

OCEAN DEOXYGENATION AND COASTAL HYPOXIA

FACT SHEET

SUMMARY

The secondary effect of climate change on seawater oxygen levels has only recently gained attention, but the consequences could be substantial.

The decline of oxygen concentrations in seawater is alarming. The average ocean oxygen concentration is expected to decline over the next century by up to 7%, leading to a large increase in the extent of hypoxic water bodies in the ocean interior. Hypoxia is the condition in which dissolved oxygen is below the level necessary to sustain most animal life. Declining oxygen concentrations have already been observed in several locations, most notably in the North Pacific and the tropics. There is also strong evidence for a global increase in the frequency, extent, intensity and duration of coastal hypoxia linked to global warming and eutrophication.



POSSIBLE IMPACTS

The sensitivity of a specific marine organism to changes in seawater oxygen concentrations is highly non-linear and depends strongly on the temporal dynamics (episodic, periodic, seasonal...) and spatial extent of the changes.

Oxygen concentration	Impact on organisms
\nearrow 60 $\mu\text{mol/kg}$	No observed effects
\leftarrow 60 $\mu\text{mol/kg}$ (Hypoxia)*	Organisms show reduced fitness and aberrant behaviour. Depending on dynamics in oxygen changes and motility of the organisms, further decrease in oxygen concentrations would lead to migration and increased mortality of the different species
5 – 10 $\mu\text{mol/kg}$ (Suboxia)	Disappearance of practically all multi-cellular life
\sim 0 $\mu\text{mol/kg}$ (Anoxia)	Only anaerobic microorganisms present

* This is the conventional reference level for hypoxia; thresholds can vary strongly between different groups of organisms. Crustaceans and fish, both important for the fishing industry, seem to be the most sensitive.

Declining oxygen concentrations can also have a large impact on global biogeochemical cycles. In so-called 'oxygen minimum zones' (large hypoxic water bodies in the ocean interior), denitrification rates increase, releasing more nitrogen into the atmosphere which can limit ocean productivity.

In coastal areas, hypoxia can also initiate a feedback loop by increasing nutrient release from sediments, stimulating primary production and further increasing the oxygen consumption by micro-organisms that live on the algal biomass.

WHAT ARE THE FUTURE PROJECTIONS?

Climate simulations predict:

- An overall decline in ocean oxygen concentrations;
- An expansion of mid-depth 'oxygen minimum zones';
- An increased prevalence of coastal hypoxia and the formation of 'dead zones' characterized by the absence of benthic fauna and fish.

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HOW DOES CLIMATE CHANGE AFFECT OCEAN OXYGEN LEVELS?

- Higher seawater temperatures will increase the respiratory and metabolic rates of organisms, thereby increasing the biological oxygen demand;
- Oxygen is less soluble in warmer water and an increase in global temperature will decrease the inventory of oxygen within the ocean;
- Higher temperatures in combination with changes in wind and precipitation patterns will increase ocean stratification, thereby reducing the downward oxygen transport;
- In coastal areas, the increase in nutrient run-off will stimulate primary production, increasing the supply of organic matter sinking down and stimulating respiration in bottom waters.



Hypoxia scheme design: S. Luedeling, www.medieningenieure.de

ONGOING RESEARCH

Several European projects are currently investigating the effects of declining oxygen concentrations. The main focus of these projects is on the deployment, upgrading and linking of observatories for continuous oxygen monitoring to resolve temporal dynamics and long-term trends in oxygen concentrations (for example, EU FP7 HYPOX www.hypox.net).

Research is also investigating the mechanisms leading to hypoxia, placing the emphasis on the interplay between hypoxia and the availability and regeneration of nutrients.

FURTHER READING

- Diaz RJ and Rosenberg R (2008). Spreading Dead Zones and Consequences for Marine Ecosystems. *Science* 321:926-929.
- Keeling RF, Körtzinger AK and Gruber N (2010). Ocean deoxygenation in a warming world. *Ann. Rev. Mar. Sci.* 2:199-229.
- Vaquer-Sunyer R and Duarte C M (2008). Thresholds of hypoxia for marine biodiversity. *Proc. Natl. Acad. Sci. U.S.A.* 105:15452-15457.
- Gewin, V. Oceanography: Dead in the water *Nature* 466, 812-814 (2010)

RESEARCH GAPS AND PRIORITIES

- Characterise spatial and temporal dynamics of oxygen in both open ocean and coastal environments;
- Identify drivers of oxygen depletion;
- Identify effects of oxygen depletion processes on biodiversity in diverse environments;
- Separate natural variability from anthropogenic impacts;
- Establish a global observation system that continuously monitors oxygen concentrations at high resolutions, linked to other physical, biogeochemical and biodiversity parameters as well as climate observations;
- Improve models to better predict the frequency, intensity and duration of future hypoxia.



Deployment of the Loch Etive Cabled Observatory (LECO)

This fact sheet is based on a chapter of the CLAMER / Marine Board Special Report *Synthesis of European Research on the Effects of Climate Change on Marine Environments* (Deliverable 1.2) written by **Filip Meysman** (Netherlands Institute for Ecology of the Royal Netherlands Academy of Arts and Sciences) and **Felix Janssen** (Max Planck Institute for Marine Microbiology, Germany).