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OZONE DEPLETION MAY LEAVE A HOLE IN PHYTOPLANKTON GROWTH

New research suggests that the growth of phytoplankton is reduced by 56% when stratospheric ozone drops below 17% or less than 300 Dobson Units (DU).

The research, conducted by scientists from the Australian Government Antarctic Division, the Antarctic Climate and Ecosystems Cooperative Research Centre, and the University of Tasmania, sounds a warning that ozone depletion over Antarctica could have a bigger impact on marine life in the Southern Ocean than previously thought.

Antarctic Division biologist, Dr Andrew Davidson, Honours student Nina Cadman, and their colleagues*, used satellite data to determine concentrations of ozone and phytoplankton chlorophyll over 10 million square kilometres of the marginal ice zone around the East Antarctic coast during November and December, between 1997 and 2000.

Ozone depletion affects living organisms by allowing more damaging solar ultraviolet-B radiation (UVBR) to reach Earth. Since the mid-1970s, man-made chlorofluorocarbons and halons have caused a profound decline in stratospheric ozone over Antarctica. As a result, ozone concentrations during spring (September-November) commonly fall below 50% (around 180 DU) and may decline below 30% of pre-ozone depletion levels – more than doubling the amount of UVBR reaching the Earth's surface. Some ozone depletion even persists until February, leading to a 50-100% increase in UVBR around the height of summer.

'Thus, UVBR is enhanced throughout the period of greatest biological production in Antarctic waters,' Dr Davidson said.

Comparing satellite measurements of chlorophyll and ozone, the research team found that the rate of chlorophyll accumulation at ozone concentrations less than 300 DU was around half that at higher ozone concentrations. This resulted in 56% less chlorophyll being accumulated in the marginal ice zone over November and December at low ozone concentrations.

'Interestingly, the 56% inhibition we obtained equated to around a six percent inhibition of each phytoplankton generation over the two months of our study,' Dr Davidson said.

'Previous studies suggest Antarctic phytoplankton are inhibited around six percent by ozone depletion in the marginal ice zone but, crucially, have neglected to consider any cumulative effect of UV-induced inhibition of successive generations.'

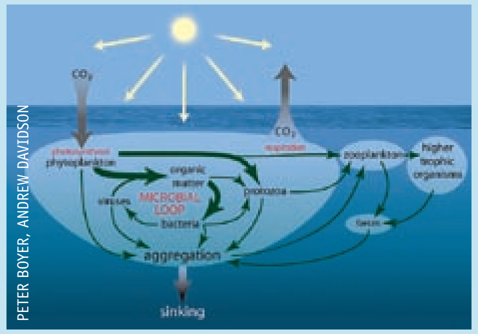
Phytoplankton is the base of the marine food web, acting either directly or indirectly as a food source for all other organisms. As a result, Dr Davidson said such marked inhibition would profoundly reduce the amount of food available for other organisms in Antarctic waters. It could also affect global climate, as phytoplankton production facilitates the transfer of carbon from the atmosphere to the deep ocean for geological time periods, thereby reducing the accumulation rate of greenhouse gas and global warming.

However, Dr Davidson cautions that there are limitations associated with this preliminary research.

'Ozone rarely falls below 300 DU around the height of summer and we require more information at this critical time. In addition, changes in ozone concentration coincide with changes in a range of environmental variables. So we cannot exclude the possibility that the ozone acts, partly or wholly, as a proxy for another unmeasured environmental factor that influences chlorophyll accumulation,' he said.

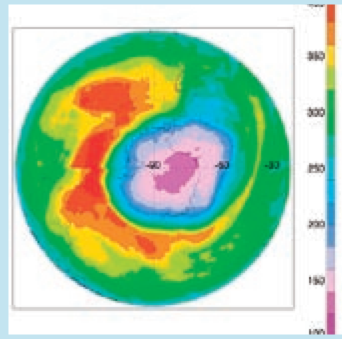
The team is addressing this, and other questions, through continued research.

