

effect. Further, it is recognized that UV-B radiation may both inhibit and stimulate plant flowering, depending on the species and growth conditions. Recognizing that interactions between UV-B radiation and other environmental factors are important in determining potential UV-B radiation effects on plants, EPA (1987, ES-42) notes that extensive, long-term studies would be required to address these interactions.

With regard to effects on aquatic organisms, EPA (1987, ES-42) notes that while initial experiments show that increased UV-B radiation has the potential to harm aquatic life, difficulties in experimental designs and the limited scope of the studies prevent the quantification of potential risks. Some study results suggest that most zooplankton show no effect due to increased exposure to UV-B radiation up to some threshold exposure level, with exposures above such threshold levels eliciting notable effects. For species under UV-B stress, such effects could include reduced time spent at the surface of the water, which is critical for breeding in some species, possibly leading to changes in species diversity. It is also noted that, as do all other living organisms, aquatic biota cope with exposure to UV-B radiation by avoidance, shielding, and repair mechanisms, although uncertainty exists as to the extent to which such mitigation mechanisms would occur (U.S. EPA, 1987, ES-43). It is recognized that determination of UV-B radiation exposure in aquatic systems is complex because of the variable attenuation of UV-B radiation in the water column, and that further research is needed to improve our understanding of how UV-B radiation exposure affects marine species, particularly given their world-wide importance as a source of protein.

With regard to EPA's characterization of UV-B radiation-related effects, one commenter noted that there is now more information about the welfare effects of UV-B radiation than there was in the record of the 1997 review,⁷⁴ and asserted that this information is sufficient for the Agency to reach "rough" quantitative conclusions about some of these effects. The commenter further expressed the view that the relevant information on UV-B radiation-related effects should be evaluated as part of EPA's air quality criteria and be made subject to CASAC review.

Moreover, this commenter suggested that EPA's calling the risks "potential" effects in the proposed response is inconsistent with its concluding that such effects are "real" in the context of stratospheric O₃ depletion.

The EPA agrees that there is now more information on the effects of UV-B radiation on plants, aquatic ecosystems and materials than was available in the 1997 review, and notes that there is also more information available now on the direct adverse effects of O₃ on vegetation and ecosystems. While EPA agrees that relevant information about the welfare effects of ground-level O₃, including both potential UV-B radiation-related beneficial effects and direct adverse effects, should be evaluated as part of updated air quality criteria, EPA believes that all such updated information should be evaluated during the periodic review of the O₃ criteria and standards that is now underway. A fuller discussion of EPA's procedural approach to responding to the remand, especially with regard to incorporating new information in updated air quality criteria and CASAC review, can be found in the introduction to section II above.

Further, EPA strongly disagrees with the commenter's assertion that currently available information on the effects of stratospheric O₃ depletion is sufficient for developing credible quantitative estimates of UV-B radiation-related effects associated with changes in ground-level O₃ likely to result from attainment of a more stringent O₃ NAAQS. While EPA has developed quantitative estimates of the impacts of relatively large and broadly uniform increases in incident UV-B radiation associated with projected changes in the global reservoir of stratospheric O₃, it is not necessarily the case that EPA can now develop credible estimates of impacts associated with the relatively very small and locally variable increases in incident UV-B radiation that may result from future projected changes in ground-level O₃. The EPA believes that this commenter is ignoring both the fundamental differences in the nature and relative magnitude of the temporal and spatial variability of O₃ levels in the stratosphere and ground-level troposphere, and the importance of area-specific assessments for addressing impacts related to changes in ground-level O₃ that take into account relevant factors (as discussed in section II.B above). Area-specific factors that would be important in assessing the potential for UV-B radiation-related consequences of a more stringent O₃ NAAQS on plants, aquatic ecosystems,

and materials in any geographical area are the same or analogous to factors that are important in assessing the impacts on human health. Such factors include the temporal and spatial patterns of ground-level O₃ throughout a geographic area where reductions are likely to occur, the associated temporal and spatial patterns in UV-B radiation flux, and the sensitivity and spatial and temporal exposure patterns of plants, aquatic systems and materials to the relatively very small and highly variable changes in UV-B radiation associated with relevant changes in ground-level O₃.

For example, the commenter specifically noted that new information on the effects of stratospheric O₃ depletion finds that solar UV-B radiation can affect marine ecosystems by damaging the early developmental stages of some marine organisms that, in turn, can result in significant reductions in the size of the populations of larger animals that feed on these animals. Thus for marine ecosystems, increased UV-B radiation is most likely to have an effect over specific geographic areas and during specific periods of time in the life cycles of some marine organisms. This geographic and temporal specificity is not important in estimating the impacts associated with changes in stratospheric O₃, given its relative spatial and temporal stability. Such assessments of the effects of long-term declines or restoration can reasonably assume that short-term and local-scale variations in important factors, such as developmental stages of marine organisms, will tend to "even out" over time, permitting more confidence in the magnitude and direction of such assessments. In contrast, such geographic and temporal factors would have a major influence in estimating impacts associated with the localized and highly variable changes in ground-level O₃ associated with attaining a more stringent O₃ NAAQS. In particular, as discussed above in section II.B.2, coastal areas tend to have much lower ground-level O₃ levels relative to inland areas, and there is little evidence to indicate that attaining a more stringent O₃ NAAQS would appreciably change O₃ levels, and associated UV-B radiation penetration, at ground-level over marine ecosystems. Further, the seasonality of ground-level O₃ levels, and efforts to reduce ground-level O₃ to attain a more stringent O₃ NAAQS, would be important to take in account in any credible assessment of impacts of changes in ground-level O₃ levels on the seasonal developmental stages of organisms in marine

⁷⁴ The commenter specifically cited an EPA Web site pertaining to stratospheric O₃ depletion (<http://www.epa.gov/ozone/science/effects.html>), with information on the effects of UV-B radiation on plant growth, aquatic organisms and materials of commercial interest.