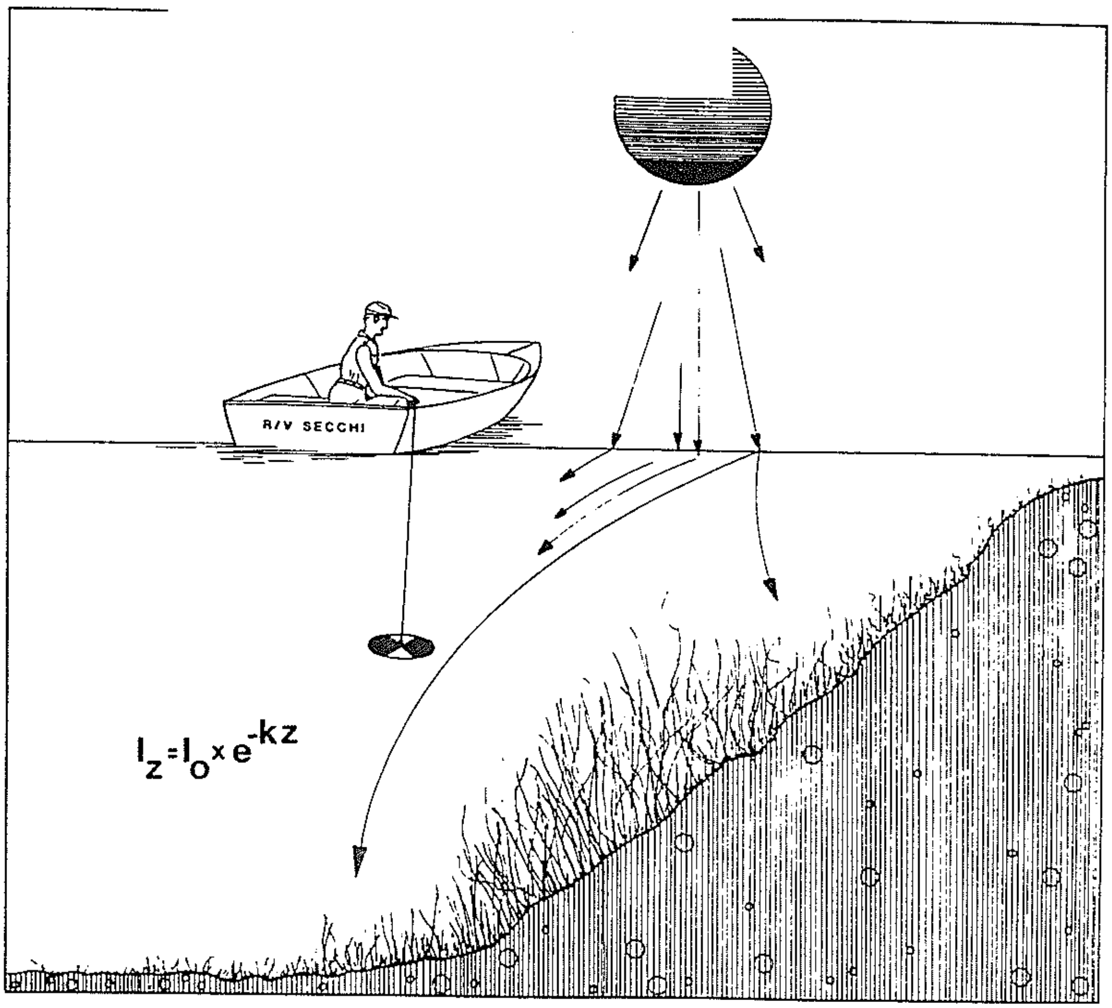
# THE LIGHT REQUIREMENTS OF SEAGRASSES






## RESULTS AND RECOMMENDATIONS OF A WORKSHOP



NOAA TECHNICAL MEMORANDUM NMFS-SEFC-287

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## DAY #1: SCIENTIFIC PRESENTATIONS

The scientific presentations covered a broad scope of laboratory physiological experiments, mesocosm research, field studies, and growth models for nearly all the seagrass species in the United States. Factors which influence the attenuation of light in the water column and control the growth of epiphytes on seagrass leaves also were discussed. These sessions were reviewed and synthesized in an open discussion period during the first evening.

