appendix J

Development of Chesapeake Bay Percent Light-at-the-Leaf Diagnostic Requirements

The amount of ambient surface light required at the leaf surface to support underwater bay grasses survival, growth and propagation was determined by comparing the results of the following three lines of evidence: application of the 1992 bay grass habitat requirements; accounting for epiphytic light attenuation; and comparison of field conditions and bay grass growth gradients.

CALCULATION USING THE 1992 BAY GRASS HABITAT REQUIREMENTS

A set of percent light-at-the-leaf (PLL) requirements was derived by applying the salinity regime-based values for the 1992 Bay grass habitat requirements for K_d, dissolved inorganic nitrogen, dissolved inorganic phosphorus and total suspended solids (Table J-1; Batiuk et al. 1992) into the algorithm (Equation J-1) for determining PLL:

$$PLL=100[\exp(-K_d Z)][\exp(-K_e B_e)] \qquad \text{(Equation J-1).}$$

See Table VII-1 in Chapter VII for how K_e and B_e are calculated in Equation J-1. Using this algorithm, a PLL value of 8.3 percent was calculated for tidal-fresh and oligohaline salinity regimes. The calculated PLL value was 17.3 percent in mesohaline regimes and 13.5 percent in polyhaline regimes. The mesohaline and polyhaline PLL values differed, despite having the same 1992 K_d, total suspended solids and dissolved inorganic nitrogen habitat requirements, because their dissolved inorganic phosphorus bay grass habitat requirements for the two regimes differed (Batiuk et al. 1992; Dennison et al. 1993). By applying the 1992 underwater bay grass habitat requirements, the PLL requirements of 8 percent for tidal- fresh/oligohaline habitats and 15 percent (the average of 17.3 and 13.5 values) for mesohaline and polyhaline habitats were derived from this line of evidence.

Table J-1. The 1992 underwater bay grasses habitat requirements for the Chesapeake Bay and its tidal tributaries.

Salinity Regime	Bay Grass Growing Season	Light Attenuation Coefficient (meter^{-1})	Total Suspended Solids (mg liter^{-1})	Chlorophyll *a* (μg liter^{-1})	Dissolved Inorganic Phosphorus (mg liter^{-1})	Dissolved Inorganic Nitrogen (mg liter^{-1})
Tidal-fresh	April-October	1.5	<15	<15	<0.02	none
Oligohaline	April-October	1.5	<15	<15	<0.02	none
Mesohaline	April-October	2.0	<15	<15	<0.01	<0.15
Polyhaline	March-May, Sept.-November	2.0	<15	<15	<0.02	<0.15

Source: Batiuk et al. 1992.

ACCOUNTING FOR EPIPHYTIC LIGHT ATTENUATION

As noted in Chapter IV, the scientific studies used to derive the percent light-through-water (PLW) criteria did not consider the shading effects of epiphytes, which grow on underwater plant leaves at all depths and on experimentally shaded plants in the field. Several studies in various estuarine habitats indicate that light attenuation by epiphytic communities tends to contribute an additional 15 to 50 percent shading on underwater plants (e.g., Bulthuis and Woelkerling 1983; van Dijk 1993). A detailed study of turtlegrass beds in Florida coastal waters (Dixon 2000) showed that, while light levels at the maximum depth of seagrass colonization averaged about 22 percent of surface irradiance (PLW), epiphytic attenuation reduced this to approximately 14 percent of the surface light that is actually available for plant photosynthesis (PLL). This represents an average of approximately 35 percent more shading by epiphytes.

Light attenuation by epiphytic material appears to be important throughout the Chesapeake Bay, contributing 20 to 60 percent more attenuation (beyond the PLW) in the tidal-fresh and oligohaline regions, where nutrient and total suspended solids concentrations were highest, and 10 to 50 percent in the less turbid mesohaline and polyhaline regions (Figure J-1). These calculated contributions of epiphyte shading are consistent with the values derived for PLW and PLL by applying the 1992 bay grass habitat requirement values (see Table J-1) in equations IV-1 and J-1, respectively, where PLL represents approximately 30 percent additional light reduction beyond PLW.

