Assessing the influence of enhanced solar ultraviolet radiation on marine phytoplankton and its consequences for ecosystem structure and function

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Man's influence on processes that conspire to influence earth's climate - the overall question of global climate change, presents one of the most serious challenges to humankind. It is generally agreed that our planet will become warmer as a result of the build up greenhouse gases in the atmosphere. At the same time, there is growing concern that earth's surface will experience large increases in incident solar ultraviolet radiation (UVR, 280-400nm) as a result of the decline in stratospheric ozone concentrations. Until recently, it was thought that stratospheric ozone losses were confined to the 'ozone hole' appearing over the Antarctica, but recent observations indicate large downward trends over the Arctic and mid-latitude areas of the Northern Hemisphere (Booth *et al.*, 2000) (Figs. 1 & 2).

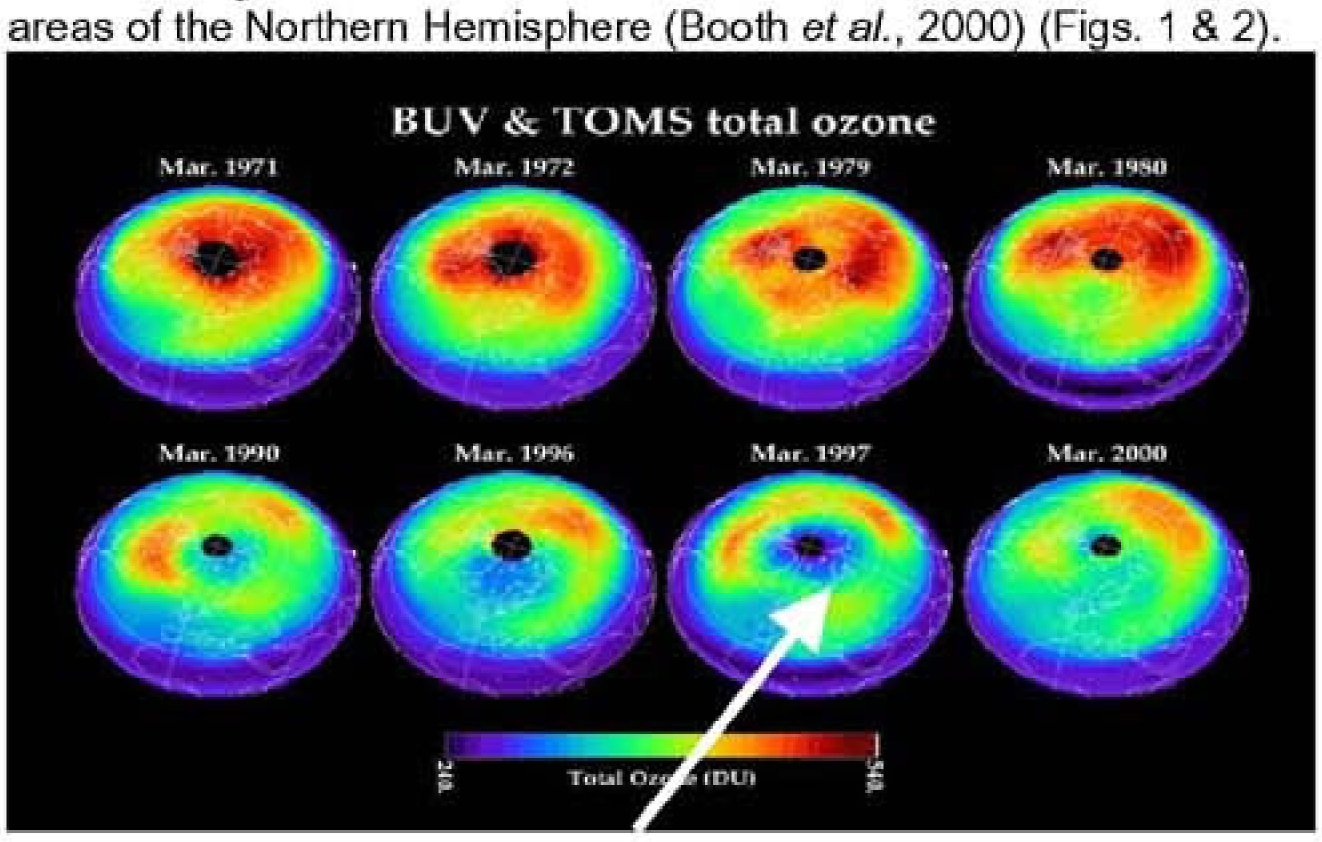

Fig. 1. Changes in stratospheric ozone over the Arctic from 1971 to 2000. Courtesy TOMS data, NASA, USA. Arrow shows the development of an ozone hole in March 1997

Despite international efforts to reduce the use of ozone destroying compounds, stratospheric ozone losses will continue unabated over the next several years and it is predicted that these losses will lead to formation of an Arctic ozone hole as severe as that currently forming over the Antarctic.

