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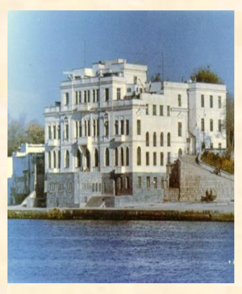
EFFECT OF PHYTOPLANKTON BLOOM ON SPECTRAL DOWNWELLING IRRADIANCE



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Effect of phytoplankton blooms on the intensity and spectral features of downwelling irradiance in the coastal waters of the Crimea during the summer period has been assessed based on measured biooptical data (Fig. 1) and modeling, which has been done by two scenarios: (1) Imitation of the bloom of Bacillariophyceae/Dinophyceae using chlorophyll a concentration as an indicator of the bloom intensity (2-10 times); (2) Imitation of the coccolithophore (class Prymneseophyceae) blooms. In this case, an increase in the proportion of this taxon in the total number of cells (Ncocco) in the phytoplankton community from 0.1 to 1 was analyzed, which corresponded to the development of coccolithophore bloom when the abundance of coccolithophore cells increased, while the abundance of other phytoplankton species decreased to 0. In this scenario we assumed that the concentration of chlorophyll a in the water practically did not change (Berseneva et al., 2004).

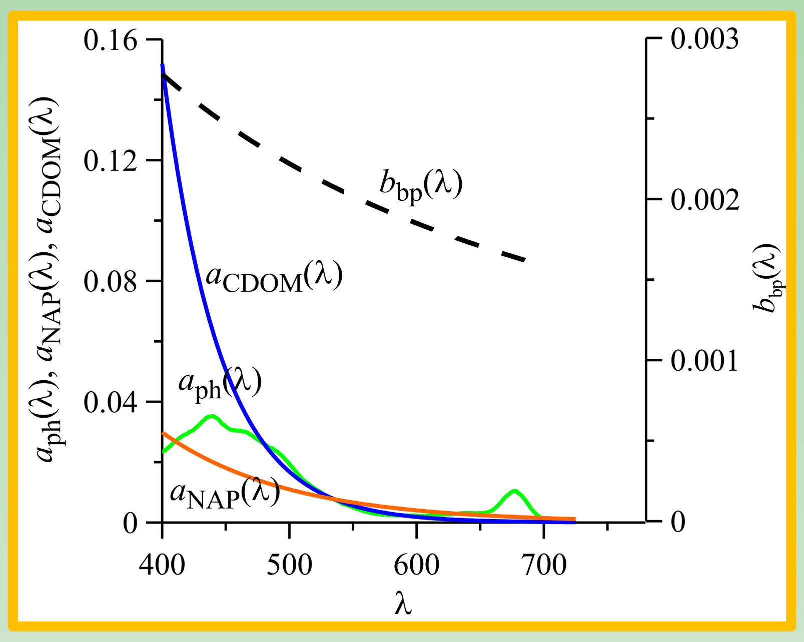

Figure 1. Control conditions in coastal waters of the Black Sea: light absorption by phytoplankton pigments ($a_{ph}(\lambda)$, m^{-1}), by non-algal particles ($a_{NAP}(\lambda)$, m^{-1}), by colored dissolved organic matter ($a_{CDOM}(\lambda)$, m^{-1}) and particulate backscattering ($b_{bp}(\lambda)$, m^{-1}).

Results. Increase in the bloom intensity leads to a decrease in the water transparency (Fig. 2, 3) and in narrowing of the euphotic zone (Fig. 4). In coastal waters mixed intensively down to the bottom the narrowing of the photosynthesis zone resulted in decrease in light intensity for phytoplankton mixed within the water layer (Fig. 4). Narrowing of the euphotic layer in the case of coccolithophore bloom was less than the bloom was associated with other taxa. It was due to significantly (almost by an order of magnitude) higher values of phytoplankton light absorption coefficients compared with the coefficients of particulate backscattering (Fig. 1).

The spectral features of downwelling irradiance (at the same optical depth) varied depending on the taxon blooming (Fig 5). The increase in bloom intensity lead to a shift of penetrating irradiation to longer wavelengths spectrum domain, which was more pronounced in the case of diatom/dinoflagellate bloom than in the case coccolithophores bloom. This difference was caused by differences in both the spectrum shape and coefficient values of absorption and backscattering of light by phytoplankton.

