Setting Seagrass Depth, Coverage, and Light Targets for the Indian River Lagoon System, Florida

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ABSTRACT: Seagrass protection and restoration in Florida’s Indian River Lagoon system (IRLS) is a mutual goal of state and federal programs. These programs require the establishment of management targets indicative of seagrass recovery and health. We used three metrics related to seagrass distribution: areal coverage, depth limit, and light requirement. In order to account for the IRLS’s spatial heterogeneity and temporal variability, we developed coverage and depth limit targets for each of its 19 segments. Our method consisted of two steps: mapping the union of seagrass coverages from all available mapping years (1943, 1986, 1989, 1992, 1994, 1996, and 1999) to delineate wherever seagrass had been mapped and determining the distribution of depth limits based on 5,615 depth measurements collected on or very near the deep-edge boundary of the union coverage. The frequency distribution of depth limits derived from the union coverage, along with the median (50th percentile) and maximum (95th percentile) depth limits, serve as the seagrass depth targets for each segment. The median and maximum depth targets for the IRLS vary among segments from 0.8 to 1.8 and 1.2 to 2.8 m, respectively. Halodule wrightii is typically the dominant seagrass species at the deep-edge of IRLS grass beds. We set light requirement targets by using a 10-yr record of light data (1990-1999) and the union coverage depth limit distributions from the most temporally stable seagrass segments. The average annual light requirement, based on the medians of the depth limit distributions, is 33 ± 17% of the subsurface light. The minimum annual light requirement, based on the 95th percentile of the depth distributions, is 20 ± 14%; the minimum growing season light requirement (March to mid September) is essentially the same (20 ± 14%). Variation in depth limits and light requirements is probably due to factors other than light that influence the depth limit of seagrasses (e.g., competition, physical disturbance). The methods used in this study are robust when applied to large or long-term data sets and can be applied to other estuaries where grass beds are routinely monitored and mapped.

Introduction

BACKGROUND AND PURPOSE

Seagrass coverage in the Indian River Lagoon system (IRLS) has generally declined since 1943, the earliest year for mapped seagrass coverage (Steward et al. 2003). A 1999 survey of seagrass coverage showed the highest acreage loss since 1943, up to 60%, in a 56-km reach of the IRLS from Cocoa to Palm Bay (Steward et al. 2003: Fig. 1). Most seagrass loss in the IRLS has been attributed to increasing light limitation, primarily at the deep edge of grass beds where light becomes a primary factor (Dennison 1987; Duarte 1991; Morris and Tomasko 1993; Kenworthy and Fonseca 1996; Virnstein et al. 2002). Light limitation is commonly the principal factor limiting the distribution of seagrasses and other submersed aquatic vegetation worldwide (Bulthuis 1983; Orth and Moore 1983; Duarte 1991; Walker and McComb 1992: Short and Wyllie-Echeverria 1996). For the IRLS, development of seagrass distribution targets is a key step in directing state and federal management programs with mutual goals of seagrass recovery and protection. These programs require targets to direct management efforts and a basis for monitoring progress, which seagrass restoration targets can help provide. Because seagrass losses are typically at the deep edge, distributional targets should include depth limits, corresponding acreages, and associated light requirements.

We present the methods and results used to establish seagrass depth targets, areal coverage targets, and light requirements for the IRLS. An earlier method proposed a lagoon-wide, single-value depth target (1.7 m) based on a more limited set of data collected at just 10 sites (Virnstein and Morris 2000; Morris et al. 2002). The method described here is a system-wide, stratified approach. It is an improvement over the earlier method for three reasons: natural heterogeneity and variability of this large estuarine system were considered by setting multiple, spatially specific depth targets (Virnstein et al. 2003); the most stable seagrass segments, rather than all segments, in the IRLS were used to set the light requirement; and substantially more data were used to determine the depth limits (n = 5,615 depth measurements in this study versus n = 60 in the earlier study).

Seagrass depth and light targets are the basis for developing water quality criteria. These additional criteria include pollutant load and concentration reductions that will serve to increase water column
light penetration, enabling an increase in seagrass coverage and density in the IRLS (Steward et al., 1996, 2003; Virnstein and Morris 2000).

GENERAL DESCRIPTION OF THE IRLS

The IRLS includes Mosquito Lagoon, Banana River Lagoon, and the northern and central Indian River Lagoons. Watershed boundaries are also depicted.

light penetration, enabling an increase in seagrass coverage and density in the IRLS (Steward et al., 1996, 2003; Virnstein and Morris 2000).

**Methods**

The natural spatial heterogeneity of the IRLS was considered by dividing the system into 4 sublagoons (Mosquito Lagoon, Banana River Lagoon, and northern and central IRL) and the sublagoons were divided into 19 segments (Fig. 1). Depth limit and coverage targets were established for each of the 19 segments based on the combined topological overlay or union of seagrass coverages from multiple mapping years. Segments that contained the most temporally stable seagrass coverages were used as reference areas to determine each sublagoon's maximum ecological compensation depth (see Gallegos and Kenworthy 1996; Dennison 1987) and the corresponding light requirement (expressed as percent of surface light). We used up to 7 different years of seagrass maps, 10 yr of subsurface light data (1990–1999), and bathymetry data from 1996.

**Seagrass Mapping, Light, and Bathymetry Data**

Since 1986, seagrass coverage has been mapped every 2–3 yr by the St. Johns River Water Management District (SJRWMD; Virnstein 2000; Steward et al. 2003). There is also good to excellent aerial photography of the IRLS taken in 1943. This study used seagrass maps derived from aerial photographs taken in 1943, 1986, 1989, 1992, 1994, 1996, and 1999. The aerial photographs were typically taken within a single week between late winter and late summer. Mapping included the standard steps: aerial photography, groundtruthing (except for 1943), photo-interpretation and delineation of seagrass polygons, registration of the polygons to a base map, digitization of maps into a geographic information system (GIS), and assessment of accuracy (Dobson et al. 1995; Virnstein and Morris 1996; Virnstein 2000). True-color aerial photographs were typically taken in 23 × 23 cm (9 × 9 inch) format at 1:24,000 scale and georeferenced to a base map prior to photo-interpretation. These photographs were visually interpreted into two density classes (continuous dense beds and patchy beds) with a minimum mapping unit of 0.1 ha. The deep edge of a grass bed typically was ≥10% seagrass cover. Positional accuracy was <12 m. The accuracy of seagrass coverage classification of the two most recent mappings was 92–96%.

The IRLS contains all 7 species of seagrass that occur in Florida. In order of decreasing abundance, these species are *Halodule wrightii*, *Syringodium filiforme*, *Thalassia testudinum*, *Halophila johnsonii*, *Halophila decipiens*, *Halophila engelmannii*, and *Ruppia maritima* (Virnstein and Morris 1996).