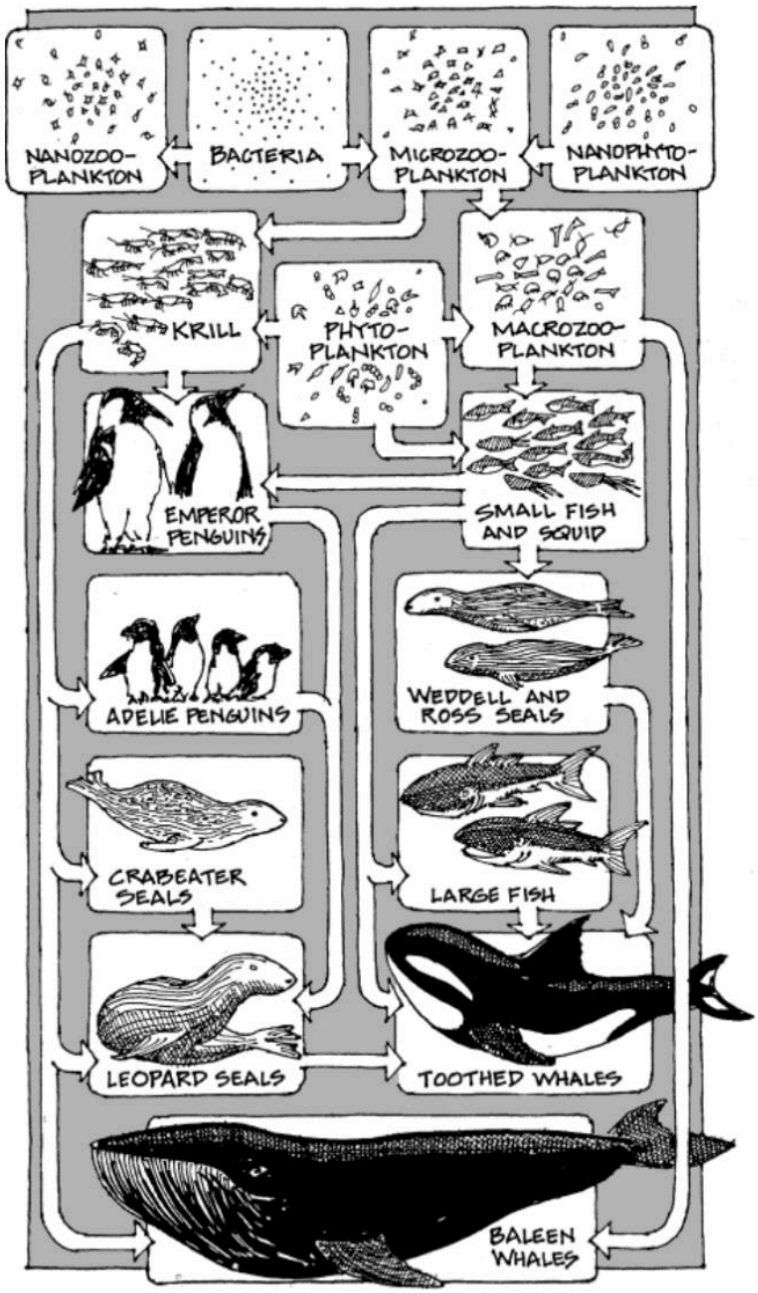
Are Phytoplankton Declining, and Should You Be Concerned?



I recently saw an article about how phytoplankton are decreasing 2% per year, and was undeniably concerned. I even took a break from writing my article on forest density to write this smaller article, simply because that is extraordinarily concerning. You might've laughed when you read that, and I would have too had I not learned about phytoplankton via an Environmental Science class. My hope in writing this article is to not only help you understand why phytoplankton are important, but also to figure out if they are even declining in the first place.

What are Phytoplankton?

Phytoplankton are microscopic, or at least very tiny depending on the roughly 100,000 species, plant-like creatures whose photosynthesis produces more oxygen than all the worlds forest combined[1]. They live in both saltwater and freshwater systems, and are the very base of the aquatic food web. Without them the majority of life in waterways would simply cease to exist in a very short time as the result of a swift trophic cascade. The picture[2] above is a good representation of this; Each section is a different Trophic level, and when you remove the first Trophic Level from an ecosystem the Trophic Levels above that one cease to exist as a result of starvation. Phytoplankton are also responsible for the Harmful Algae Blooms that render lakes and ponds unsafe to swim in, and these "HAB's" are even possible out in the ocean. They are usually caused by an excess of nutrients, which can be natural (such as volcanic ash), or artificial (such as lawn and crop fertilizer)

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[1] https://earthobservatory.nasa.gov/features/Phytoplankton
[2]https://earthobservatory.nasa.gov/features/Phytoplankton

Are They Actually Declining?