It was obtained that the spectral features of downwelling irradiance effected on spectrally weighted chlorophyll a specific absorption coefficient of phytoplankton (Fig. 6), which effect on photosynthetic characteristics of phytoplankton community

It was shown that in the case of coccolithophore bloom the change in water transparency leading to a narrowing of the euphotic layer was the main factor effecting the photosynthetic capacity of phytoplankton, while in the case of bloom of the other taxa (dinoflagellate/diatom), the change in the spectral features of downwelling radiance should also be taken into account.

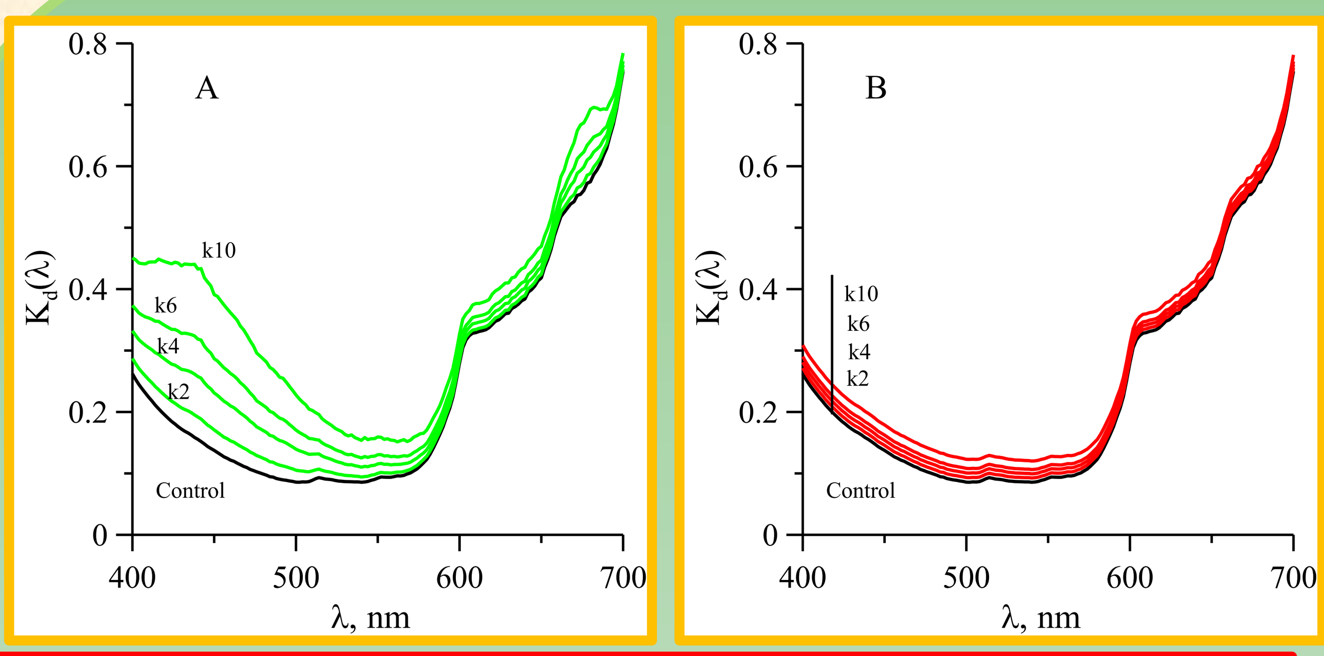

Figure 2. Spectra of light attenuation coefficients for downwelling irradiance ($K_d(\lambda)$, m^{-1}) in the case of diatom/dinoflagellate (green lines, A) and coccolithophore (red lines, B) blooming with different intensity (k) in comparison with the control (black line).