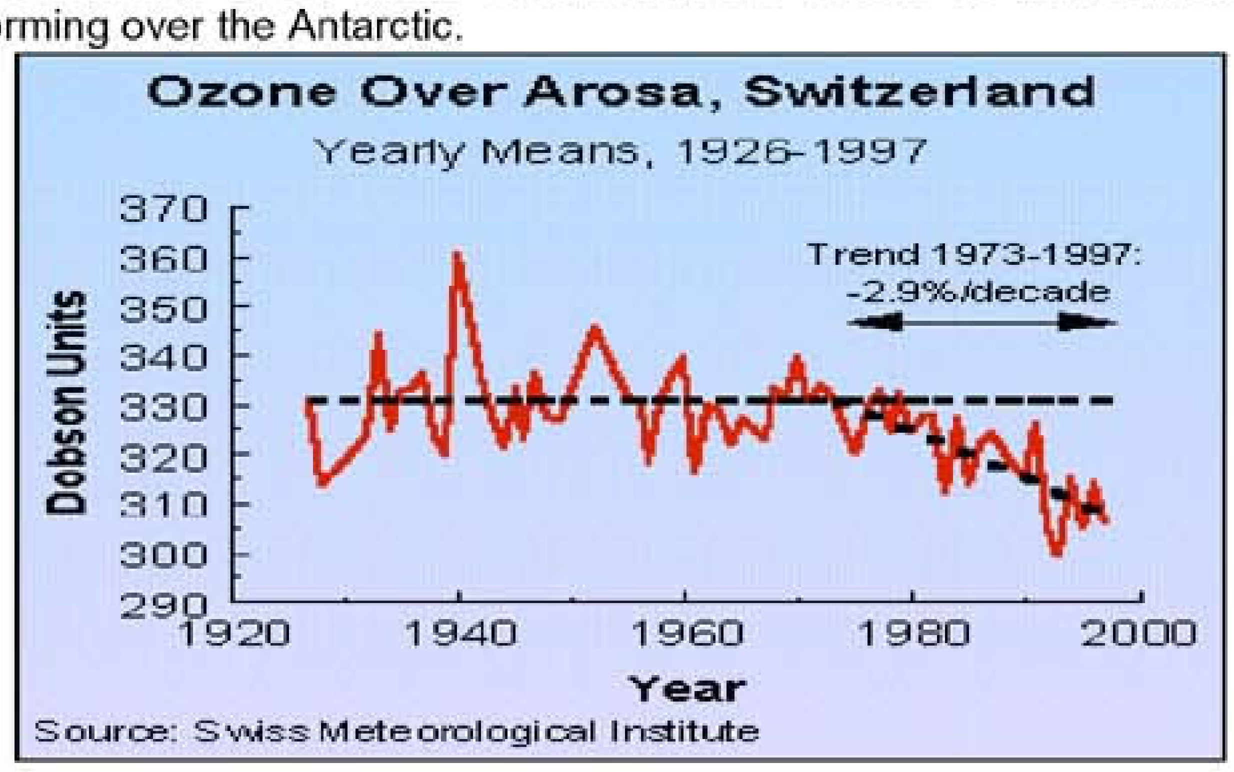

Fig. 2. Trends of stratospheric ozone over Switzerland

UVR is harmful to all forms of life on this planet, especially plants, because of their dependence on solar radiation for photosynthesis and growth. Phytoplankton in the sea, are particularly vulnerable to enhanced UVR and evidence from the Antarctic Ocean and the tropics suggests that present levels of UVR are impairing phytoplankton productivity. Yet, efforts at extrapolating these findings to allow for accurate and unambiguous predictions of the consequences of UVR enhancement on the aquatic food web and biogeochemical cycles have proved to be problematic. A major complication is that phytoplankton sensitivity to UVR varies widely across taxonomic groups. If these differences are large enough, we hypothesize that an increase in UVR arriving at the surface of the ocean could cause species shifts in phytoplankton communities and changes in the quality of food available to higher trophic levels.

Phytoplankton belonging to the Class Dinophyceae (Dinoflagellates), appear to possess several physiological, biochemical as well as morphological features, that could potentially be utilized to mitigate the harmful effects of UVR. For example, most Dinoflagellates are capable of avoiding high light intensities on account of their motility.. In addition, several Dinoflagellates are capable of synthesizing compounds such as mycosporine-like amino acids (MAA's) and pigments, which could function as screens against UVR. Together, these characteristics could offer dinoflagellates a competitive advantage over other phytoplankton in a UVR enhanced environment. As part of this research proposal, we will compare the physiological and biochemical responses of Dinoflagellates and other phytoplankton groups with the goal of predicting whether an increase in ambient solar UVR at earth's surface will lead to more frequent outbreaks of Dinoflagellate blooms. This is particularly worrisome because Dinoflagellates are capable of producing toxins that can cause fish mortality and lead to the complete collapse of fishing industries. For countries such as Japan, Norway, UK, USA etc, coastal fisheries is an important food and economic resource and the possibility of more frequent occurrences of toxic dinoflagellate blooms is particularly a matter of concern. As part of this study we will trace the pathways leading to the formation of MAAs and try and understand under what conditions these compounds are produced. In our past studies the effects of UVR on the biosynthesis of amino acids (Goes *et al.*, 1995a; b), we were able to observe that UVR had no effect on the shikimate pathway (Fig. 3). Interestingly this pathway also leads to the formation of MAAs. We will also investigate the formation of toxins and examine