**Kelvin Michael, Manuel Nunez, Simon Wotherspoon and Ben Raymond*



This schematic illustrates the role of marine microbes in the Southern Ocean carbon (energy) cycle. Arrows show the main directions of carbon flow and thicknesses indicate the magnitude of flow. Carbon dioxide (CO_2) from the atmosphere dissolves in seawater and is converted into living matter by phytoplankton, providing the energy that fuels the Antarctic food web. Respiration of this carbon releases CO_2. Most of this matter is consumed by protozoa or bacteria, with only a small proportion reaching higher trophic levels (such as zooplankton, fish, squid, penguins, seals and whales). However, large, heavy particles sink, carrying carbon derived from the atmosphere to the interior of the ocean, where it remains for geological periods of time.

This map shows the regions around the east Antarctic coastline from which satellite-derived measurements of chlorophyll and ozone were obtained.



Stratospheric ozone concentrations over Antarctica and the Southern Ocean on the 1st November 1999. Measurements from TOMS (Total Ozone Mapping Spectrometer) and TOVS (TIROS Operational Vehicle Sounder) satellites.
Both data sets merged and grided by Andrew Klekociuk, AGAD.

Krill school takes shape

Shape matters to Antarctic krill – it may affect where they swim in a school and could have implications for the estimation of krill biomass in the Southern Ocean.

The shapes of 220 krill were digitised (using the yellow reference points) and a mathematical technique, geometric morphometrics, was used to generate an average krill shape.

Dr Luke Finley of the Australian Government Antarctic Division used digital photography and computer software to digitise the shapes of 220 male, female and juvenile krill. Using geometric morphometrics, a mathematical technique for visualising and quantifying shape, he generated a generic krill shape – the average shape of all the krill photographed.

By comparing individual krill shapes with the generic krill shape, Dr Finley found that mature female krill had a larger upper body (thorax) than males or juveniles, which they use to store their eggs. Male krill, however, appear to be built for speed with more streamlined bodies and longer more powerful tails. These differences are most apparent during the krill breeding season in the Antarctic summer.

'Female krill breed near the continental shelf of Antarctica and then swim out into the open ocean to lay their eggs. They are more interested in conserving energy and investing in the production and safety of their eggs, than speed, and their shape reflects this behaviour,' Dr Finley said.

'Males, on the other hand, may sacrifice their safety and physical condition for speed and increasing their chance of mating with females – a live fast, die young strategy.'

Dr Finley used these shape measurements and other research to hypothesise what a school of krill might look like.

'My theory is that a school is comprised of a dense core of female, sub-adult and juvenile krill, and that these individuals cycle through to the edge of this core to feed, defecate or release eggs. In contrast, males tend to stay on the outside of the school and use their superior speed to dart into the edges of the school to mate.'

This theory is difficult to prove as there are limits to how effectively a school can be sampled in the open ocean. However, trawl samples taken through a krill school by other researchers, found that krill caught near the edge of a school were predominantly males, while those caught in the middle of a school were predominantly females.

Dr Finley's research could have implications for how precautionary krill catch limits are set in the Southern Ocean by the Commission for the Conservation of Antarctic Marine Living Resources.

Currently, acoustic scientists at the Antarctic Division are working on improving the procedure for the estimation of krill biomass. There are certain parameters used in the estimation that could be improved, and integrating the diversity of krill shapes observed during Dr Finley's study may help this process.

'It leads to the question of whether we should split krill into different shapes when we do these estimates, such as adult males and females, rather than using a generic krill shape,' Dr Finley said.

'Also, different geographic regions could be characterised by different krill shapes. For example, juvenile krill are more likely to be found inshore, while egg-bearing females are present in the open ocean. These are some of the questions we will be investigating to see if they have any effect on biomass estimates.'

Dr Luke Finley on board the Aurora Australis.