outer continental shelf. Fishermen and scientists both know that this low-oxygen water sometimes appears in the summertime along the continental margin and on the outer portions of the shelf. What is different in the last five years is the presence of low-oxygen water in the inner shelf (less than 50 m (165') of water) and the occasional appearance of severe hypoxia in these shallow waters.

11) Why is the dead zone worse in some years, and not in others?

Year to year changes in the severity of the dead zone can be connected to shifts in offshore ocean conditions and the patterns of coastal winds. The winds are in turn connected to larger, atmospheric changes over the Pacific Ocean. Ocean conditions off Oregon and Washington reflect larger-scale oceanic changes in the Pacific. The dead zone is a local expression of the larger changes happening in the atmosphere and the ocean. The evidence suggests that the area off Cape Perpetua is particularly susceptible to hypoxia, but that the changes causing the hypoxia are happening over a much broader area.

12) Why do some folks say that a dead zone in Oregon is not unusual or that dead zones have happened in Oregon prior to 2002?

There appears to be confusion about the location of low-oxygen water under discussion. It is normal for low-oxygen water to appear occasionally on the sea floor along the outer and middle portions of the continental shelf, many miles from the coast. Those conditions have been known by scientists and fishermen for a long time and are not termed a 'dead zone.' The low-oxygen water there may kill some species, but its occurrence is not unusual and not new.

The occurrence of low-oxygen water close to shore (the inner shelf, less than 50 m (165') of water) is highly unusual and not reported prior to 2002. This appearance of hypoxia close to shore is what we call a 'dead zone.' In addition to the location of hypoxia in waters inside the 50m (165') depth contour, the levels of oxygen in this inner-shelf water in 2006 and previous dead zone years are considerably lower than the levels of oxygen at the margin of the continental shelf.

13) Why was 2006 different than other years?

The 2006 dead zone was significantly different from earlier Pacific Northwest dead zones (2002-2005) in four major ways. It was (a) larger, (b) thicker, (c) lower in oxygen, and (d) longer lasting.

(a) Larger: The 2006 dead zone was significantly larger, occurring not only off central Oregon, but extending up into northern Oregon and along most of the Washington coast as well. In Oregon the dead zone was more than 4 times larger in area than in years past, stretching from Florence to Cascade Head. (In the four previous years,

the northern extent was around Newport) The dead zone off the Washington coast was documented as occurring along the Olympic Peninsula, with dead fish and crabs washed up on beaches and reports from scientists indicated low-oxygen waters close to shore.

(b) Thicker: The mass of low-oxygen water that was close to shore in 2006 was thicker than in previous years. At our 50 m (165') station off Newport, the bottom 4/5ths of the water column was hypoxic in early August. Only the top layer had enough oxygen to support life.

(c) Lower in oxygen: In 2006, PISCO scientists measured the lowest level of oxygen ever recorded in shallow waters anywhere along the West Coast. These waters were 'anoxic', meaning 'without oxygen.' Levels of dissolved oxygen less than 0.05 ml/l persisted at the 50 m (165') station off Cape Perpetua for many weeks. These levels of dissolved oxygen are much lower than the low oxygen that is typical off the edge of the continental shelf. The very low levels resulted in mass mortalities of most animals who could not escape.

(d) Longer-lasting: The 2006 dead zone persisted for 4 months – from mid-June to mid-October. This duration more than doubles the previous record of 6 weeks set in 2004.

14) What happens when oxygen levels get close to zero?

The scientific term for 'no oxygen' is 'anoxia." The extremely low levels of dissolved oxygen measured off Cape Perpetua in August and September of 2006 (0.05 ml/l) were very close to anoxia (and lower than any of our measurements in 2002-2005). Under anoxic conditions, specialized microbes may colonize and become abundant. The bacterial mats we observed in the 21 August 2006 images seen through cameras mounted on a Remotely Operated Vehicle (ROV) moving along the seafloor may be these anoxia-loving microbes.

Anoxia-loving microbes do not thrive in oxygenated waters. When normal levels of oxygen return to the area, these microbes are eventually replaced by the microbes and animals usually found at those depths. We anticipate that because oxygen levels were so low for so long in the Cape Perpetua region, it may take longer than usual for the areas to recover.

