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Seagrass Bed Ecology: Exploring the Relationship Between Seagrass, Epiphytes and Fauna

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Abstract: One of the most significant coastal ecosystems in both tropical and temperate climates is the seagrass bed ecosystem. This ecosystem is widespread and frequently dominates the environment in shallow-water coastal areas. Large-scale detritus production, sediment stabilization, a diverse range of floral and faunal groups, and high primary and secondary productivity are all well-known characteristics of this ecosystem. Seagrass beds are essential coastal ecosystems that support high biodiversity levels and provide essential ecosystem services like carbon sequestration, nitrogen cycling, and habitat provision. The organisms known as epiphytes, which grow on the seagrass's surface and affect trophic connections and the overall functioning of the ecosystem, are crucial components of these ecosystems. These creatures include algae, bacteria, and invertebrates. Seagrass bed ecology research looks at the complex relationships between seagrass and allied epiphytes and fauna, with a focus on their ecological roles, interdependencies, and effects on seagrass productivity and health. Seagrass beds are thought to indirectly support fisheries in addition to these essential roles by providing organic matter that is incorporated into coastal nutrient cycles and encouraging secondary production, which includes fishing species.

Keywords: Seagrass Beds; Epiphytes; Fauna.

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I. Introduction

About 0.01% of flowering plants are seagrasses, which are marine monocots that have evolved to live in submerged marine environments. The spatial heterogeneity and structural complexity of seagrass habitats exhibit a discernible latitudinal gradient. Numerous faunal and floral assemblages, including fish, crabs, sponges, corals, algae, and mollusks, are linked to the seagrass ecosystem. Communities of seagrasses can be monospecific or multispecies. They display a range of rhizome traits, leaf shapes, and shoot densities. Because of physical and biological problems, many meadows don't look the same. Seagrasses grow on soft sediments from the low water mark to depths of roughly three to five meters, and they are home to a wide range of related biota. Light becomes a constraining factor that significantly impacts photosynthesis in the deeper end of seagrass meadows. The lower limit is typically associated with light irradiance. Shoots may emerge as the rhizome system develops and spreads laterally. The rhizome system allows a well-established seagrass bed to laterally spread into exposed strata. The rhizomes and roots are the main organs that absorb the dissolved nutrients from the pore water in sediments. Seagrasses are flowering plants whose pollen is carried by water currents. They are carried by water currents and produce seeds. Because of the structure of their rhizomes, seagrasses seem to reproduce more asexually. Seedlings have a hard time colonizing new areas if the sediment is not already rich in dissolved nutrients and physically stable. This can be accomplished with the aid of other plants, like seaweeds, which stabilize the sediments and provide nutrients. As a result, a seagrass bed may eventually take the place of an exposed sand patch. Because of their diverse functions and intricate ecosystem, seagrass communities must be preserved and enhanced.

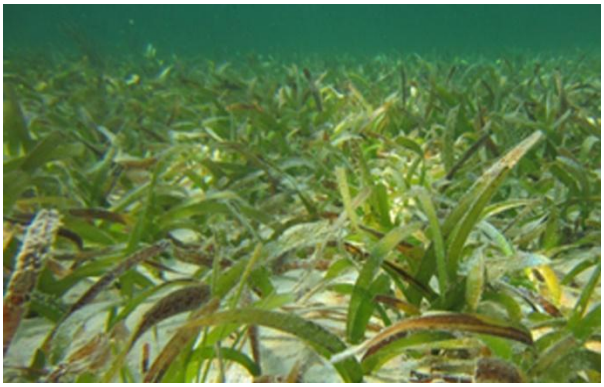


Figure 1: Seagrass Bed

Seagrasses are significant primary producers, much like salt marsh and mangrove communities. They act as homes and nurseries, support substrata, and provide a variety of wildlife with both direct and indirect nourishment. Seagrass meadows are recognized for their rich and varied ichthyo-fauna. In figure 1 shows, the seagrass beds are believed to be crucial for sustaining populations of fish and invertebrate species that are commercially exploited because they offer one or more of the following benefits: (a) a permanent habitat that permits the full life cycle to be completed; (b) a temporary nursery area that facilitates the juvenile stages' successful development; (c) a feeding area for different life-history stages; and (d) predator protection. While drift species are known to provide gammaridean amphipods with habitat and food, the functions of benthic algae are less clear. Additionally, the health of coastal ecosystems can be tracked using these submerged flowering plants. Therefore, it is clear that seagrass meadows require management and conservation when their many ecological functions are taken into account.

