

Environmental Effects On The Plankton Community And The Changes It Causes To Our Ecosystem

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Abstract:

Plankton accounts for nearly half of the earth's global primary production thus, playing a key role in the carbon cycle. Because of the rising change in the earth's climate, it's initiating acidification, and temperature rises. This can cause changes in the food web, our oxygen levels, as well as kill off plankton, and many other organisms. Here, we will examine the effects of our environment, and what impact that has on Plankton. As well as, explore what effects that would cause to our ecosystem as we know it.

Introduction:

Oxygen, an odorless, colorless, tasteless gas that is essential to living organisms. It not only sustains life, but also plays a key role in our ecosystem. But, to think about and consider how essential oxygen is, you must also think about who produces oxygen, what roles they play, and how are they important.

So, who are our oxygen producers? Well, what comes to mind is trees, but there are actually more that produce much, much more oxygen for our environment. Those producers would be land plants, marine algae, and phytoplankton.

It has been estimated that phytoplankton produces roughly half of the earth's oxygen. While, trees/ Land plants produce 20%, and marine algae produces 30%.

(Plankton and their Types)

What are plankton? Well, "Plankton" stems from the Greek word "wanderer" or "drifter". "An organism is considered plankton if it is carried by tides and currents, and cannot swim well enough to move against these forces ("What are plankton?")." They are also classified by their size, type, and how long they spend drifting. There are two main categories of plankton. These are Phytoplankton, and Zooplankton.

Phytoplankton are a microscopic marine algae who get their food from photosynthesis. These plankton include colonies and chemo-organotrophic unicells. This also includes multicellular organisms. The multicellular organism and colonies depend on kleptoplastids as well as symbionts for their capacity to photosynthesize. The most common of these are diatoms. The other main class of phytoplankton are dinoflagellates. These may be fully or partially photosynthetic. A good example of phytoplankton would be cyanobacteria. This is also known as blue-green algae. They have a cell wall of silica and are the most abundant and diverse of diatoms. In an article by Columbia Climate school, they said, "There are probably 100,000 different species of phytoplankton, each of which may have different characteristics, different ecological functions, and different distributions. Zooplankton, too, includes many, many, different groups (Cho)."