Despite a wide diversity of experimental approaches, the scientists were able to demonstrate and verify by field, mesocosm, and modelling studies that the light requirements of temperate and tropical seagrasses are very similar, and are at least three to ten times greater than the traditional definitions used for the euphotic depth. The light level at which aquatic plants achieve net photosynthesis, the euphotic or compensation depth, has been defined as the depth in the water column where 1 to 5 % of the incident light remains (Ryther, 1956; Steemann-Nielsen, 1975). Unlike plankton, but similar to many submerged freshwater aquatic plants (Chambers and Kalff, 1985), seagrasses require at least 15 to 25% of the incident light just for maintenance. This is due to the large metabolic demand of their non-photosynthetic root and rhizome tissue which grow in anaerobic sediments and consume oxygen derived almost exclusively from leaf photosynthesis. In order to grow, reproduce and perpetuate their existence, seagrasses must produce more oxygen than needed for maintenance respiration, therefore, they require more light than provided at the compensation point.

When developing guidance criteria, water quality regulations or management policy, it was emphasized that resource agencies must consider that seagrasses have higher light requirements than most other marine aquatic plants. Unlike phytoplankton, seagrasses are rooted on the bottom and are not usually transported upward into the photic zone as is frequently the case with plankton. This fixed position makes seagrasses particularly vulnerable to declining or fluctuating water transparency. For these reasons, special attention must be given to maintain and improve the level of water transparency in order to sustain and enhance existing seagrass populations.

Declines in seagrass abundance have been most pronounced at the deeper edges of grassbed distributions, strongly suggesting that these declines were related to decreasing water transparency. Many of these declines have been attributed to excessive nutrient loading in water bodies, and are correlated with increased light attenuation associated with extremely high levels of chlorophyll, dissolved inorganic nitrogen, dissolved inorganic phosphorus, leaf epiphytes and suspended sediments. Likewise, where nutrient discharges have been controlled or reduced, seagrasses have returned, demonstrating the potential for successfully restoring seagrasses by managing for improved water quality with specific long term goals for habitat protection and enhancement.

The scientific presentations demonstrated that seagrass photosynthesis and growth are extremely sensitive to light levels. Field studies demonstrated that the maximum depth of seagrass distribution was correlated with average water column light attenuation, leading to the prediction that the overall abundance of seagrasses is a direct function of bathymetry and water column transparency. Experimental mesocosm research clearly demonstrated that exposure to varying degrees of increased light levels from 11% of the incident light to as much as 80%, linearly increased seagrass productivity. This relationship provides two critical management paradigms:

1) Incremental improvements in water clarity will yield corresponding higher seagrass productivity, deeper depth penetration, thus broader distribution.

2) Incremental degradation in water clarity will yield corresponding lower seagrass productivity, restricted depth penetration and thus, decreased distribution.

Based on conclusive scientific findings, it can now be unequivocally stated that the capacity of the coastal environment to withstand deterioration in water transparency is finite. Furthermore, once the buffering capacity is exceeded, additional declines in water transparency will continue to precipitate linear losses of seagrass habitat. Some seagrasses may demonstrate a temporary resiliency in their response to degradation of water transparency by drawing on stored reserves but, unless water transparency is significantly improved, there will be a predictable net loss in productivity and areal coverage. Scientists attending the workshop concluded that any enhancement of seagrass productivity through improved water clarity will lead to improved growth, successful reproduction and an increase in the overall coverage and distribution of seagrasses. In turn this will enhance the fish, shellfish and wildlife resources dependent on seagrass habitat for food and shelter and improve shoreline and benthic stability, leading to direct aesthetic and economic benefits for man.

To abate further seagrass losses, and impacts to associated economic and aesthetic benefits, workshop participants concluded that immediate actions be taken by local, state and Federal authorities. These actions must be designed to prevent any further deterioration in water quality which would exacerbate the attenuation of light in the water column or increase the growth of epiphytic algae on the surfaces of the seagrass blades beyond that which is normally tolerated by the plants. Even though there may be uncertainties in specifying the quantitative aspects of the relationship between water transparency and seagrass survival, this uncertainty shouldn't prevent immediate actions designed to solve water quality problems.

