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## Effects of solar ultraviolet radiation on photosynthesis of the marine red tide alga *Heterosigma akashiwo* (Raphidophyceae)

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### Abstract

In order to assess the short- and long-term impacts of UV radiation (UVR, 280–400 nm) on the red tide alga, *Heterosigma akashiwo*, we exposed the cells to three different solar radiation treatments (PAB: 280–700 nm, PA: 320–700 nm, P: 400–700 nm) under both solar and artificial radiation. A significant decrease in the effective quantum yield ( $Y$ ) during high irradiance periods (i.e., local noon) was observed, but the cells partially recovered during the evening hours. Exposure to high irradiances for 15, 30, and 60 min under a solar simulator followed by the recovery (8 h) under dark, 9 and 100  $\mu\text{mol photons m}^{-2} \text{s}^{-1}$  of PAR, highlighted the importance of the irradiance level during the recovery period. Regardless the radiation treatments, the highest recovery (both in rate and total  $Y$ ) was found at a PAR irradiance of 9  $\mu\text{mol photons m}^{-2} \text{s}^{-1}$ , while the lowest was observed at 100  $\mu\text{mol photons m}^{-2} \text{s}^{-1}$ . In all experiments, PAR was responsible for most of the observed inhibition; nevertheless, the cells exposed only to PAR had the highest recovery in any condition, as compared to the other radiation treatments. In long-term experiments (10 days) using semi-continuous cultures, there was a significant increase of UV-absorbing compounds ( $\text{UV}_{\text{abc}}$ ) per cell from 1.2 to  $>4 \times 10^{-6} \mu\text{g UV}_{\text{abc}} \text{cell}^{-1}$  during the first 3–5 days of exposure to solar radiation. The highest concentration of  $\text{UV}_{\text{abc}}$  was found in samples exposed in the PAB as compared to PA and P treatments. Growth rates ( $\mu$ ) mimic the behavior of UV-absorbing compounds, and during the first 5 days  $\mu$  increased from  $<0.2$  to ca. 0.8, and stayed relatively constant at this value during the rest of the experiment. The inhibition of the  $Y$  decreased with increasing acclimation of cells. All our data indicates that *H. akashiwo* is a sensitive species, but was able to acclimate relatively fast (3–5 days) synthesizing UV-absorbing compounds and thus reducing any impact either on photosystem II or on growth.

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 Keywords: Growth; *Heterosigma akashiwo*; UV-absorbing compounds; Photosynthetic quantum yield; Toxic blooms; UVR

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