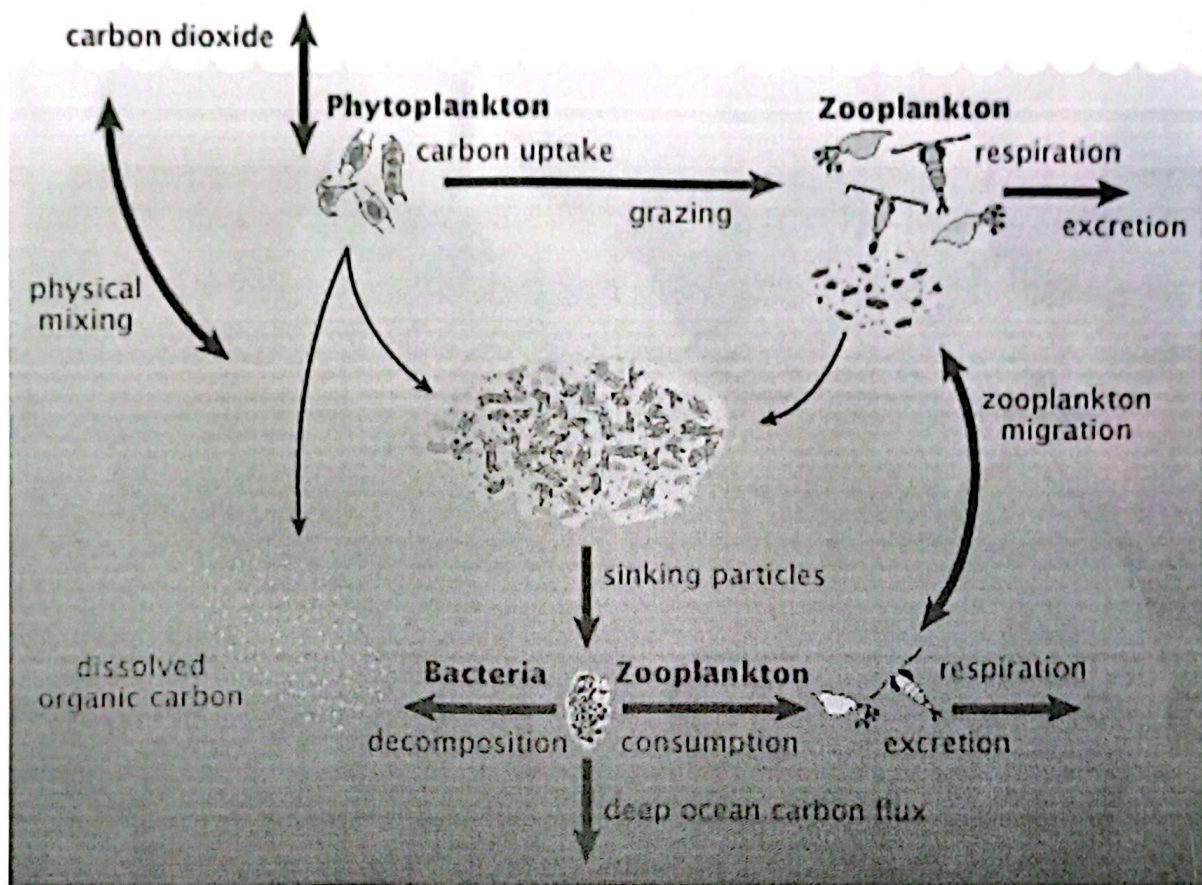
Zooplankton are "tiny" or "microscopic" animals. They usually feed on phytoplankton, and there are two main types of zooplankton. One of which is Holoplankton, whom spend their entire life as plankton. A good example of zooplankton would be copepods and krill. Including jellyfish.

Outside the main categories there are plankton called meroplankton. Meroplankton are plankton that have both planktonic and benthic stages in their life cycle. Meroplankton spend their larval and reproductive stage as zooplankton. These are creatures such as starfish or sea urchins.

(Plankton and their impact on our oceans)

Plankton plays a key role in our oceans system. All marine life health and productivity vitally depend on them. Plankton even plays key roles in the earth's carbon cycle. Phytoplankton are photo-synthesizers. This means they will take in carbon dioxide, and produce oxygen. But how much carbon? Well "Oceans have absorbed an estimated 40 percent of all the carbon dioxide humans have put into the atmosphere since the Industrial Revolution (Cho)."

But, what happens with the phytoplankton who die, and what does that have to do with carbon dioxide? When phytoplankton die the carbon, they had taken in sinks to the ocean depths. This causes the process known as the biological pump. This makes up the earth's largest carbon sink. Which also ends up becoming a deep ocean carbon flux. (See below image for plankton carbon cycle).



Simmon, R., Lindsey, R., & Scott, M. (2010). *Plankton Carbon Cycle* . What are

Phytoplankton? NSA Earth Observatory . Retrieved October 26, 2023, from <https://earthobservatory.nasa.gov/features/Phytoplankton>.

(Plankton and Their Impact On Us)

When you think of oxygen producers, you usually picture trees, grasses, shrubs, and other plants. But, phytoplankton produces as much oxygen as plants combined. Due to the abundance of their work, it is estimated that they produce roughly half of the earth's oxygen.

Plankton are not only beneficiary to humans because of their key role in the carbon cycle but, also because their enzymes can be used for food products, cosmetics, pharmaceuticals, food

Supplements, chemical-based products, fertilizers, and even to treat cancer, AIDS, diabetes, and other diseases. They can also be used for biofuels. It has been estimated that they can "produce up to 30 times more energy than other biofuels (Cho)."