Hopefully after reading the last portion of this article you better understand why the decline of phytoplankton would be extraordinarily concerning. However, are they actually decreasing? Especially at a rate of 2% per year? Although that may sound in-consequential, at that rate in 50 years they could be extinct. Potentially in your lifetime, and much more certainly in your children's or grandchildren's lifetimes. However, what's actually happening? Honestly, the answer is complicated. Throughout the ocean(s) we are seeing decreases as high as 40% since 1950. However, Harmful Algae Blooms, and non-harmful Algal Blooms (some phytoplankton are toxic) seem to be happening more and more, and some areas of the ocean are even seeing increases in phytoplankton. So what's actually happening? Below are bulletins of the different facts I pulled from articles, study's, and videos.

- One study that studied 35 different types of phytoplankton found; "**Phytoplankton biomass is projected to decrease over much of the tropical and subtropical ocean due to lower nutrient supply rate** , consistent with previous studies. **Increases in phytoplankton biomass occur in high latitude regions due to the retreat of sea ice, longer growing seasons, and increased growth rates at higher temperatures,** again consistent with previous work. However, the increased ecological complexity of our model allows us to look beyond changes in biomass alone to uncover the community structure alterations that underlie the climate change response. **Projected changes in biomass are in general reflected in phytoplankton richness, which declines by 2100 in large parts of the northern hemisphere subtropical and temperate regions (64% of area 23−55° N declines), and increases in polar and some equatorial regions (69% of area poleward of 55° or within 23° of the equator increases). In some tropical regions, up to 30% of modelled phytoplankton types become locally extinct, whereas in polar regions colonisation exceeds extinction, and richness increases by up to 30%."**[3]
- Another study found, "**in eight out of ten ocean regions, an estimated global rate of decline of ~1% of the global median per year."**[4]
- In response to the above study another group of researchers wrote; "**Eight decades of data on phytoplankton biomass collected in the North Atlantic by the Continuous Plankton Recorder (CPR) survey, however, show an increase in an index of chlorophyll (Phytoplankton Colour Index) in both the Northeast and Northwest Atlantic basins, and other long-term time series, including the Hawaii Ocean Time-series (HOT), the Bermuda Atlantic Time Series (BATS) and the California Cooperative Oceanic Fisheries Investigations (CalCOFI) also indicate increased phytoplankton biomass over the last 20–50 years.** These findings, which were not discussed by Boyce *et al.*, are not in

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[3] Henson, S.A., Cael, B.B., Allen, S.R. *et al.*Future phytoplankton diversity in a changing climate. *Nat Commun* **12**, 5372 (2021). https://doi.org/10.1038/s41467-021-25699-w

[4] Boyce, D., Lewis, M. & Worm, B. Global phytoplankton decline over the past century.*Nature* **466**, 591–596 (2010). https://doi.org/10.1038/nature09268

accordance with their conclusions and illustrate the importance of using consistent observations when estimating long-term trends."[5]

- In terms of the actual Algal Blooms taking place this study found; "**The total global bloom-affected area has expanded by 3.97 million km (13.2%) between 2003 and 2020, equivalent to 0.14 million km^2 yr^{-1} ($P < 0.05$).** Furthermore, the number of countries with significant bloom expansion was about 1.6 times those with a decreasing trend. **The global median bloom frequency showed an increasing rate of 59.2% (+2.19% yr^{-1}, $P < 0.05$) over the observed period."** [6] That same study also importantly noted that "**…blooms weakened in tropical and subtropical areas of the Northern Hemisphere.**"
- Another factor to take into consideration is ocean acidification. This is the lowering of the oceans PH as a result of higher CO2 levels in the water. We recently hit the highest concentration of CO2 in the atmosphere in 30 million years, so this is something we absolutely need to keep in mind. In terms of the actual oxygen being produced by phytoplankton one study found "**…community-level primary production [photosynthesis] decreased consistently following CO_2enrichment in the North Pacific Subtropical Gyre and northern South China Sea, while no significant changes were observed at the northernmost boundary of the subtropical gyre**."[7]
- So far there has been a trend of increases in phytoplankton throughout the Arctic, and this study further solidifies that nothing;"**…the Arctic Ocean, we show that primary production increased by 57% between 1998 and 2018. Surprisingly, whereas increases were due to widespread sea ice loss during the first decade, the subsequent rise in primary production was driven primarily by increased phytoplankton biomass, which was likely sustained by an influx of new nutrients.**"[8]
- In the **North-East Atlantic Ocean** (below the Arctic) researchers noted; "**Long-term trends (e.g. 1960 to 2019 for CPR) indicate most plankton lifeforms, including diatoms, dinoflagellates, holoplankton, large copepods, and small copepods, have declined in abundance throughout beyond-shelf regions of the North-East Atlantic from 1960 to 2019. Considering all assessment units equally, Sen's slope estimates of the median rate of decrease in abundance per decade were 5 % for dinoflagellates, 7 % for holoplankton, 9 % for large copepods, and 8 % for small copepods. Diatom and fish larvae/egg abundance increased 0.1 % and 3 % per decade, respectively. Conversely, meroplankton demonstrated a very different pattern of increasing abundance or no change across most assessment units, with a median increase of 12 % per decade.**"[9]

