The following appendix accompanies the article:

Temporal changes in effects of ambient UV radiation on natural communities of Antarctic marine protists

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Appendix 1. Light model description

Throughout the experiments, erythemal UV radiation and PAR measurements were obtained using a Solar Light Company 501A Biometer (PA, USA) and a LI-COR LI-190SA Quantum sensor (Nebraska, USA) mounted on the roof of the minicosm container. The Biometer and LI-COR were sampled every second and the average irradiance logged at 10-minute intervals. Due to the failure of the spectroradiometer, we were unable to quantify the spectral irradiance of the light to which microbial communities were exposed during the experiments at Davis Station. Consequently, upon return to Australia, the transmittance of PAR and erythemal UV into each minicosms container was modelled and the model used to quantify the 10 min averaged irradiances received by the microbial community in each tank during each experiment. Stratospheric ozone concentrations and specific cloud conditions at Davis Station could not be replicated. However, measurements were performed in austral spring to ensure similar solar zenith angles and, like Davis, were obtained in conditions ranging from clear sky to heavily overcast.

The biometer used at Davis (above) was calibrated against a Kipp and Zonen Brewer Spectroradiometer (Lincolnshire, UK) over 3 d of simultaneous measurement of solar radiation between 12:00 and 16:30 h local time. For comparison with the biometer, results from the spectroradiometer were spectrally weighted using the erythemal weighting function of McKinlay & Diffey (1987). The LICOR LI-190SA PAR sensor used at Davis was calibrated against and a LI-COR LI-190SZ Quantum Sensor. The biometer and LICOR LI-190SA PAR sensor were mounted on the roof of the container as at Davis. The remaining sensors were used to measure the coincident irradiance at various positions in a minicosms to quantify attenuation due to: 1) the dome, reflective tubing, water surface and each UV-attenuating screen, 2) depth and 3) changes in solar zenith angle. Attenuation of light by 4) the microbial community in the minicosms was also estimated. A minicosm was filled with 0.22 µm filtered seawater and measurements obtained vertically at 2, 27 and 57 cm depth, and laterally between the centre and walls of the tank.

1) Attenuation from the container roof to the surface of the water (ks): PAR and UV was measured at 2 cm depth below the water surface under each of the 6 different UV-attenuating screens on several days over a 6 week period. Results were used to derive attenuation factors for PAR and erythemal UV for each of the 6 light treatments (see results).

2) Depth: The attenuation coefficient of PAR and erythemal UV with depth in the minicosm was determined from measurements made at a range of positions and depths in the tanks (above). The average transmittance at each depth was graphed and the attenuation coefficient (kdepth) for PAR and erythemal UV determined from the power term of the least squares exponential regression. Due to absorption of light by the natural polythene walls of the minicosm, kdepth for UV and PAR were 0.0326 and 0.0162 cm^{-1}, respectively.

3) Solar zenith angle: Changes in the transmittance of light to the minicosms as a result of varying solar zenith angle were obtained (as above) over a period of 6 weeks. Results showed that solar elevation had little influence on the transmittance of UV and PAR into the water column. Any slight influence was incorporated into other attenuating factors (above) that were made under a variety of sun angles.

4) Microbial biomass: We used a theoretical approach to quantifying attenuation of the PSAR and erythemal UV by the microbial biomass in each tank, due to differences in the microbial composition between Antarctic and Tasmanian coastal waters and the inability to grow microbial communities sourced from Tasmanian waters in winter. The absorption spectrum of a filtered sample of suspended matter in the Weddell Sea from 0.5 m depth of (Gieskes & Kraay 1990) was scaled using an optical density (OD) of chlorophyll *a* (chl *a*) of 88.7 cm^{-1} for 1g l^{-1} in water at ~673 nm wavelength (Jeffrey & Humphrey 1975, Gieskes & Kraay 1990). The radiative transfer model UVSPEC (Mayer & Kylling 2005), was used to determine the incident spectral irradiance I0 for Davis station at noon local solar time on the 21st of December using an albedo of 0.5, stratospheric ozone value of 300 DU and a sub-arctic atmosphere file. The transmitted spectral irradiance (I_T) between 280 and 700 nm was then calculated using the equation:

$$I_T = I_0 10^{-OD}$$

I_T was then weighted with the erythemal weighting (McKinlay & Diffey 1987) to calculate the erythemal UV irradiance transmitted. PAR was calculated by summing the spectral irradiances from 400 to 700 nm. The transmitted values were then compared to I_0 to determine the transmittance, T cm^{-1} of the microbial community. The attenuation cm^{-1} over a range of chl *a* concentrations [chl *a*] was calculated using the equation derived from Beer's Law:

$$k_{biomass} = -\ln(T)$$

Linear regression of $k_{biomass}$ against chl *a* concentration resulted in the equation for attenuation by microbial biomass for erythemal UV of:

$$k_{biomass} = 0.0012 * C_i$$

and for PAR of:

$$k_{biomass} = 0.00045 * C_i$$

where C_i is the chl *a* concentration [chl *a*] in the minicosm tank at a given point in time.

Chl *a* concentrations in each light treatment were determined from samples at various times during the incubation experiments at Davis Station. The biomass at each 10-min interval in at each light treatment was then linearly interpolated from the chl *a* data using the equation:

$$C_i = C_1 + \left(\frac{t_i - t_1}{t_2 - t_1}\right)(C_2 - C_1)$$

where: C_i is the interpolated chl *a* concentration at any time interval, t_i

C_1 is a known concentration at time, t_1

C_2 is the next known concentration at time, t_2

$k_{biomass}$ was then calculated at every 10-min interval for both erythemal UV and PAR in each light treatment and this coefficient used to compensate for attenuation by the microbial biomass.

The average irradiances ($\bar{I}$) in the tank were calculated after Beer's Law using the equation

$$\bar{I} = \frac{I_s}{kz}(1 - e^{-kz})$$

where: $\bar{I}$ is the average irradiance transmitted into the water column over the total depth

I_s is the incoming irradiance reaching the surface of the water in the minicosm tank

k is the attenuation coefficient which is the sum of k_{depth} and $k_{biomass}$

z is the total depth of the water

The final 10-min average irradiance beneath each light treatment (I_F) during each experiment was calculated from the PAR or erythemal UV irradiances measured on the roof of the minicosm using the equation:

$$I_F = I_0 \times k_s \times \bar{I}$$

LITERATURE CITED

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