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SEASONAL AND YEAR—TO—YEAR VARIATIONS IN THE GROWTH OF *ZOSTERA MARINA* L. (EELGRASS) IN THE LOWER CHESAPEAKE BAY[1]

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ABSTRACT

Orth, R.J. and Moore, K.A., 1986. Seasonal and year-to-year variations in the growth of *Zostera marina* L. (eelgrass) in the lower Chesapeake Bay. *Aquat. Bot.*, 24: 335—341.

Seasonal and year-to-year variations in the growth of *Zostera marina* L. were measured at three sites in two locations in the lower Chesapeake Bay between 1978 and 1980. The maximum values for the 1979 above- and belowground standing crop ranged from 161—336 g dry wt m^{-2} and 61—155 g dry wt m^{-2}, respectively, leaf length was 19.6—59.7 cm and shoot density 1418—2576 shoot m^{-2}. Values for 1980 tended to be greater and may be related to climatical differences between the two years. Maximum values were usually recorded in the months of June and July when water temperatures were between 20 and 25°C. Significant loss of leaves occurred in July and August, when water temperatures ranged between 25 and 30°C, while new shoots began to appear more rapidly in late September as water temperatures dropped below 20°C. The greatest increase in all growth parameters occurred from April to June during which time reproductive shoots were present, and accounted for up to 25% of the total number of shoots.

INTRODUCTION

Zostera marina L. is the most widely distributed seagrass species in the northern Pacific and the northern Atlantic regions (den Hartog, 1970). Within the Chesapeake Bay, *Z. marina*, as well as other species of submerged aquatic plants, had been the focus of a large interdisciplinary study because of the recent large-scale bay-wide decline (Orth and Moore, 1983a). In our recent papers, aspects of the reproductive biology of *Z. marina* were discussed (Orth and Moore, 1983b; Silberhorn et al., 1983). Here, we describe changes in the standing stock of *Z. marina* at three sites in the lower Chesapeak Bay over a 30-month period.

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STUDY SITES

Z. marina was sampled from two locations in the lower Chesapeake Bay: Brown's Bay located in the Mobjack Bay, and the Guinea Marshes located at the mouth of the York River (Fig. 1). Vegetation at Brown's Bay was a mixed assemblage of *Z. marina* and *Ruppia maritima* L. (sensu lato.). The depth of overlying water was approximately 0.5 m at mean low water (MLW). Sampling at this site commenced in October 1978. Vegetation at the Guinea Marsh site was predominantly *Z. marina*, with *R. maritima* occurring only in the shallowest portions of the bed. Initially, one site was chosen for sampling, commencing in June 1978 (referred to as "Guinea Marsh offshore"). A second site (referred as "Guinea Marsh inshore"), 1000 m inshore of the first site, was added in April 1979. Water depths were similar at both Guinea Marsh sites (0.75 m at MLW); however, the inshore site, being protected on three sides by islands of *Spartina alterniflora* Lois., was less subject to wave action.

Sediments at these three sampling sites were predominantly sand (77–89%). The Guinea Marsh inshore area had a greater percentage of fine material than the offshore site (23 vs 17%) as well as smaller median grain size (3.1 vs 2.6ϕ).