Though not every advancement and thought can be set in stone, let alone environmentally friendly. Every pro has its cons. The use and manufacturing of biodiesel from phytoplankton can consume more energy than biofuel can produce. It also "may have a bigger carbon footprint than fossil-fuel diesel. In order for a viable low-carbon fuel to be made from microalgae, enhanced microalgae strains and improved infrastructure design would be necessary (Cho)."

(What's going on in our oceans?)

Due to high levels of CO₂ in our atmosphere from global warming, the ocean has been absorbing more of it. Concurrently, the oxygen levels have decreased. On-top of that claimant change has caused the ocean currents to change patterns. "Changing ocean current patterns threaten recruitment of fish stocks—the number of fish born in a given time frame that reach the juvenile stage—with very real and direct impacts on coastal communities that depend on these resources ("Climate Explainer: Oceans and Climate Change")." But what communities are affected, and what do they do?

Oceans are big contributors to adaptation, and that is through their coastal ecosystems. Such as coral reefs, mangroves, and seagrass beds. In an article by the *Climate Explainer* they say "Mangroves not only support fisheries and biodiversity, but they also strengthen the ability of coastal communities to withstand the impacts of climate change ("Climate Explainer: Oceans and Climate Change")."

They also support our economy! Oceans aren't just important for the world's overall health but also our global economy. Roughly 90% of all international goods are still transferred via the sea. Further they say in the *Climate Explainer* that the ocean contributes 1.5 trillion dollars to our global economy, and that the "shipping volume is expected to triple by 2050—so the need to decarbonize the industry is urgent ("Climate Explainer: Oceans and Climate Change")."

(CO2 Emissions and Affects on Oxygen Concentrations)

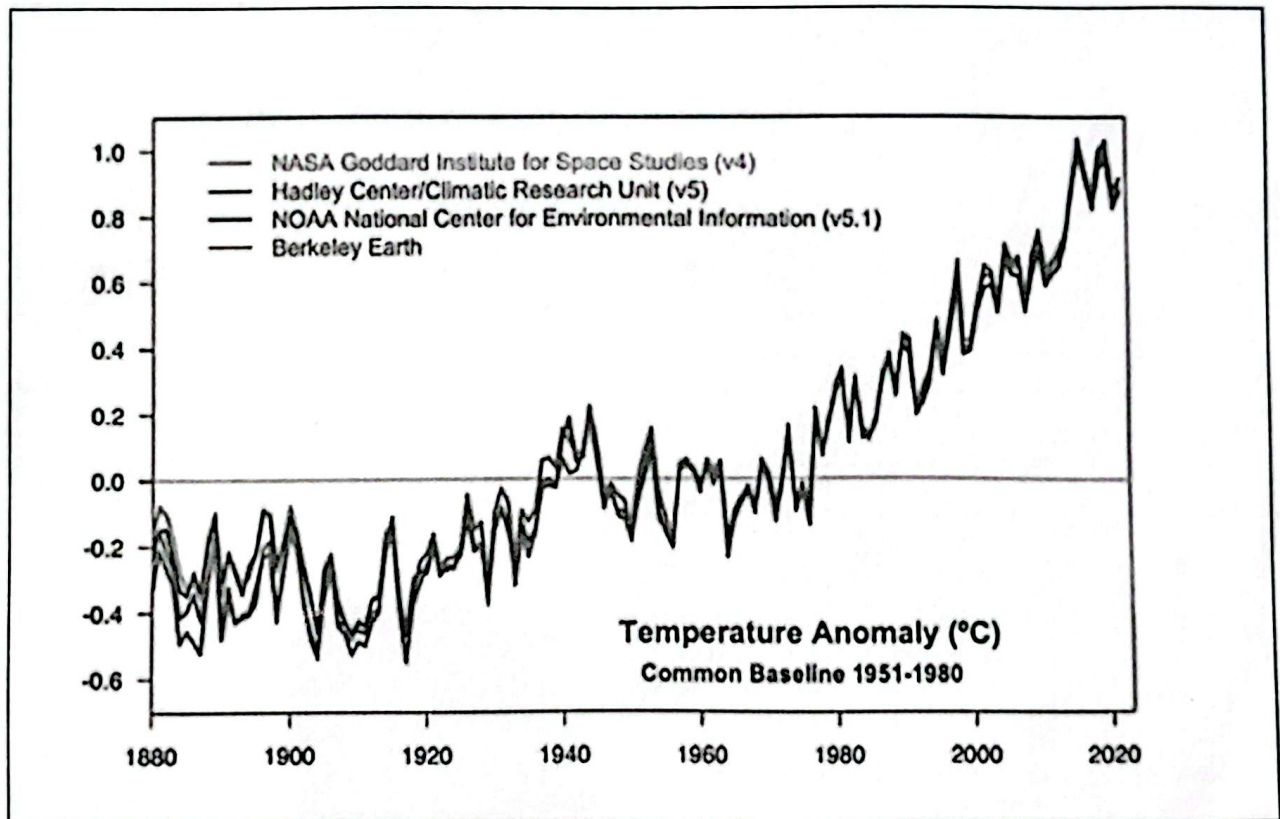
Due to the mass burning of fossil fuels and other pollutions, our oxygen levels are declining. While, this decline won't directly impact humans (in the sense of the oxygen we breathe). There are certain ecosystems that are more impacted. This is especially true to the more aquatic ones such as the ocean. But how does this happen, and why?

