

THE FOOD WITHIN SEAGRASS BEDS
AND THEIR RELATIONSHIPS TO
ADJACENT SYSTEMS

Joseph C. Zieman
Department of
Environmental Sciences
University of Virginia
Charlottesville, Virginia 22903

ABSTRACT

Seagrass meadows have been shown to be extremely productive and of great value to nearshore marine regions. The earliest studies on seagrass ecosystems indicated that the dominant pathway of energy utilization was through the detrital food web. Recent research confirms that this is indeed the primary pathway for utilization of seagrass carbon, but that other pathways, notably direct herbivory and export of material from grassbeds for remote utilization, are often significant also. Energy is also exported from seagrass beds via utilization by organisms, such as grunts and snappers that reside on coral reefs, but feed in grassbeds.

INTRODUCTION

Because of their shallow sublittoral and to some extent intertidal existence, seagrass systems are subject to stresses by man's growing use of the coastal zone. Although specialized communities, seagrass beds are among the most productive, exceeding on an areal basis, for example, phytoplankton production in upwelling areas off Peru (Ryther 1969, McRoy and McMillan 1977). These seagrass

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beds, both temperate and subtropical-tropical, also support diverse and abundant fish and invertebrate faunas which often exceed, in terms of numbers and biomass, populations in unvegetated portions of the system.

Seagrass meadows act in several ways to control or modify the ecosystem, as shown in this scheme developed by Wood et al. (1969):

1. They provide food for a very limited number of organisms such as the parrotfishes, surgeonfishes, Australian garfishes, the queen conch, sea urchins, and some nudibranchs. The green sea turtle formerly grazed heavily on the turtle grass, hence the name.
2. They serve as hosts for large numbers of epiphytes which are grazed extensively, for example, by the mullets. These epiphytes may be comparable in biomass with the seagrasses themselves.
3. They produce large quantities of detrital material which serves as food for certain animal species and for microbes which in turn are used as food by larger animals.
4. They provide organic matter to initiate sulfate reduction and an active sulfur cycle.
5. They bind the sediments and prevent erosion. This also preserves the microbial flora of the sediment and the sediment-water interface.
6. They tend to collect organic and inorganic material by slowing down currents and stabilizing the sediments.
7. The seagrasses have a rapid rate of growth and produce up to 10 g of dry leaf per m² per day.

A seagrass meadow produces a great quantity of organic matter and offers a substrate for epiphytic algae, microflora, and sessile

fauna. In the case of the animal assemblage associated with above-ground portions of seagrasses, epifauna may have a close correlation with the bed, while some infauna may be an extension of the benthic community of the surrounding area. Hooks et al. (1976) studied the abundance of invertebrates in several estuaries in northwest Florida and found that greatest numbers of organisms of all of the habitats were found in seagrass beds, and that the highest abundances were associated with the densest vegetation. They concluded that many organisms are abundant in the grass beds due to (1) shelter and refuge from predation and high current velocities and (2) a food source, whether leaves, epiphytes or detritus. Similar observations and conclusions have been drawn from studies on Zostera systems (Kikuchi 1961, Marsh 1973, Thayer et al. 1975). Santos and Simon (1974) studied the abundance and distribution of polychaetous annelids in Tampa Bay, in Thalassia, Halodule and sand habitats. They found that different assemblages were not associated with different habitats, but that the Thalassia habitat had the greatest density of organisms. This also appears true in most Zostera systems that have been studied (Orth 1971, Lappalainen 1973, Thayer et al. 1975).

Nekton species fall into three major categories: some are permanent residents of the bed, some reside in the bed only seasonally, and some only use the bed during their daily foraging for food. Briggs and O'Connor (1971) and Adams (1976) have shown a greater density of fishes over seagrasses than in adjacent marine and estuarine waters. Adams (1976) presents data for seagrass beds in the Beaufort, North Carolina area which showed somewhat higher fish biomass than had been reported for Spartina

marsh ponds. These ponds are recognized as prime nursery area.