II. Seagrass Epiphytes

Seagrass surfaces are populated by epiphytes, which can be minute invertebrates such as hydrozoans or bryozoans, algae, or cyanobacteria (Decker et al., 2020). On the surfaces of seagrass rhizomes, leaves, or stems, organisms known as seagrass epiphytes grow without parasitizing the host plant. Because they are primary producers, have an impact on seagrass health, and are an essential component of food webs, these epiphytes are essential to the dynamics of seagrass ecosystems. In the energy transfer pathway from primary producers (seagrass) to higher trophic levels, epiphytes act as mediators (Murphy et al., 2021). Due to the higher nutritional value of epiphytes, grazers such as snails and amphipods frequently favor seagrass fronds. Seagrass ecosystems depend on epiphytes for both structure and function (do Amaral Camara Lima et al., 2023).

Primary production: When it comes to seagrass ecosystem production, epiphytes usually perform better than the host seagrass in areas with an abundance of nutrients.

Nutrient Cycling: By absorbing nutrients from the water, such as phosphorus and nitrogen column, epiphytes act as environmental nutrient reservoirs.

Seagrass Stress: Dense epiphyte mats that obstruct light and reduce photosynthesis cause lower growth rates and seagrass mortality. Alterations in Epiphyte Composition: Preference for fast-growing algae over slower-growing, more structurally complex species.

Trophic Cascades: If grazer populations are decreased (for instance, due to overfishing), unchecked epiphyte growth may be conceivable. Among the useful algae are drift algae, rhizophytic algae, attached (psammophytic) algae, and seagrass epiphytes groups into which the seagrass community's numerous species of algae can be divided (Gerstenbacher et al., 2022).

There are several species in each of these functional groupings, some of which may be prolific during certain seasons. Seagrass succession is aided by Benthic macroalgae that stabilize sediments include

rhizophytic algae from the genera Halimeda, Caulerpa, and Pencillus. Seagrass beds are home to large clusters of unattached drift algae, including Laurencia, Polysiphonia, Chondria, Hypnea, Dictyota, and Gracilaria. Epiphytic micro and macroalgae, especially filamentous and sheet-like reds and greens, are affixed to seagrass blades in figure 2 (Millot et al., 2024).