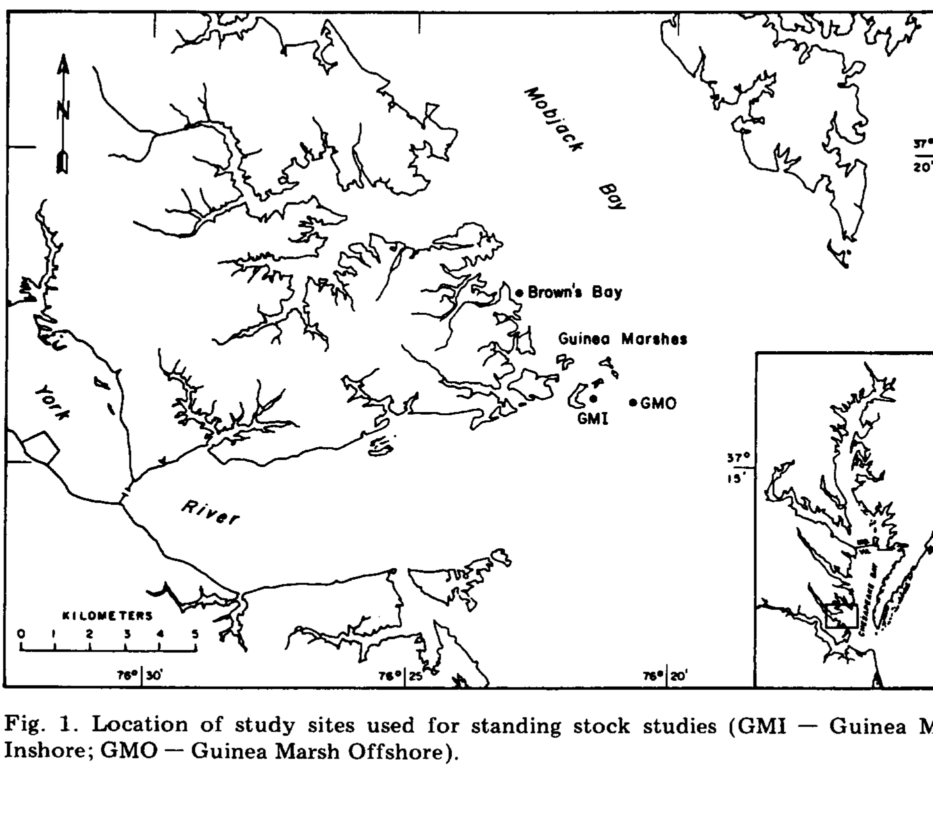

Fig. 1. Location of study sites used for standing stock studies (GMI — Guinea Marsh Inshore; GMO — Guinea Marsh Offshore).

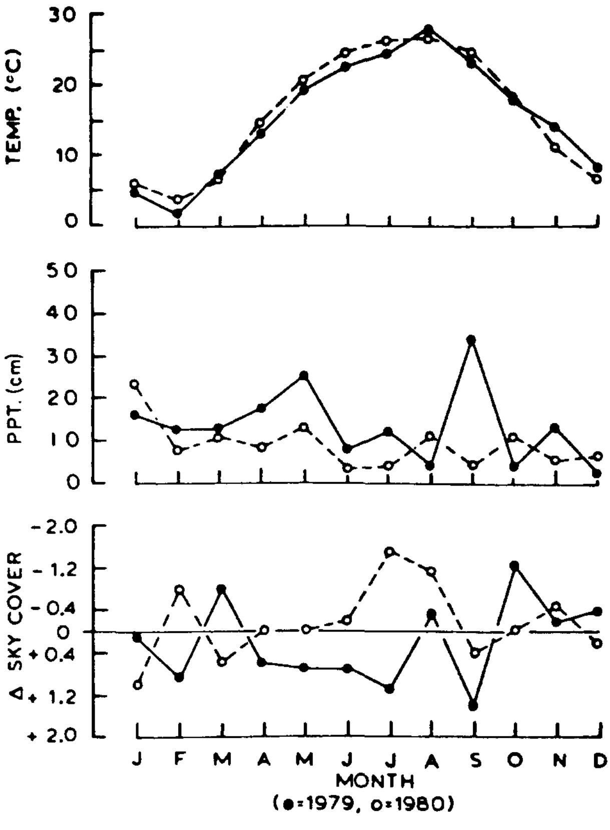

Fig. 2. Comparison of 1979 (solid circles) and 1980 (open circles) surface water temperature (Virginia Institute of Marine Science pier), monthly rainfall and the deviation in mean monthly sky cover (in tenths) from the 30 year average (Norfolk, Virginia) (reprinted with the permission of Mar. Tech. Soc. J.).

Temperature ranged from 0 to 29°C during the 3-year period from 1978 to 1980. Water temperatures for 1979 and 1980 are shown in Fig. 2. Data were obtained from a continuous temperature recorder located 12 km upriver from the Guinea Marsh site. Temperatures obtained at each site at each sampling date were compared to those of the continuous recorder and found to be similar. Data from National Oceanographic Atmospheric Administration for precipitation and sky cover, which were available for Norfolk, Virginia, a distance of 75 km away, were assumed to be representative of the sampling sites and were utilized here. Monthly rainfall and the deviation in mean monthly sky cover from the 30-year average are shown in Fig. 2. Salinities at Brown's Bay and Guinea Marsh were usually identical. Salinities were always lowest in the spring and highest in the late summer or autumn and ranged from 12.4 to 19.0‰ in 1979 and from 15.8 to 24.5 ‰ in 1980.

MATERIALS AND METHODS

Monthly samples for above- and belowground standing crop, shoot length and shoot density (vegetative and reproductive) were taken from a section of the *Z. marina* bed where cover was uniform. Initially, a 0.1-m^2 ring was placed on the bottom and all vegetation including the roots and rhizomes were removed by hand to a depth of approximately 10 cm. Four samples were collected monthly at each sampling location. In June 1979, a 0.033-m^2 core was adopted for sampling the vegetation. A comparison of the data collected using these 2 methods at 2 different sites showed no significant differences ($P < 0.05$) for the parameters being measured. Subsequently, 6 cores of vegetation were taken at each site.

