

We're Dr. Sarah Myhre and Kate Davis, authors of a paper in PLOS ONE that finds that oxygen declined in the ocean during the deglaciation, a period of warming with analogues to anthropogenic climate change— Ask Us Anything!

PLOSScienceWednesday ¹ and r/Science AMAs¹

¹Affiliation not available

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PLOS Science Wednesday: Hi Reddit, we're Dr. Sarah Myhre and Kate Davis, authors of a paper in PLOS ONE that finds that oxygen declined in the ocean during the deglaciation, a period of warming with an

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I live on the Oregon coast and we have been experiencing 'dead zones' due to extremely low oxygen in our waters. Have they occurred throughout history? Are they related to warming of the oceans? It is obvious just by looking at the sea floor that more complex life forms are impacted, but do the microbes et al also suffer significantly? How long does it take for an oxygen deprived are like that to recover?

[Pleurotus_Bibendum](#)

Yes, Oregon is a really interesting location to think about hypoxia. The coastal ocean, offshore of Oregon, is dominated by seasonal surface winds, Ekman Transport (<https://www.youtube.com/watch?v=yWCxUfeWjU4>), and upwelling (<https://www.youtube.com/watch?v=4i23pBmlcz0>). What happens is this: surface winds drive the offshore advection of surface waters, which then drives the upwelling of subsurface waters into the coastal shelf. Those upwelled waters are low in oxygen (hypoxic). When upwelled hypoxic water bathes the continental slope, it can cause die-off events. Particularly, spectacular Dungeness crab die-off events have been well documented. Here is a great factsheet on coastal Oregon deadzones: http://www.piscoweb.org/files/hypoxia_general%20low-res.pdf -Sarah

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Kate: Great questions! I will add in answer to another question here, that yes, marine life of all levels of complexity in impacted by decreased oxygenation. That includes the microbial communities.

What kinds of marine life can survive this type of dramatic oxygen shift ? And how will that impact both fishery industries and endangered species?

[firedrops](#)

Kate: There are many types of marine life that can survive in low oxygen environments. Most of these are small, slow moving or entirely non-mobile - things which require little or no oxygen to survive. This included some types of snails, bivalves, as well as microscopic life forms. There are of course, some exceptions, and the type of life you would find in low oxygen depends a great deal on how low the oxygen levels are.

Fisheries mainly depend on larger more mobile species, which cannot survive in depleted oxygen environments for extended periods of time. This means that as Oxygen Minimum Zones expand closer to surface waters, the environment suited for these animals will shrink. This shrinking of range to include only near surface waters will impact species directly as well as through changes in food webs and species interaction. More research is being generated and is still needed to understand how these drastic changes in concert with other anthropogenic changes will impact fishery and endangered species.

Current marine dead zones are largely attributed to high nutrient loads causing runaway proliferation of organisms the subsequently deplete the oxygen in the water column. Examples are areas such as the Chesapeake Bay deadzones in the run from farming areas where chicken manure is applied to farm fields. Also at the outflow of the Mississippi river into the Gulf of Mexico, carrying nutrient loads from the entire US Midwest. Similar dead zones also occur in the Baltic, Mediterranean and South China Sea. While these are related to human activity, they seem more the result of human disruption of natural Nitrogen and Phosphorus cycles rather than the Carbon cycle changes normally associated with anthropogenic Global Warming/Climate change. How relevant are oceanic oxygen level changes from past, natural climate change episodes to the current oxygen depletion scenarios? Are you postulating increased oceanic nutrient loads in past, natural climate change or are you looking at completely different mechanisms? How does the magnitude of past oxygen depletion compare to current day dead zones?

[shiningPate](#)

This is a great question and gets at the heart of some of the confusion around "dead zones" and "oxygen minimum zones". I will try to answer this in chunks.... - Sarah

Which marine species currently alive today are the most vulnerable to decreases in oceanic oxygen? Are they likely to go extinct in our lifetime or on a longer scale?

[alexjt](#)

Kate: Large, and very mobile species are generally the most vulnerable to decreases in oxygen. This includes animals that are quite important to humans such as tuna. The changes that are currently occurring in the ocean are happening rapidly and are observable on the scale of a single lifetime. However, the fate of any given species will depend not just on ocean oxygenation but how this interacts with the many pressures each species faces. For example, ocean deoxygenation, a warming oceans and fishing pressures may all work together to impact a fish species. The fate of this fish would therefore depend on all three factors.