Light penetration is the most important factor affecting seagrass growth and survival and is reduced either directly or indirectly by three major sources of light attenuation:

1) chlorophyll and microalgal or macroalgal blooms due to nutrient enrichment,

2) suspended sediments and,

3) color due to dissolved organic material.

Since these three sources are derived from both point and non-point discharges, water quality compliance criteria and standards alone cannot be expected to control or abate these pollution problems. Water quality criteria and standards are based on minimum requirements for the survival of aquatic vascular plants. Federal water color criteria and the Florida transparency standard utilize the compensation depth for photosynthetic activity as the parameter to delineate the minimum allowable light level. The standard and criteria stipulate that the depth of the compensation point not be reduced by more than 10 % (substantially) compared to natural background. Because the history of significant human impacts to many coastal ecosystems is longer than the time frame over which water quality monitoring has established natural background values, the standards can only be used to maintain the status quo. A more comprehensive approach to water quality management must be adopted in order to increase light availability in environments which will support seagrass habitat.

Regional and waterbody specific management plans must be implemented which identify and control these major sources of light attenuation. It was demonstrated at the workshop that an existing light attenuation model and readily available water quality monitoring technology can be used to mathematically and physically decompose the general light attenuation measurement to indicate the relative importance of the three sources of light attenuation listed above. Use of this model in conjunction with an appropriately designed monitoring program would enable managers to focus attention on potential human impacts that are influencing water transparency. This approach would be an extremely valuable management tool for sustaining long term improvements in water quality and habitat protection.

The habitat requirements for seagrasses and the conditions under which seagrasses will survive and grow can be documented and used to establish geographically specific water quality goals and objectives. For example, in the polyhaline region of the Chesapeake Bay, scientists and resource managers have utilized historical data bases, field surveys, laboratory experiments and numerical models to identify six frequently measured water quality parameters correlated with the growth and survival of the seagrass Zostera marina (Batiuk et al., 1990). These parameters are; 1) total suspended solids, 2) chlorophyll a, 3) dissolved inorganic nitrogen, 4)dissolved inorganic phosphorus, 5) Secchi depth, and 6) the light attenuation coefficient. Two of these parameters, total suspended solids and chlorophyll a, are directly responsible for water column light attenuation, while dissolved inorganic nitrogen and phosphorus act indirectly on light attenuation by stimulating pelagic, epiphytic and macroalgal growth. Secchi depth and the light attenuation coefficient are quantitative measures of the effect the other four parameters have on water transparency. The light attenuation coefficient should be obtained with sensors that measure photosynthetically active radiation (PAR); wavelengths which encompass the light utilized by seagrasses. Collectively, these six parameters plus an additional factor, water color, provide most of the quantitative information necessary to identify the potential sources of light

**SESSION 3; INTEGRATING MODELS WITH LABORATORY AND FIELD DATA TO DETERMINE SOURCES OF LIGHT ATTENUATION AND ITS EFFECTS ON THE DISTRIBUTION AND ABUNDANCE OF SEAGRASSES.**

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MODELING SPECTRAL LIGHT AVAILABLE TO SUBMERGED AQUATIC VEGETATION

One of the major long-term biological changes in Chesapeake Bay over the last 20 years has been the severe decline in the 11 native species of submerged aquatic vegetation (SAV). Principal causes of the SAV decline are usually attributed to increases in the runoff of agricultural herbicides, toxic discharges, suspended sediments, or plant nutrients. The latter two factors, suspended sediment and nutrients, impact SAV indirectly through their effects on the penetration of light through the water column and its availability at the leaf surface. Increased nutrient loading reduces light availability by stimulating algal growth, including phytoplankton in the water column and epiphytes on the leaf surface.

Regardless of the proximate cause of SAV decline, it is clear that adequate availability of light at the plant leaf-surface represents a minimum requirement for SAV persistence of recovery. Building on recent studies of spectral light penetration in the Rhode River, we developed a model relating optical properties of the water column to the concentrations of light-absorbing and scattering materials dissolved and suspended in the water. The model partitions the contribution to total absorption and scattering coefficients amongst the various suspended and dissolved