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[5] McQuatters-Gollop, A., Reid, P., Edwards, M. *et al.* Is there a decline in marine phytoplankton?.*Nature* **472**, E6–E7 (2011). https://doi.org/10.1038/nature09950

[6] Dai, Y., Yang, S., Zhao, D. *et al.* Coastal phytoplankton blooms expand and intensify in the 21st century. *Nature* **615**, 280–284 (2023). https://doi.org/10.1038/s41586-023-05760-y

[7] R. Dai, Z. Wen, H. Hong, T.J. Browning, X. Hu, Z. Chen, X. Liu, M. Dai, F.M.M. Morel, & D. Shi, Eukaryotic phytoplankton drive a decrease in primary production in response to elevated CO2 in the tropical and subtropical oceans, Proc. Natl. Acad. Sci. U.S.A. 122 (11) e2423680122, https://doi.org/10.1073/pnas.2423680122 (2025).

[8] K. M. Lewis *et al.* Changes in phytoplankton concentration now drive increased Arctic Ocean primary production.*Science***369**,198-202(2020).DOI:10.1126/science.aay8380

[9] Matthew M. Holland, Arnaud Louchart, Luis Felipe Artigas, Clare Ostle, Angus Atkinson, Isabelle Rombouts, Carolyn A. Graves, Michelle Devlin, Birgit Heyden, Margarita Machairopoulou, Eileen Bresnan, Jos Schilder, Hans H. Jakobsen, Hannah Lloyd-Hartley, Paul Tett, Mike Best, Eric Goberville, Abigail McQuatters-Gollop, Major declines in NE Atlantic plankton contrast with more stable populations in the rapidly warming North Sea, Science of The Total Environment, Volume 898, 2023, 165505, ISSN 0048-9697. https://doi.org/10.1016/j.scitotenv.2023.165505.

- The last research I found that kept popping up is actually the one that sent me down this rabbit hole. However I have disqualified it as a valid source as despite being the one seemingly most re-published by news outlets, they claim phytoplankton have been declining by 2% per year for the last 60 years. 2% multiplied by 60 is 120%. If this were true they would all be extinct by now, and they obviously are not.

Are They Actually Declining?

In some areas such as the Atlantic Ocean, yes phytoplankton are declining. However, they are also increasing in population size further north in the Arctic. They are seemingly shifting north. Although it is probably pretty obvious climate change is the main driver behind this, what its most influential factor is seems to be unknown. Many factors are contributing to this, including the melting of sea ice (and the release of its nutrients), ocean acidification, tampered nutrient cycling cycles as a result of warmer waters, and especially the warmer waters themselves. However…

Should We Be Concerned?

This little section is definitely my opinion, so I thought I would put that warning. If we continue to see the rapid ecological and meteorological changes we are witnessing right continue on at their current rate, then yes we should be. Species and ecosystems simply cannot keep up with the rate of change right now. Even something like our coastal salt marshes. If we could slow down coastal erosion, and sea-level rise, then sea-level rise would not be a huge issue for our coast. This is thanks to a process called accretion, which is when the salt-marsh collects sediment from the water slowly building up its height. Up until recently the marsh could keep up with the rate of sea-level rise via accretion, or at least not be totally wiped out by a few inches of rising water. Sea-level rise is happening so rapidly right now however that they are struggling to keep up, and we are subsequently losing thousands of acres of salt marsh every year.Here is a NASA study on the loss of salt marshes, as I will write a whole other article on the topic if I don't stop now. That was just a perfect example of, if we slow down the rate of climate change and rising temperatures we probably will be fine. Species will adapt and shift their range, but that is natural. Climate change itself is completely natural as well, it is just the rate we are seeing it happen is completely unnatural.

Even if we did lose all our phytoplankton right, what's the effect on humans? Phytoplankton are the very base of the marine ecosystem, and make at least 50% of the world's oxygen (some sources say more). Our oceans , especially the phytoplankton in them, are our most effective carbon sink. They also provide a primary source of income/food for ~ ⅓ of the world, and hundreds of billions of dollars in ocean tourism

However it is still unknown how much of that oxygen is going into terrestrial life, and how much is absorbed by ocean life.

Even if they provide no oxygen for us, the way I look at it is; It is completely absurd to think we can survive the inevitable trophic cascade that would result from the extinction of the very base of the aquatic food chain.

However that does not seem likely right now. Especially if we just slow down the rate of climate change, we will probably be fine. As of right now we should be concerned, but only because of the

rate at which all of this change is happening. You can see in these two graphs, although we are nowhere near the hottest earth has ever been, the rapid increase in temperature we are seeing is very unusual.
I hope you enjoyed this shorter “fact check” article, and if you want more of these please let me know!