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[alexjt](#)

Kate did a great job at answering a similar question above - and I'll add on to this. The detailed study of marine sediment cores shows us that seafloor organisms (think clams, snails, urchins, crabs) are very sensitive to the expansion of hypoxia. The recent deglaciation gives us a window into the responses of biological communities to hypoxia expansion

<http://static1.squarespace.com/static/509c628ee4b0b5d93ca27462/t/55199cf1e4b0932ce9d68de2/1427741937711/Moffitt+et+al.%2C+PN>

What we know from these records is this: abrupt decadal climate warming is associated with abrupt, decadal expansion of subsurface OMZ. Through such warming and deoxygenation events, seafloor diversity and abundance across all major clades steeply declines (on the timescale of a human life: 10-100 years). Now, the reversal of that trend, from a warm and hypoxic seafloor is a process that takes much longer (>1000 years). So, the ecological and oceanographic recovery out of abrupt warming events is very long. -Sarah

How do you hope your research will effect the world?

[Mark-P](#)

Kate: I really hope that research like this will increase our collective long-term thinking about climate. This requires observing and understanding climate and oceans on time scales longer than a single human life and putting current global changes into the context of both past and future. I believe that this type of long-term thinking is really key for understanding, mitigating and adapting to ongoing environmental changes.

Hi and thanks in advance,

My question is less of people's affect on climate than it is on climate's affect on people but I think you both are uniquely qualified to answer.

People, however undeservedly, will survive a climate change. Society may break down throughout most of the world but it will still remain in enough places. There's a ray of optimism in my pessimism. My question is where should that optimism take me? Where should my pessimism lead me to avoid? Taking into account the ocean die-offs, the breakdown or change in ocean currents and the availability of alternative resources, where is the best place to have a home?

Thanks again.

[CompMolNeuro](#)

Well, I'm a parent and that means I'm always going to be an optimist. For me, optimism means marveling in the goodness of people, the beauty of science and engineering, the discovery of space and fundamental science (think gravitational waves, <https://www.theguardian.com/science/2016/feb/11/gravitational-waves-science-thrilled-by-discovery-ripples-in-space-time>). All of us, typing at our computers, thinking about climate change, balking at ocean die-offs: we are all in places of privilege and power. We are the people that need to bootstrap our minds and hearts out of despair and into action. Look at how beautiful the world is! Look at our capacity to solve problems and care for each other! Pessimism is, to my mind, a form of self indulgence that we don't have time for anymore. There are bigger problems at stake than for us to be mired in existential dilemmas. -Sarah

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Thanks again.

[CompMolNeuro](#)

Kate: I also think that there is plenty of reason to be optimistic. We humans have proven ourselves to be an extremely adaptable and flexible group, and that is exactly what we should continue to embrace. This means being flexible now in making changes in our own lives and our societies in ways that mitigate climate change. It also means that we may ultimately need to be adaptable to living in environments and with resources different than what our ancestors had. This is likely to be the case wherever we choose to make our homes.

What do you guys think the marine ecological environment will look like in say 20 or 50 years?

[thereversestranger](#)

Well: there are major changes underway. The surface and deep ocean will continue to absorb heat and CO₂ from the atmosphere. The heating of the ocean will increase the stratification of water (i.e. ocean mixing will be reduced, as will the strength of thermohaline circulation). Ocean heating will also drive the thermal expansion of the interior of the ocean - this is one of the primary contributors to sea level rise. The absorption of CO₂ from the atmosphere will drive changes in the chemistry of surface and deep waters - there are significant biological consequences to acidifying the global surface ocean. Basically, we are looking at the fundamental reorganization of biological communities and ecological provinces in the ocean. These physical drivers (warming, stratification, acidification) all area associated with significant biological consequences. -Sarah

Hi All - Just to add a little context about the research that Kate and I authored...we looked at marine sediment cores from the last deglaciation (i.e. the warming and ice-sheet melting that occurred from 18,000-10,000 years ago) to try and understand the spatial changes to subsurface oxygen zones that co-occurred during this most recent event of global-scale warming. The deglaciation is not an analog to what we are doing to the planet right now. You could consider it a pseudo-analog or an informative laboratory. This is because the deglaciation was fundamentally caused by the changing relationship between the earth and the sun - the orbital geometry, or Milankovitch Cycles, of how our planet moves around the sun (https://en.wikipedia.org/wiki/Milankovitch_cycles). What we found is this (in a nutshell): whole ocean basins lose oxygen in sync when the climate system warms. The spatial extent of this

phenomena is particularly important, because this kind of physical and chemical change to our ocean completely dwarfs the way that we consider managing and conserving the global ocean right now. - Sarah

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Also, here is a nice module on a different, prior events of climate warming: the Paleocene Eocene Thermal Maximum. <https://www.e-education.psu.edu/earth103/node/639> Such events, similar to the deglaciation, inform our understanding of how the earth-ocean-atmosphere system operates.

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Kate: I'll chime in here as Sarah makes a really critical point. There is really no time in Earth history that climate change has occurred as it is occurring today. We are seeing something that is unique and unprecedented in cause and probably the rate at which it is occurring as well. Looking at past pseudo-analogues can help us uncover important things like ocean-scale relationships between climate and oxygenation, and act as an important but imperfect guide to piecing together a longer-term picture of what is being observed in the modern ocean.