Well, when we burn fossil fuels, the carbon and oxygen molecules combine they form greenhouse gasses. This is the main contributor to climate change. In an article by the MIT climate portal they state that "This process traps the oxygen molecules that are in our air into the CO₂—which means there's less oxygen for life to breathe ("How will future warming and CO₂ emissions affect oxygen concentrations?")."

On a less frightening note they do mention "Oxygen makes up about 20% of the atmosphere, and even with all our carbon emissions, total atmospheric oxygen levels have only dropped "a very tiny fraction ("How will future warming and CO₂ emissions affect oxygen concentrations?")." Despite how that sounds, it does not make the issues we face less real or important than they are.

It is also very important to note, and keep in mind that scientist always take evidence as a priority, not the opinions. If you look at the image below from the Scientific Consensus, you'll see that they show the temperature anomaly. As well as who documented what, and how it raised through the years. They also mention "Scientific evidence continues to show that human activities (primarily the human burning of fossil fuels) have warmed Earth's surface and its

ocean basins, which in turn have continued to impact Earth's climate. This is based on over a century of scientific evidence forming the structural backbone of today's civilization ("Scientific Consensus | Facts – Climate Change: Vital Signs of the Planet")."



Temperature data showing rapid warming in the past few decades, the latest data going up to 2022. According to NASA, 2016 and 2020 are tied for the warmest year since 1880, continuing a long-term trend of rising global temperatures. On top of that, the nine most recent years have been the hottest. Credit: NASA's Goddard Institute for Space

"WMO Global Annual to Decadal Climate Update." *WMO Library*, UN Climate Change Conference - United Arab Emirates Nov/Dec 2023, 08 Sep 2023, <https://library.wmo.int/viewer/66224/?offset=4#page=1&viewer=picture&o=&n=0&q=>. Accessed 22 September 2023.

thermal limits are actually less able to acclimate to changes in temperature within the span of their life.

(Plankton and Their Ability to Withstand)

It is no surprise that, amongst every community in the world, adaptability plays a key role in their survival. If it wasn't for our ability and other organisms' ability to adapt and evolve. It would beg the question... would we be standing here today? So, that also begs the question if plankton can handle the rapid changes of our world today. In a sense, they can! The Columbia Climate School seems to even agree, saying "Climate change may also be increasing the frequency of large phytoplankton blooms in both fresh water and the ocean (Cho)." As well as following it up with "Due to their short lifecycles, plankton respond more rapidly than higher trophic level organisms to environmental changes (Cho)." But, these changes don't magically happen. This process of adaptation takes many, many years to happen and hone.

