Ocean acidification, a quantifiable process contributing to risk of atmospheric and oceanic oxygen depletion and so possible human extinction? A call for research. (2018)

Satellite colour based assessment of plankton levels

Oxygen usage
Fire
Forest and crops
O_2 - 6GTA?

Fossil Fuels
O_2 - 26GT? 2014
100GTA by 2100 ? (RCP 8.5)

Humans
O_2 - 3.7GTA?
https://doi.org/10.1016/j.scib.2018.07.023

Live stock
O_2 - 2.7GTA?

Soil Carbon
O_2 used by soil bacteria??
C In Soils - 2355GT?.
(Top 300cm)
Reduced retention in modern agricultural soils with low return of organic matter
???
C In Tundra - 1024GT?
(Top 300cm only)
Switch from **an**erobic to aerobic bacterial activity so high ? O_2 usage as thawed tundra dries
???

Oxygen // Carbon circulation use and storage

Virgin forest

Green plants

Net O_2
Some carbon sequestration
(Through transfer via silt to ocean floor - likely limited)

Crops
Manure
Sewage
Food
Fodder
Fuel

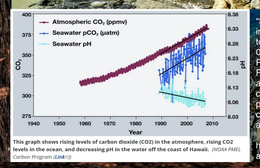
Erosion
Run off
Fertilisers

Organic matter

River outflows to oceans, erosion, organic matter inc carbon

Sewage - nitrates - phosphates - pollutants

Tundra melt
minerals - carbon
melt water



This graph shows rising levels of carbon dioxide (CO2) in the atmosphere, rising CO2 levels in the ocean, and decreasing pH in the water off the coast of Hawaii. (NOAA PMEL Carbon Program (LMH))

"So far, ocean pH has dropped from 8.2 to 8.1 since the industrial revolution, and is expected by fall another 0.3 to 0.4 pH units by the end of the century. A drop in pH of 0.1 might not seem like a lot, but the pH scale, like the Richter scale for measuring earthquakes, is logarithmic. For example, pH 4 is ten times more acidic than pH 5, and 100 times (10 times 10) more acidic than pH 6. If we continue to add carbon dioxide at current rates, seawater pH may drop another 120 percent by the end of this century, to 7.9 or 7.7, creating an ocean more acidic than any seen for the past 20 million years or more."

https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification

Oxygen recombination with carbon to form CO_2

Land ???
Oxygen production split
Sea 40-70%+ ???

Eutrophication
Plankton Blooms
- Carbon
- Minerals
- Phosphates
- Nitrates
- Pollution

Oxygen Loss
- Warming water
- Lower dissolved oxygen
- Higher respiratory rates

Nitrification N_2O so oxygen usage

Plankton etc. die off
Some sequestered
Most recycled

Mineral upwelling in currents

"The Ocean is Losing its Breath"
http://unesdoc.unesco.org/images/0026/002651/265196e.pdf

CO_2 GT ?

Gas exchange

O_2 GT ?

Are oceans buffering anthropogenic oxygen use?
(Warming + Henry's constant)

Greater Co_2 = increased ocean acidification irrespective of global warming - the impact of ocean acidity on photo-synthetic marine oxygen production ???

There are very few studies.

Photosynthetic Organisms
- all green but in what mix
???
- Phototrophic - O_2 always
- Mixotrophic - O_2 sometimes
- Heterotropic - O_2 never

O_2 GT? 'GO$_2$NE' but where?
into the atmosphere or into sequestered organic matter?

Reducing depth of minimum oxygen zone < 5% saturation level
(Normal surface@20°Saturated dissolved O_2 7.4 mg/l.)
(Hypoxia considered to happen at < 2.0mg/l)

Sequestered Organic matter - Carbon - Calcium Carbonate, Silica and other minerals

Methane Hydrate
??

Global warming gets more attention, but is ocean damage a greater species extinction risk?

Volcanic Subduction

Every breath you take you need oxygen

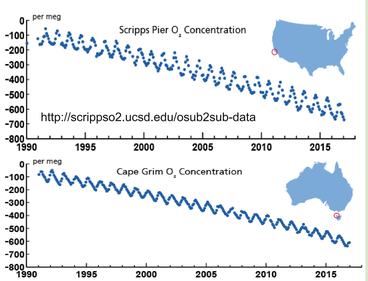
"Most extinctions are associated with global warming and proximal killers such as marine anoxia"
https://doi.org/10.1016/j.palaeo.2016.11.005

Were oceans to become anoxic and sulfidic, could atmospheric hydrogen sulfide H_2S reach 20-200 ppm? Long term exposure, would be sub-optimal for human physiology. H_2S is heavier than air, so accumulates during times of low air movement, increasing concentrations. Periodic sulphidic H_2S emitting oceanic atmospheric related events have been observed near Namibia. "Local inhabitants reported the intensive smell and the corrosive effects of H_2S." **"The U.S. government considers sulfide a high priority chemical threat, both industrially and as a potential weapon of mass destruction."**
https://oem.bmj.com/content/oemed/47/4/283.full.pdf https://hal.archives-ouvertes.fr/hal-01713215/document https://www.nature.com/articles/srep23831

The only home we have

"eutrophication has increased exponentially since the 1960s; hundreds of systems worldwide have been reported with oxygen concentrations <2 mg L"

Falls in atmospheric oxygen - small but consistent - Scripps data



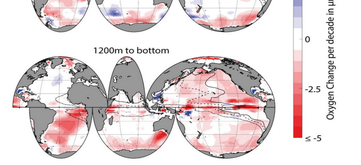
Photosynthesis inhibtion + depth penetration reduction - due to reduced light levels ???