15) What are the long-term consequences of a dead zone and is the dead zone recovering?

The long term consequences are unknown at this point. In the last five years, the dead zone has lasted from a week to as long as four months. If the dead zone affects only a small area, lasts a short time, and if many animals can escape to other places while the low-oxygen water is present, it is likely that there may be little long-term impact. The longer the dead zone persists, the lower the amount of oxygen, and the larger the area, the greater is the likelihood of serious impacts.

Data from underwater surveys with a Remotely Operated Vehicle (ROV) conducted by OSU researchers and the Oregon Department of Fish and Wildlife, indicate that the areas hardest hit by the 2006 dead zone were in the very early stages of recovery in early spring 2007, with different marine animals showing different potential for recovery.

Follow-up underwater surveys in late June 2007, however, indicate that ecosystem recovery may be stalled or even reversed because of the re-emergence of severe hypoxia along the inner shelf. Frequent surveys in summer 2007 showed that, as the dead zone receded, fish species moved back onto the reefs. For long-lived and less mobile bottom-dwelling marine life, scientists have continued to see lasting impacts from the 2006 event. Continued research will be essential for charting the long term course of recovery for these impacted communities.

16) What are the impacts to the fishing industry?

The impacts on the fishing industry are not clear. Based on conversations with fishermen and recorded catches, it appears that the dead zone has not reduced catches in the last few seasons. These dead zones have occurred at the tail end of the commercial crab season. There have been record catches of crabs in past years despite the presence of a number of dead zones.

It is clear from the surveys done by Oregon Department of Fish and Wildlife (ODFW) and PISCO scientists that there were numerous dead crabs and crab molts on the seafloor off Cape Perpetua in 50 m (165') of water on August 8 and 21, 2006. It is also clear that there were an exceptionally large number of live crabs in Yaquina Bay in August 2006, suggesting that many crabs may have escaped the low-oxygen water and found refuge in the Bay (though at least some of these were caught in recreational crab traps). Nearshore hypoxic conditions also occurred in the summers of 2004 and 2005, yet the commercial Dungeness crab harvests following those events set records. Crab population sizes along our coast are determined by many factors including ocean currents, ocean productivity and crab movement from other areas. Additional research that can be used by scientists to place the possible effects of hypoxia into full context are needed.

The impacts on rockfish are also unclear. ROV surveys in Cape Perpetua region indicate no fish at all in places where they usually are abundant during severe hypoxia events. Many observers have reported fish appearing in shallower water or higher in the water column than usual. These observations suggest that at least some fish may have escaped the low-oxygen water and found refuge close to shore or near the surface.

In summer 2007, scientists from NOAA Fisheries began work with OSU scientists to investigate effects of hypoxia on commercial fish species. By adding a dissolved oxygen component to its surveys, NOAA Fisheries scientists will help identify impacts on commercially important fish species. This collaborative research enables all scientists to better understand this newly recurring hypoxia and inform fisheries management about impacts from hypoxia.

17) Is seafood caught during a dead zone safe to eat?

Yes! Fish or crabs for sale would likely have been caught outside the low-oxygen waters and should be as safe as those caught during any other time of year.

18) Is the dead zone along the Pacific Northwest coasts the same as the one in the Gulf of Mexico or the Chesapeake Bay?

No, those dead zones are caused by an excess of nutrients running off the land. The dead zone off Oregon and Washington is not caused by nutrients running off the land, but rather nutrients being upwelled from the deep sea.

19) Does this type of coastal upwelling dead zone happen anywhere else in the world?

Yes, there are a few other places where the same type of wind-driven coastal upwelling is causing similar dead zones: off the coasts of Peru and Chile, and off Namibia and South Africa. Coastal upwelling ecosystems collectively represent about 1% of the world's oceans, but they have historically produced about 20% of the world's fisheries.

20) Where can I get further information about the dead zone?

Periodic updates about the dead zone are posted on the PISCO website http://www.piscoweb.org/outreach/topics/hypoxia

For more information, contact: Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) email: hypoxia@science.oregonstate.edu; phone: 541-737-8645.