It is no surprise that an organism that small can withstand harsh changes in the world. It holds a sense of hope for the future. But what are those changes? Well, the warming of the oceans temperatures can cause some phytoplankton to change. Some scientists have even theorized that the plankton community could possibly adapt to the large amounts of carbon in our atmosphere; making them go from carbon absorbers to become carbon emitters.

So, even if the change could be considered a negative for our environment. There could still be hope that their adaptability goes for a more positive change in the future.

(When will Adaptations Stop?)

As I said in (Plankton Thrive or Dive: What is Their Thermal Tolerance?) “The ARR is a ratio that quantifies how acclimation can alter thermal tolerance. It shows that copepods with higher thermal limits are actually less able to acclimate to changes in temperature within the span of their life.” Meaning that the acclimation of CO₂ can alter how an organism can survive normally lethal heat stress. Thus, if the temperature were to go even higher or just drastically drop, it can change their life span. In an article from *Nature Communications*, they state that “We find that the majority (71%) of affected species did not relocate to the warmer low latitudes, but went extinct. This indicates that some plankton species cannot track optimal temperatures on a global scale, as assumed by ecologic models; instead, assemblages undergo restructuring and extinction once local environmental thresholds are exceeded (Trubovitz et al.).” This means that if the temperatures change too drastically, there could be a chance of extinction of certain plankton species.

(Impact Reductions, and What We Can Do)

Our oceans contain many marine life, the coastal seas specifically contain 90% of all our marine life, and coral reefs only cover roughly 1% of our ocean yet contain almost half of our marine life. Coral is so important because it creates the structure that the entire reef community depends, and the reef also depends on the life that lives in it. From a video by *Our Planet* they say, "The shallow seas are vitally important in the fight against climate change. Seagrass absorb

35 times as much carbon dioxide as the same area of rainforest, and that reduces the damage caused by the recent warming of our seas ("Our Planet | Coastal Seas")."

Despite the importance of our ocean, many people still don't take care of it, so what can we do? Fish responsibly, attend protests for the ocean, practice safe boating. There are so many animals hurt by it every year, use less energy, reduce waste, and shop wisely. There are so much people can do for the ocean. They just need to research, and act on it.

Works Cited

"AR6 Synthesis Report: Climate Change 2023." *IPCC*, <https://www.ipcc.ch/report/ar6/syr/>. Accessed 22 September 2023.

Bever, Fred. "New research finds plankton may have unexpected resilience to warming ocean waters." *WBUR*, 23 March 2022, <https://www.wbur.org/news/2022/03/23/plankton-carbon-warming-ocean>. Accessed 22 September 2023.

Carder, Michael. "Changes in Phytoplankton Biomass and Zooplankton Abundance." *OSPAR - Assessments*, 30 June 2023, <https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/changes-plankton-biomass-abundance/>. Accessed 22 September 2023.

Cho, Renee. "Plankton Are Central to Life on Earth. How Is Climate Change Affecting Them?" *State of the Planet*, 23 August 2023, <https://news.climate.columbia.edu/2023/08/23/plankton-are-central-to-life-on-earth-how-is-climate-change-affecting-them/>. Accessed 22 September 2023.

Cho, Renee. "Plankton Are Central to Life on Earth. How Is Climate Change Affecting Them? | Lamont-Doherty Earth Observatory." *Lamont-Doherty Earth Observatory*, 23 August 2023, <https://lamont.columbia.edu/news/plankton-are-central-life-earth-how-climate-change-affecting-them>. Accessed 22 September 2023.

"Climate Change 2023 Synthesis Report." *IPCC*, https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_LongerReport.pdf. Accessed 22 September 2023.

"Climate Explainer: Oceans and Climate Change." *World Bank*, 8 February 2022, <https://www.worldbank.org/en/news/feature/2022/02/08/what-you-need-to-know-about-oceans-and-climate-change>. Accessed 22 September 2023.