Jet trails
Haze
Smog
Turbidy run-off
Micro-plastics

'Oxygen change in the ocean 1960 - 2010'

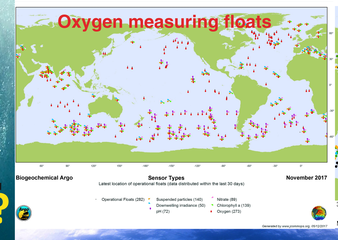
1 mg L^{-1} (milligram per litre) = 0.7 ml L^{-1} (millilitres per litre) = 32 µmol L^{-1} (micromoles per litre)

Normal surface-saturated dissolved oxygen levels O_2 7.4 mg/l. @20°C

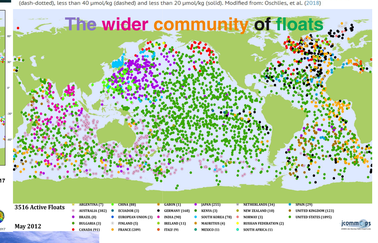


Oxygen change in the ocean. Observational estimate of the 50yr (1960 to 2010) oxygen change in the upper (0-1,200m) and deep (1,200m – sea floor) ocean in micromole per kilogram per decade (µmol/kg/decade). Data are taken from Schmidtko et al. (2017). Lines indicate boundaries of oxygen minimum zones with less than 80 µmol/kg of oxygen anywhere within the water column (dash-dotted), less than 45 µmol/kg (dashed) and less than 20 µmol/kg (solid). Modified from: Oschlies, et al. (2018)

Oxygen measuring floats



The wider community of floats



Over the past 50 years, the open ocean lost approximately 0.5–1 petamoles of oxygen per decade, which translates into 1–2%, or 2.4–4.8 petamoles (77–154 billion tons of O2) less oxygen in our current ocean than five decades ago

(e.g. Bopp et al., 2013; Schmidtko et al., 2017).http://unesdoc.unesco.org/images/0026/002651/265196e.pdf

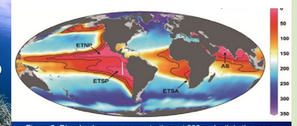


Figure 3. Dissolved oxygen concentrations at 300 m depth in the open ocean. Oxygen can be low enough to limit biological and ecological processes in large areas of the ocean (e.g. areas shown in red and orange, as well as magenta OMZs). ETNP, eastern tropical North Pacific; ETSP, eastern tropical South Pacific; ETSA, eastern tropical South Atlantic; AS, Arabian Sea; BS, Black Sea. (Fig. Kavelage 2012) http://unesdoc.unesco.org/images/0026/002651/265196e.pdf

"along the Namibian coast off south-western Africa, for example, low oxygen events can cover 20,000 km and last for several weeks, with severe ecosystem consequences"
http://unesdoc.unesco.org/images/0026/002651/265196e.pdf

" If you cannot measure it you cannot manage it" 'Bloomberg philanthropies'

"If all of the plants on Earth died, how long would it be before we run out of oxygen? The answer is probably 100 to 400 years". http://scienceline.ucsb.edu/getkey.php?key=3097

"Global warming, acidification and deoxygenation are linked. Increasing carbon dioxide concentrations in the earth's atmosphere result in higher ocean temperatures, more acidic conditions and deoxygenation. The warming caused by greenhouse gasses, including CO2, lowers oxygen solubility in seawater, increases respiration rates of individual organisms, increases stratification of the water column, reduces oxygen solubility and ventilation, and inhibits the exchange between surface waters rich in oxygen and subsurface waters low in oxygen. Respiration by microbes, plants and animals depletes oxygen and produces CO2, causing further acidification. Nutrients increase total respiration in water bodies by increasing the total production of organic biomass."
Fig 19.http://unesdoc.unesco.org/images/0026/002651/265196e.pdf

"The ocean is so acidic that it is dissolving the shells of our baby oysters."
https://ocean.si.edu/ocean-life/invertebrates/farming-oysters-despite-acidic-seas

"the Pacific Northwest oyster industry has struggled with significant losses due to ocean acidification as oyster larvae encountered mortality rates sufficient to make production non-economically feasible."
https://today.oregonstate.edu/archives/2013/jun/study-ocean-acidification-killing-oysters-inhibiting-shell-formation-0

R A Brown
McCarrison Society
Funding - Self-funded
Contact - McCarrison.com
Conflicts of Interest - None

Abstract - OS41B-2022