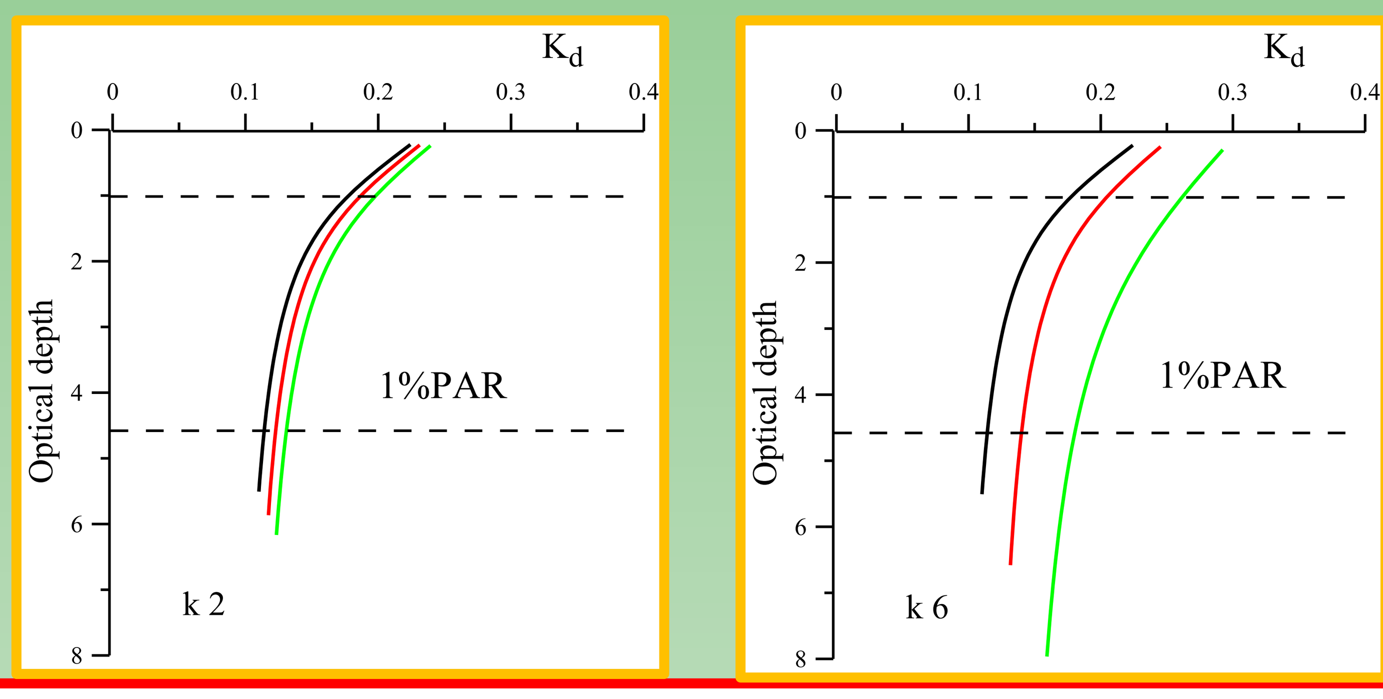

Figure 3. Dependence of diffuse attenuation coefficient of downwelling irradiance (Kd , m^{-1}) on optical depth in the case of diatom/dinoflagellate (green lines) and coccolithophore (red lines) blooming with different intensity (k) in comparison with the control (black line)