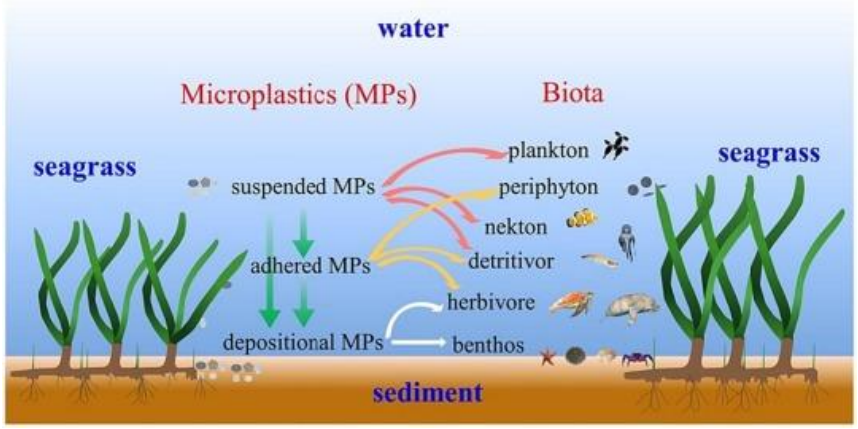


Figure 2: Schematic Representation of the Seagrass – Epiphytes – Grazer System

III. Seagrass – Epiphyte – Fauna Relationship

The main components of seagrass phototrophic epiphytes include crustose and ephemeral algae, diatoms, and cyanobacteria. Seagrass primary production has been extensively studied, but because of their low biomass, epiphytic primary production has frequently been regarded as minimal and inconsequential. Nonetheless, recent research in seagrass meadows has demonstrated that, both in terms of weight-specific and overall annual production, epiphytic primary production may frequently surpass seagrass production (Chen et al., 2021). Due to their high cellulose content, low nitrogen content, and presence of phenolics, seagrasses are not considered preferred food in these ecosystems. It has been proposed that large vertebrate herbivores are the only animals that typically consume seagrasses to a significant degree. Both floral and faunal seagrass epiphytes have the ability to add structural complexity (Hoffmann et al., 2020). For animals that passively settle, seek protection from predators, or favor environments with shelters that correspond to their body size, the increased habitat variety brought about by epiphytes may be significant. By giving related animals food and habitat, epiphytes have the potential to alter the characteristics of a seagrass ecosystem. However, because both the existence of food and modifications to structural complexity can increase an organism's density, it is challenging to interpret these interacting effects. Seagrasses tend to internalize the energy and material production of the sun and the surrounding ecosystems, including riverine, marsh, and mangrove habitats, as well as offshore coral reefs (in the tropics). They export surplus material as particulate and dissolved debris. With high levels of variety and herbivore and debris feeding webs, seagrass ecosystems can be incredibly complicated. A diverse array of plants and animals can be found in seagrass beds. Mollusks are commonly investigated in seagrass beds because they can contribute significantly to the seagrass biodiversity. Animal diversity and abundance are increased by the seagrass meadows' diverse ecosystem. Seagrass ecosystems are home to incredibly varied faunal assemblages (Jiang et al., 2023). They are crucial in transforming seagrass, microalgal, and macroalgal plants' primary production into secondary production that is subsequently consumed by higher trophic level organisms. Most frequently, fauna is divided into three major groups. Infauna are species that live in the sediment among the seagrasses' rhizomes (such as bivalves, polycheates, and holothurians); epibenthic fauna are relatively large animals that are highly mobile and not closely associated with specific seagrass plants; and epifauna are both mobile and sessile species that live on or permanently attached to the seagrass stems, leaves, or among the seagrass detritus (such as amphipods and gastropods).

IV. Methodology

The relationship between seagrass epiphytes and related species can be examined using laboratory analysis, field sampling, and experimental techniques. During fieldwork, seagrass samples are collected using standardized quadrat techniques, and study locations are selected based on a range of environmental parameters, including nutrient levels and hydrodynamics. After the epiphytes have been carefully scraped from the seagrass blades, their dry weight and organic content are measured in order to determine their biomass. After that, their composition is inspected under a microscope to check for species such as diatoms and algae. Seagrass and fauna associated to epiphytes are collected at the same time using suction sampling, core sampling, or leaf washing. They undergo species-level sorting and identification in the lab. Seagrass beds, which are essential undersea ecosystems offering a variety of ecosystem services, are formed by seagrasses, which are extremely productive submerged marine angiosperms found in shallow coastal and estuarine environments. These beds support the populations of marine creatures including ducks, dugongs, and green turtles by acting as their habitats, nurseries, and feeding grounds shows in figure 3.

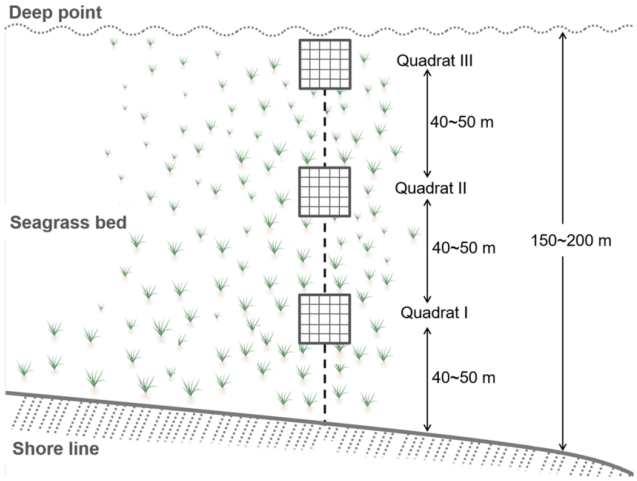


Figure 3: Schematic Transect Sampling Seagrass

Additionally, they improve water transparency by settling suspended particles and halting sediment resuspension, which aids in sedimentation. Furthermore, seagrasses' strong root and rhizome systems successfully protect sediments along beaches and coasts against tide and wave erosion. Finally, they have an impact on climate control because they are important carbon sinks in marine habitats.

V. Conclusion

In conclusion, the effects of human activity and global climate change are making the problems facing the seagrass bed ecology more severe. Human activity has a particularly noticeable effect on seagrass habitats. Coastal nutrient enrichment alters the organic carbon storage of sediments by changing the activity of microbes and algae. Seagrass and the epiphytic microorganisms can tolerate and degrade the negative effects of sulfide, heavy metals, and refractory organic compounds within a certain concentration range. The cascade effect that would result from the terrestrial input of microplastics, which would carry substantial amounts of pollutants and sediment particles, radically changing the biological and non-biological conditions of the seagrass ecosystem, requires more investigation. Numerous elements have a complete impact on the seagrass beds, and it would be impossible to overlook their intricate coupling effects. In order to more precisely identify the environmental strain that seagrass beds experience and develop scientific conservation and restoration plans for seagrass beds, it will be crucial in the future to conduct thorough analyses of numerous elements using mathematical models.

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