

COMPREHENSIVE SERIES IN PHOTOCHEMISTRY  
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Volume 1 UV Effects in Aquatic Organisms and Ecosystems  
Edited by E.W. Helbling and H. Zagarese

COMPREHENSIVE SERIES IN PHOTOCHEMISTRY  
& PHOTOBIOLOGY – VOLUME 1

# UV Effects in Aquatic Organisms and Ecosystems

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# **Modulation of UVR exposure and effects by vertical mixing and advection**

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## Abstract

Vertical mixing processes determine the depth range of water that exchanges through the relatively shallow photoactive zone where most UVR effects occur as well as the residence time of constituents (molecules and organisms) in this zone. Depth of mixing varies through the global ocean and among lakes as a function of latitude, season and various regional effects. The rate of vertical mixing is a function of convective and turbulent energy relative to water column stability. Mixing rates can be broadly characterized through scaling relationships however estimates of residence times in the photoactive zone vary from a few minutes to longer than a day so specific estimates are needed to assess how UVR exposure is modulated in any particular system.

There are few studies of UVR effects in the context of variable vertical mixing, these have used both experimental and modeling approaches. The results suggest that UVR effects are modulated by vertical mixing to the extent that responses are dependent on the duration and irradiance of exposure. Vertical mixing can actually enhance UVR effects integrated over the water column when responses depend on cumulative exposure and UVR effectiveness declines with exposure duration (photobleaching of dissolved organic matter, photoinhibition of Antarctic phytoplankton, mortality of ichthyoplankton). In contrast, if repair is present, but modest, vertical mixing can moderate effects (e.g., increase survival of zooplankton). If damage and repair are balanced so that responses reach a steady state over typical exposure times, vertical mixing can have little effect on water column responses.

Our present understanding of mixing and UVR effects has been limited by both the availability of physical measurements and the oversimplified representation of mixing processes in experiments and analyses. This is expected to change in the future as it becomes more practical to incorporate mixing measurements into field work, and as experimental exposures and mixing models become more sophisticated and allow a better approximation of actual water column conditions.