Epiphytic material was assumed to make a 30 percent additional contribution to light attenuation throughout Chesapeake Bay shallow-water habitats. This figure was based on literature values for seagrass minimum light requirements, where epiphyte effects were either avoided with experimental manipulation (e.g., Czerny and

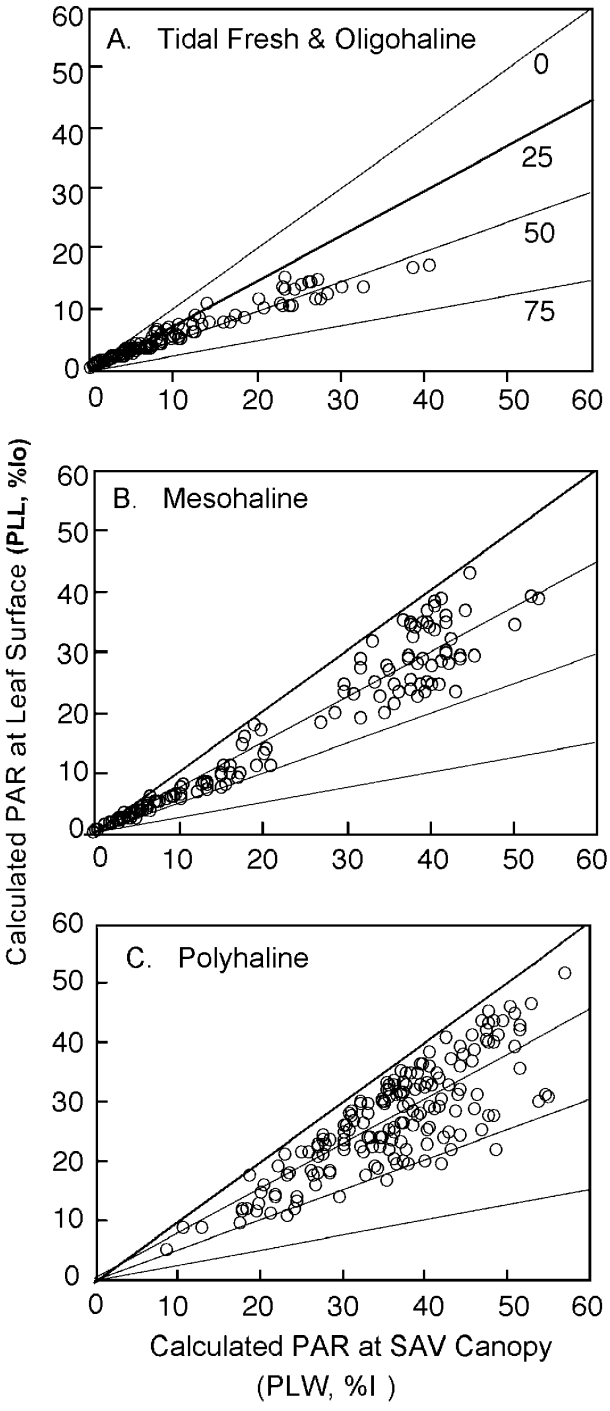

Figure J-1: Comparing values for percent light-at-the-leaf (PLL) and percent light-through-water (PLW) calculated for Z=1 meter using equations IV-1 and J-1 for water quality monitoring stations in Virginia portion of the Chesapeake Bay for 1985–1996 in three salinity regimes. Lines indicate position of points where epiphyte attenuation reduced ambient light levels at the leaf surface by 0, 25, 50 and 75 percent.

Dunton 1995) or taken into account with direct measurement (e.g., Dixon 2000) and results from analysis of Chesapeake Bay data.