"Coastal Water Temperature Guide." *National Centers for Environmental Information*, <https://www.ncei.noaa.gov/products/coastal-water-temperature-guide>. Accessed 22 September 2023.

Collins, Hannah. "A plankTON of heat: How do copepods respond to temperature and warming oceans?" *Oceanbites*, 22 November 2021, <https://oceanbites.org/a-plankton-of-heat-how-do-copepods-respond-to-temperature-and-warming-oceans/>. Accessed 28 October 2023.

"5 reasons to thank plankton that you're alive today - WWF.CA." *World Wildlife Fund Canada*, 20 April 2016, <https://wwf.ca/stories/5-reasons-to-thank-plankton-that-youre-alive-today/>. Accessed 22 September 2023.

"How will future warming and CO2 emissions affect oxygen concentrations?" *MIT Climate Portal*, 6 April 2022, <https://climate.mit.edu/ask-mit/how-will-future-warming-and-co2-emissions-affect-oxygen-concentrations>. Accessed 22 September 2023.

Josephs, David. *Lakes, Ponds, and Temporary Pools*. F. Watts, 2000.

Kent, Jennifer Theresa. "Marine Plankton face threat of extinction as planet warms." *University of Nevada, Reno*, 23 December 2020, <https://www.unr.edu/nevada-today/news/2020/marine-plankton>. Accessed 28 October 2023.

"Marine plankton and ecosystems affected by climate change." *Newswise*, 8 September 2023, <https://www.newswise.com/articles/marine-plankton-and-ecosystems-affected-by-climate-change>. Accessed 22 September 2023.

Murphy, Grace E. P., et al. *Cascading effects of climate change on plankton community structure*. Halifax, Department of Biology, Dalhousie University, 2019.

"Our Planet | Coastal Seas." *YouTube*, 2 October 2022, <https://youtu.be/r9PeYPHdpNo?si=KF9Q9mYSmrmOpjXm>. Accessed 22 September 2023.

"Press conference slides FINAL_PDF." *IPCC*, 20 March 2023, https://www.ipcc.ch/report/ar6/syr/downloads/press/IPCC_AR6_SYR_SlideDeck.pdf. Accessed 22 September 2023.

"Scientific Consensus | Facts – Climate Change: Vital Signs of the Planet." *NASA Climate Change*, <https://climate.nasa.gov/scientific-consensus/>. Accessed 22 September 2023.

"The Secret Life of Plankton." *YouTube*, 2 October 2022, https://youtu.be/xFQ_f02D7f0?si=Bi0sX1dpBC3nXuIA. Accessed 22 September 2023.

Simmon, Robert. "What are Phytoplankton?" *NASA Earth Observatory*, 2010, <https://earthobservatory.nasa.gov/features/Phytoplankton>. Accessed 26 October 2023.

"Trends in Ecology & Evolution." *Science Direct*, 2 October 2022, <https://www.sciencedirect.com/science/article/abs/pii/S0169534705000650>. Accessed 22 September 2023.

Trubovitz, Sarah, et al. "Marine plankton show threshold extinction response to Neogene climate change." *Nature Communications*, Nature Communications, 22 October 2020, <https://www.nature.com/articles/s41467-020-18879-7#Sec1>. Accessed 28 October 2023.

"What are plankton?" *National Ocean Service*, <https://oceanservice.noaa.gov/facts/plankton.html>. Accessed 22 September 2023.

"Why Are Plankton the Most Vital Organisms on Earth?" *YouTube*, BBC Earth, 2 October 2022, <https://youtu.be/UjnYJVKysfo?si=kGhjlIMjLtlblfeW>. Accessed 22 September 2023.

"WMO Global Annual to Decadal Climate Update." *WMO Library*, UN Climate Change Conference - United Arab Emirates Nov/Dec 2023, 08 Sep 2023, <https://library.wmo.int/viewer/66224/?offset=4#page=1&viewer=picture&o=&n=0&q=>. Accessed 22 September 2023.