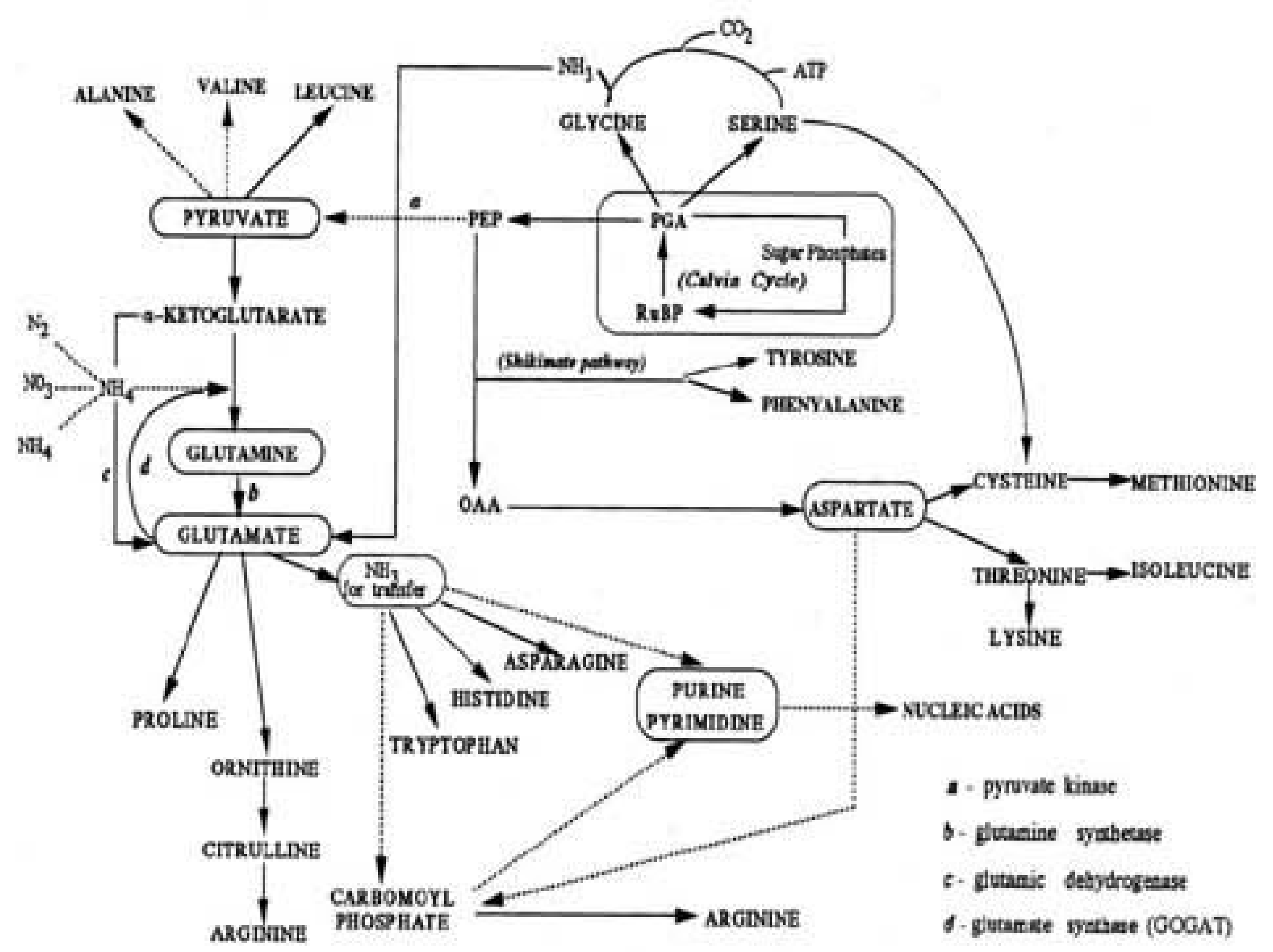

Fig. 3. Schematic diagram showing the major pathways of amino acid synthesis in phytoplankton. Unbroken lines indicate pathways that are unaffected by UVR, whereas broken arrows indicate pathways that are affected by UVR. (Goes et al., 1995a, b)

whether the production of toxins is related to UVR. We will also examine dinoflatellate-viral relationships for their bio-remediation potential to combat the outbreak of harmful dinoflagellate blooms.

References:

Booth, C.R., G. Bernhard, J.C. Ehramjian, L.W. Cabasug, V.V. Quang, and S.A. Lynch. (2000). United States National Science Foundation/Biospherical Instruments Inc., San Diego, CA.

Goes, J. I., N. Handa, S. Taguchi, T. Hama, H. Saito (1995a) *J. Plankton Res.*, **17**: 1337-1362.

Goes, J. I., N. Handa, S.Taguchi, T. Hama (1995b) *Photochem. Photobiol.*, **62**: 103-110.