Accounting for the epiphytic contribution to light attenuation, PLL requirements for mesohaline/polyhaline and tidal-fresh/oligohaline habitats were calculated to be 15 percent and 9 percent of surface irradiance, respectively. These values, which represent the minimum PLL needed to support bay grasses growth, include the additional 30 percent epiphytic light attenuation beyond the respective PLW requirements. For mesohaline/polyhaline habitats, factoring the additional 30 percent epiphytic light attenuation into the 22 percent PLW requirement yields a 15 percent PLL requirement as 30% = 100(22-15)/22[1]. A 9 percent PLL requirement for tidal-fresh/oligohaline habitats was derived by factoring the additional 30 percent epiphytic light attenuation into the 13 percent PLW requirement, as 30% = 100(13-9)/13.

The derived underwater bay grass PLW and PLL requirements for the Chesapeake Bay's mesohaline and polyhaline habitats (22 percent and 15 percent surface light, respectively) are remarkably close to the respective values of 22 percent and 14 percent surface light derived through field experimentation for turtlegrass in Florida (Dixon 2000).

COMPARISON OF FIELD CONDITIONS AND BAY GRASSES GROWTH GRADIENTS

Medians of nearshore water quality data (from the Choptank and York rivers) and Chesapeake Bay Monitoring Program midchannel data were assessed for relationships between the calculated PLL values, bay grasses growth categories and the proposed mesohaline/polyhaline and tidal-fresh/oligohaline PLL requirements of 15 percent and 9 percent, respectively. The calculated PLL values from observed water quality conditions associated with 'persistent' and 'fluctuating' bay grass beds were either very close or well above the PLL requirements, or the limited set of deviations could be readily explained (Batiuk et al. 2000). These diagnostic PLL requirements were further validated through a comprehensive analysis of 14 years (1985-1998) of Chesapeake Bay water quality monitoring data. The validation results were published in Chapter VII in Batiuk et al. (2000). From these three lines of evidence, PLL requirements of 15 percent ambient surface light for mesohaline/polyhaline habitats and 9 percent surface light for tidal-fresh/oligohaline habitats were established.

[1]6.6 percent represents 30 percent attenuation of the 22 percent light-through-water requirement. Therefore, light-at-the-leaf requirement is 15.4 percent, which is rounded down to 15 percent.

LITERATURE CITED

Batiuk, R. A., R. Orth, K. Moore, J. C. Stevenson, W. Dennison, L. Staver, V. Carter, N. B. Rybicki, R. Hickman, S. Kollar and S. Bieber. 1992. *Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis.* CBP/TRS 83/92. U.S. EPA Chesapeake Bay Program, Annapolis, Maryland.

Bulthuis, D. A. and W. J. Woelkerling. 1983. Biomass accumulation and shading effects of epiphytes on leaves of the seagrass, *Heterozostera Tasmanica* in Victoria, Australia. *Aquatic Botany* 16:137-148.

Czerny, A. B. and K. H. Dunton. 1995. The effects of in situ light reduction on the growth of two subtropical seagrasses, *Thalassia testudinum* and *Halodule wrightii*. *Estuaries* 18:418-427.

Dennison, W. C., R. J. Orth, K. A. Moore, J. C. Stevenson, V. Carter, S. Kollar, P. W. Bergstrom and R. A. Batiuk. 1993. Assessing water quality with submersed aquatic vegetation habitat requirements as barometers of Chesapeake Bay health. *Bioscience* 43:86-94.

Dixon, L. K. 2000. Establishing light requirements for the seagrass *Thalassia testudium*: An example from Tampa Bay, Florida. In: *Seagrass Monitoring, Ecology, Physiology and Management*, S.A. Bortone ed., CRC Press, Boca Raton, Florida. Pp. 9-32.

Van Dijk, G. M. 1993. Dynamics and attenuation characteristics of periphyton upon artificial substratum under various light conditions and some additional observations on periphyton upon *Potamogeton pectinatus* L. *Hydrobiologia* 252:143-161.