Global phytoplankton declines over the past century

Frequently Asked Questions (FAQs)

What are marine phytoplankton?

Phytoplankton are microscopic algae which float and drift in the upper layers of the oceans. They are globally distributed. They carry out the process of photosynthesis, which means that they have the machinery to use solar energy to convert inorganic matter to organic forms which can serve as food sources for other organisms. They are thus the first step in the marine food web – the fuel which supports the entire marine ecosystem. Phytoplankton are important to humans by having strong impacts on the stability of our global climate, the maintenance of sustainable fisheries, and keeping our global oceans healthy.

Briefly, what have you found?

There are 2 main results. Firstly, we show that phytoplankton has declined globally over the past century. The rate of decline was approximately 1% of the global average per year, which translates to a decline of approximately 40% since 1950. Declines were particularly evident since 1950 and in polar and tropical regions of the global ocean. Secondly, we show that declining phytoplankton concentrations are negatively related to changing oceanographic conditions, and particularly to rising sea surface temperatures.

How did you do this study?

In this study we analyzed data collected onboard marine research vessels over the 20^{th} century. The majority of these data were measurements of ocean transparency from one of the oldest and most consistently used oceanographic instruments, the so-called Secchi disk. By combining Secchi measurements with additional measurements of phytoplankton concentration we constructed a database of almost half a million observations which covered the entire global ocean and extend back to the very beginning of oceanographic data collection in the late 1800's. We then carefully analyzed these data using statistical models in order to estimate time trends.

Were you surprised by the findings?

Yes. Previous work has document declines in different parts of the ocean. We expected to observe phytoplankton declines in some areas, and increases in others, but were very surprised to find clear evidence of declines in eight out of 10 regions around the world. Only one region, the South Indian Ocean, was increasing.

How much has phytoplankton declined over the past century?

Phytoplankton has declined by an average rate of 1% of the global average per year, which translates to a decline of approximately 40% since 1950. This does not mean that phytoplankton has declined everywhere, but represents an average rate of change. Phytoplankton declines have been greater since 1950 and in polar and tropical regions of the global ocean. Coastal regions appear to have increased concentrations in recent years.

Have phytoplankton been declining everywhere in the world?

No. We found that phytoplankton concentrations have undergone significant declines in 8 large ocean regions, were approximately stable in one region and increased in another. Declines tended to be greater in polar and tropical regions, while phytoplankton in the Indian Ocean appeared to increase. When considered globally, this results in an average phytoplankton decline globally.

Have phytoplankton been steadily declining over the past century?

No. We found that phytoplankton concentrations fluctuate from year to year and that these shorter-term variations are often driven by climate variations, such as El Nino Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO). But when we look at the long-term overall trend, we see declines in most ocean regions.

Why is this important?

Phytoplankton are one of the most important groups of organisms on the planet, as they produce half of the plant matter globally. As such they form the foundation of the entire marine ecosystem, so changes in phytoplankton concentration will ultimately affect everything in the food chain from tiny zooplankton to whales, seabirds, fish, and humans. Secondly, phytoplankton is important to earth's climate system. By taking up carbon dioxide, and by influencing cloud formation, and the reflection and absorption of solar energy, phytoplankton strongly affect our global climate. Third, by fuelling global fisheries, phytoplankton production support the supply of food from the oceans.

How does your work differ from previously published papers on global phytoplankton abundance?

Previous studies have not been able to provide a clear picture of long-term phytoplankton trends. Most previous work has been based on the analysis of satellite data, which is only available consistently since 1997, and only a few regional studies have considered long-term phytoplankton trends. By looking at global trends in phytoplankton over long time scales we are better able to separate short-term fluctuations from long-term trends, and to understand better how global warming is affecting these trends.

How different are your findings from earlier studies?

Our findings are generally supported by earlier, particularly the link to increasing temperature and stratification. The rate of decline in the North Pacific that we calculate is precisely the same as a previous analysis dating back to 1900 in this ocean basin.

Are global phytoplankton declines a serious concern?

Yes. Phytoplankton are critically important for the ocean, in the same way that all plants are on land. They have strong effects on earth's climate, support all fisheries, take up carbon dioxide, produce oxygen, and are the foundation of the entire marine food web.

How certain are you, that your findings are accurate?

We have been extremely careful in quality control of the data used in our analyses and in our choice and interpretation of statistical tools used to reach our conclusions. Our work has been reviewed by leading experts in the field. Apart from the long-term trends, the analysis approach results in well-resolved seasonal cycles in all ocean basins that are entirely consistent with conventional thinking. The analyses also clearly demonstrate a dependence on large scale climate indices – like the El Nino/Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO) - that are consistent with recent theory. All of the declines we observed were statistically significant and robust to methodology. Our findings broadly match results from earlier studies by other researchers that used alternate data to derive phytoplankton trends, therefore we can be quite certain that our findings are accurate.

What causes the decline you documented?

Rising sea surface temperatures appear to be related to the declines in phytoplankton. We believe that as temperatures continue to rise, the oceans are possibly becoming more stratified or stable which is slowing the delivery of nutrients which the phytoplankton require to grow.

How big a problem is this, compared to other problems that we already know about (e.g. oil spill, pollution, overfishing)?

This is a huge problem. As the base for most of the marine food chain, phytoplankton supports virtually all life in the oceans. It is hard to compare directly to other impacts, but the global and long-term nature of this problem is a cause for concern.

What does this mean for fisheries?

Phytoplankton is the fuel which supports the entire marine ecosystem, including fisheries. Although it is probably quite complex, declining phytoplankton could mean that there will be less resources available for marine fisheries.

What does this mean for us here in Canada?

Canada has the longest coastline in the world, and has important marine industries. According to our data, phytoplankton is declining in the North Atlantic, North Pacific and Arctic Ocean. Further investments into improved observations and interpretation are necessary to track changes in phytoplankton concentrations, understand resulting changes in regional dynamics and predict future consequences.

Can we somehow stop this plankton decline?

Continuing to monitor global phytoplankton levels with the use of in situ and satellite remote sensing and doing what we can to curb rising ocean temperatures would appear prudent.

What do you recommend should be done with these findings?

Our findings are another indication that the global oceans are increasingly stressed, and suggest that a changing climate may be responsible for this. We hope that our findings will provide further incentive to curb rising ocean temperatures. As we state in the paper, the potential consequences of a loss of marine phytoplankton provides strong incentive for an enhanced in situ and space-borne observational basis to reduce uncertainties in future projections.