After removal of the vegetation and sediment from the ring or core, all material was placed in a cloth mesh bag and washed free of sediment. Roots, rhizomes and leaves were then placed in another bag and held in running seawater until processed, normally within 24—48 h. Processing included: (1) separating the shoots from the living roots and rhizomes; (2) counting all shoots and measuring the longest leaf of 100 shoots; (3) counting reproductive shoots (when present) and recording total length; (4) drying roots, rhizomes and leaves for 48 h at 45°C; (5) placing the material in a desiccator, after drying to allow cooling to room temperature; and (6) weighing the material to the nearest 0.01 g after removing from the desiccator.

RESULTS

Peak shoot standing crop at the three sites occurred in June or July during both years with higher standing stocks recorded for 1980 compared to 1979 (Fig. 3A). Shedding of older leaves occurrred between July and September when water temperatures generally exceeded 25°C, resulting in low standing stocks between September and March. Reproductive shoots were present between March and June and accounted for 10—42% of the aboveground standing crop (Fig. 3A). Root and rhizome standing crop followed a seasonal pattern similar to the aboveground standing crop, with higher mean values in 1980 compared to 1979 (Fig. 3B).

Shoot densities were highest in June or July and decreased to minimum values in September following the summer die-off (Fig. 3C). New shoots began to emerge in October when water temperatures had dropped below 20°C, and shoot production continued throughout the winter months to the following June—July maximum. Newly germinated shoots between October and April partially accounted for the increase in shoot density. Reproductive shoots, when present, accounted for 11—25% of the total number of shoots in 1979 and 4—20% in 1980 (Fig. 3C).

Leaves reached their maximum length in June or July at the three sites (Fig. 3D). Among sites, shoots were shortest at Brown's Bay. At the Guinea Marsh Inshore site, shoots attained their greatest length in the summer of 1979 (59.7 cm), being almost twice as long as in 1980 (25.5 cm).