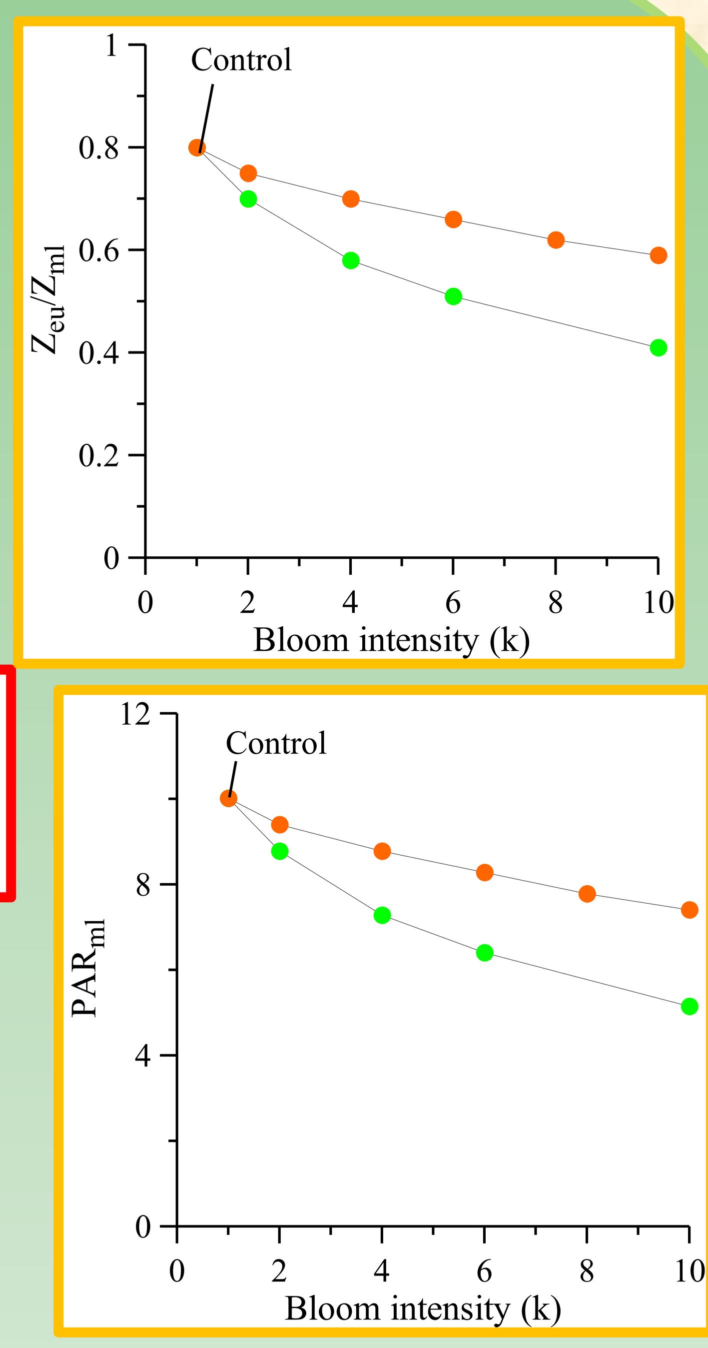

Figure 4. Effect of intensity (k) of diatom/dinoflagellate (green lines) and coccolithophore (red lines) blooms on ratio between euphotic zone and mixed layer (Zeu/Zml) and on light intensity averaged within the mixed layer (PARml, E m^{-2} d^{-1})

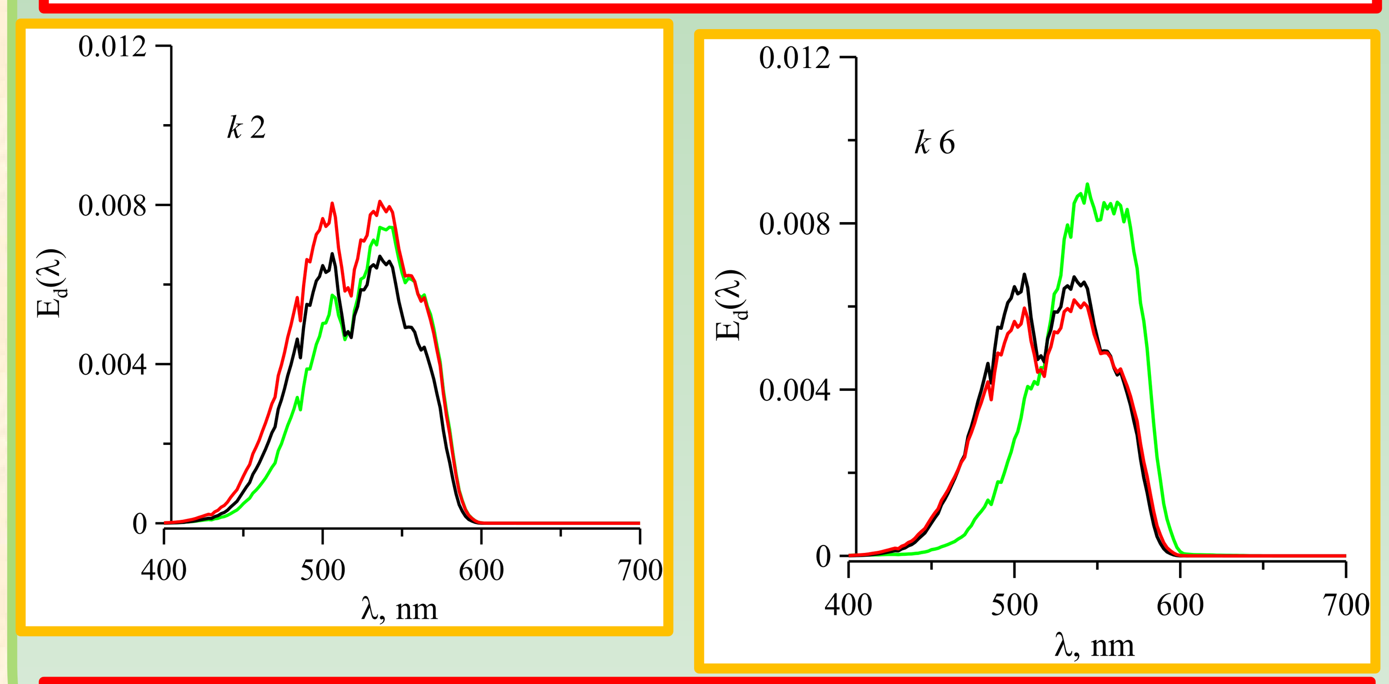

Figure 5. Downwelling irradiance (Ed(λ), E m^{-2} d^{-1}) at the bottom of the euphotic layer (1% photosynthetic available radiance) in the case of diatom/dinoflagellate (green lines) and coccolithophore (red lines) blooming with different intensity (k) in comparison with the control (black line).

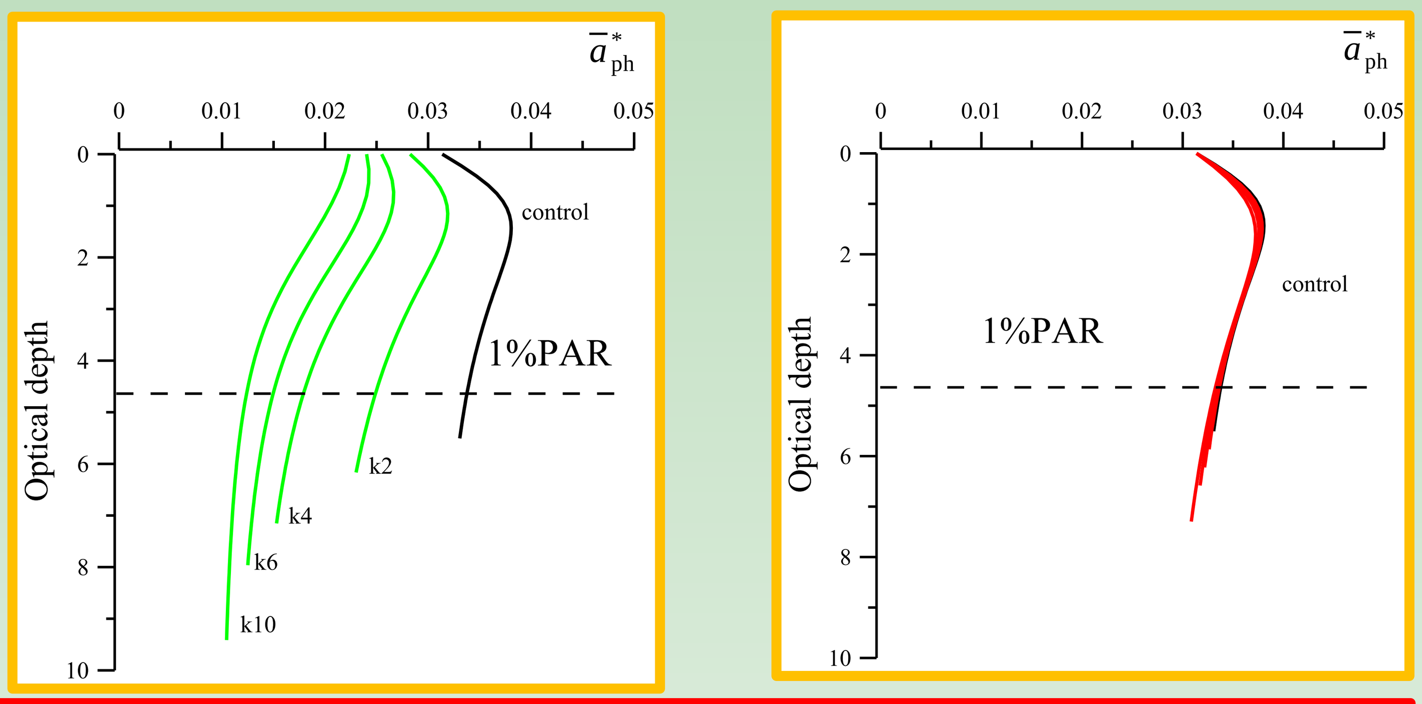

Figure 6. Dependence of the spectrally weighted chlorophyll a specific absorption coefficient of phytoplankton pigments ($\bar{a}^*_{ph}$) on optical depth in the case of diatom/dinoflagellate (green lines) and coccolithophore (red lines) blooming with different intensity (k) in comparison with the control (black line)

CONCLUSIONS:

- The phytoplankton bloom effect on water transparency and spectral downwelling irradiance, but there are difference between coccolithophore and other taxons (diatom/dinoflagellate) because of the difference between magnitude of absorption and backscattering coefficients and spectrum shape as well.
- The diatom/dinoflagellate bloom lead to the shift of penetrating wavelengths to the longer wavelength part of the spectrum, which become more significant with increasing of bloom intensity. In opposite to these taxons coccolithophore bloom results in a less decrease of water transparency and in a slight (even not apparent) change in spectral downwelling irradiance.
- The changes in spectral downwelling irradiance (diatom/dinoflagellate bloom) result in decreasing of phytoplankton capacity to absorb available light, which in turn effect on photosynthetic capacity of phytoplankton (namely it will reduce chlorophyll a specific rate of photosynthesis).

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