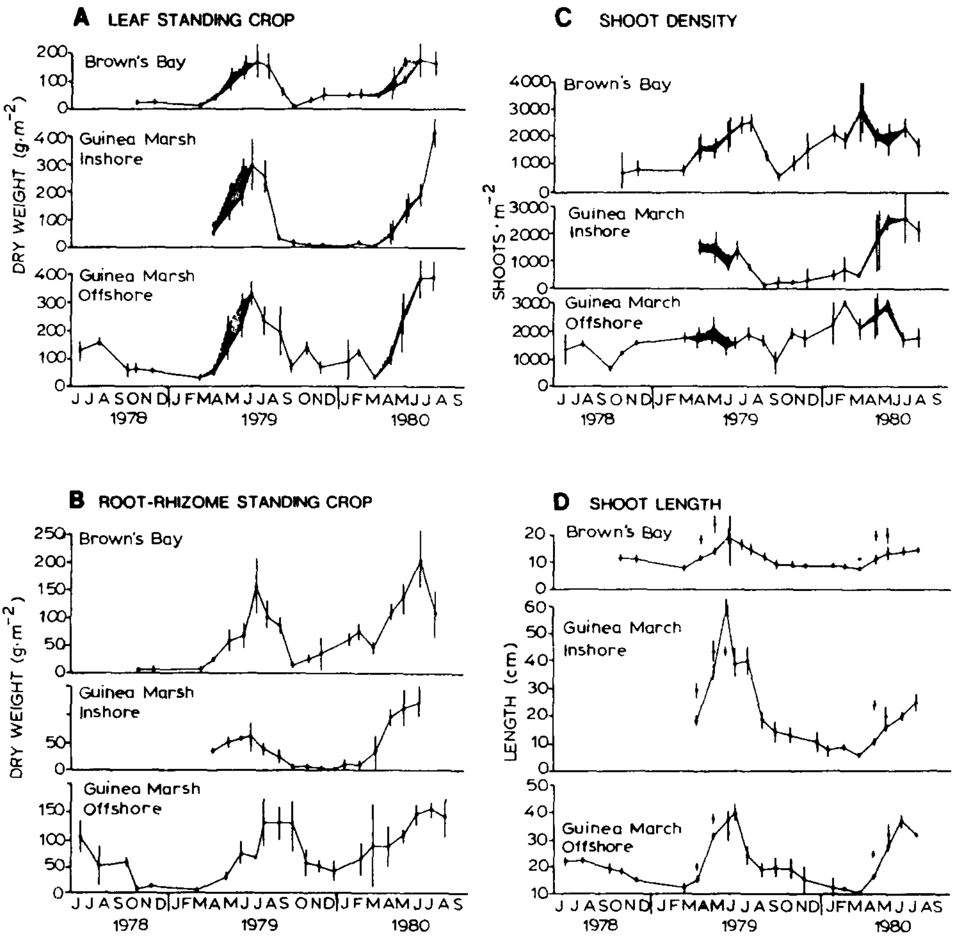

Fig. 3. (A): *Zostera marina* shoot standing crop ($g \cdot m^{-2}$ ± SD) for each sampling site each season. Shaded areas represent additional contributions by reproductive shoots. (B): *Zostera marina* root and rhizome standing crop ($g \cdot m^{-2}$ ± 1 SD) for each site each sampling period. (C): number of *Zostera marina* shoots$\cdot m^{-2}$ (± 1 SD) for each sampling site each sampling period. Shaded areas represent contribution by reproductive shoots. (D): shoot length (cm) (± SD) for vegetative shoots of *Zostera marina* during each sampling period for each site. Unattached points represent length of reproductive shoots for the sampling period.

DISCUSSION

Zostera marina in the Chesapeake Bay exhibited distinct seasonal trends in its growth pattern at the three sampling sites. Vigorous growth occurred from March to July with maximal values for all measured parameters being recorded in June or July. Flowering took place from April to June with seed release completed by mid-June (Silberhorn et al., 1983). Minimal values for all measured parameters followed the extensive leaf loss that occurred in July and August when water temperatures approached 30°C. Increasing shoot production in September or October, coinciding with a decline in temperatures below 20°C, resulted in the gradual increase in the density of shoots. However, because these shoots had very little biomass, the response in total standing crop (Fig. 3A) was not evident until April as water temperatures rose above 10°C. Also, because new shoots and leaves on existing shoots were continually produced, but grew slowly throughout the winter, the mean length of the shoots actually declined (Fig. 3D) until the spring growth period (April—June), a characteristic also noted for a European *Z. marina* bed (Jacobs, 1979). In addition, seed produced by the preceding year's spring flowering began to germinate in October—November (Orth and Moore, 1983b) and continued to germinate and grow throughout the winter, adding to the total number of shoots.

The differences in measured parameters between 1979 and 1980 may, in part, be related to different climatic conditions between the two years. Monthly mean surface water temperature, monthly precipitation and the deviation in monthly mean sky cover from the 30-year average (Fig. 2) indicated there was more rainfall (total amount each year = 165 vs 114 cm) and more sky cover in 1979 compared to 1980, as well as a difference in the heating pattern of surface water (Wetzel and Penhale, 1983). The increased sky cover and resulting lower solar insolation in 1979, especially in the spring and early summer seasons when *Z. marina* is in the most active growth phase, could have resulted in reduced vigor of the plants as suggested by Sand-Jensen (1975), Jacobs (1979) and Sand-Jensen and Borum (1983).

Yearly differences in growth parameters may also be related to the biology of the individual beds of *Z. marina* as well as specific short-term physical stresses which may initiate these biological changes. At the Guinea Marsh inshore site in early 1979, the bed was characterized by the presence of very long vegetative shoots (longest leaf lengths up to 60 cm) with 21.5% of the total number of shoots being reproductive during the flowering season. During the summer, the plants became almost completely defoliated leaving only a few remaining shoots. This significant dieback did not occur in the other areas. One possible hypothesis is that the relatively protected cove-like area in which the vegetation was growing was subject to extremely high water temperatures during certain short-term periods. Based on other observations in the area, it is not unlikely that during periods when low slack water and maximum midday solar insolation occurred water temperatures could exceed 35°C. In the other more exposed sites water temperatures generally do not rise above 30°C.

Seedling recruitment (up to 66 m^{-2}) at the inshore site accounted in the main part for the revegetation in 1980. Their vigorous growth in the spring of 1980 resulted in a greater abundance of shoots (2597 vs 1418 m^{-2}), but maximum length of the longest leaf never exceeded 30 cm compared to 60 cm in 1979.

Comparison of our data for *Z. marina* beds in Chesapeake Bay with other locations in the United States (Burkholder and Doheny, 1968; Penhale, 1977; Vaughan, 1982), Canada (Harrison, 1982), Japan (Aioi, 1980) and Europe (Sand-Jensen, 1975; Jacobs, 1979, Nienhuis and de Bree, 1980) indicated similar seasonal trends for growth and reproduction, but with a shift, depending on the latitude, in the period when maximal values were attained. Maximum values reported here for plant parameters fall within the range of maxima reported for other areas (Jacobs, 1984).

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