GRASSBED UTILIZATION

Seagrass food webs fall into three general categories: (1) direct herbivory, (2) detrital food webs within grass beds, and (3) detrital food webs of material that have been exported from the seagrass system. Classically the detrital web within the bed has been considered the main path of energy flow, and in most circumstances has been considered the only significant pathway. Studies in progress for the past several years have continued to show that this is the primary food web within a seagrass meadow, but that in some areas the other two pathways may be much more significant than previously suspected.

DIRECT HERBIVORY

The major vertebrate consumers of seagrasses in the Caribbean and temperate area are green sea turtles (Chelonia mydas), West Indian manatee (Trichechus manatus), waterfowl, and fishes. While populations of the green sea turtle are low in many areas of the Caribbean, green sea turtles are still regularly observed and may contribute to conspicuously "mowed" areas of seagrass beds (Ogden and Zieman, unpubl. observations). The impact of turtle feeding on seagrasses has never been fully evaluated. Manatees were once common in the mainland areas bordering the Caribbean, but were probably never important seagrass consumers in the smaller islands of the West Indies (Bertram and Bertram 1968). Stewart (1962) lists 20 species of waterfowl that feed on one or another species of

seagrass in the Chesapeake Bay region. Black brant, pintail, and scaup ducks are the most common waterfowl species which feed extensively in grassbeds. Cottam (1934) estimated that eelgrass constitutes about 80 percent of the winter food of the black brant, and McRoy (1966) estimated that black brant and Canada geese consume about 17 percent of the standing crop of eelgrass in Izembek Lagoon, Alaska during summer and fall. When nearly all of the eelgrass along the United States coast disappeared in the 1930's, the black brant all but disappeared.

Fishes associated with seagrass beds have been studied more thoroughly. Seagrass feeding in fishes is confined almost exclusively to the Caribbean (Randall 1965, 1967) and the best studies that have been done so far on diets of Caribbean fishes are by Randall (1967) and on Gulf coast fishes are by Carr and Adams (1973). Randall (1965) indicates that the movements of fishes, feeding in part on seagrasses, from reefs into seagrass beds are responsible for the formation of "halos" around West Indian patch reefs. Invertebrate consumers of seagrasses are most prevalent in tropical systems, and in temperate systems very few species feed directly on the living eelgrass blades.

Conspicuous halos surrounding coral reefs in the West Indies and south Florida are evidence of the grazing activity of herbivorous fishes and invertebrates. The primary grazers responsible for this zone are the urchin, Diadema antillarum (Ogden et al. 1973), and parrotfish and surgeonfish (Randall 1965). Both groups use the reef for shelter and protection, venturing into the relatively narrow (10 m) zone where they may feed, but are still near the protective cover of the reef.

The small grassbed parrotfish, Sparisoma radians, also abounds in the grassbeds of the West Indies and south Florida which are under strong oceanic influence. Ogden and Zieman (1977) showed that the parrotfish grazing in the vicinity of coral reefs form two distinct groups. The smaller parrotfish, Sparisoma radians, which is a grassbed inhabitant, ventures to within about 20 m of a reef and then its abundance decreases. Similarly, the larger parrotfish of the reef zone are highly abundant in the first 5 to 10 m from the reef but the number of fish decreased greatly at 20 m distance. The canopy of the grassbed presents a three dimensional shelter for small (less than 15 cm) fishes, but is two dimensional to organisms greater than 20 cm which cannot hide in the leaves. Very large parrotfish, such as Scarus guacamaia, are also seen in the grassbeds, but they are extremely wary, and the middle sized herbivores are confined to areas near the reef and its available shelter (Ogden and Zieman 1977).

Studies during the past few years in the Caribbean and in southern Florida have shown direct grazing to be a more important pathway than previously suspected. Greenway (1976) found that 48 percent of the production of Thalassia in Kingston Harbor, Jamaica, was grazed by the extremely abundant urchin Lytechinus variegatus. In St. Croix an average of 5 to 10 percent of the daily production of seagrasses is directly consumed by herbivores, with a maximum consumption of 15 to 20 percent (Zieman et al. 1979). Seagrasses are not damaged by grazing because the region of the leaf preferentially consumed is the outer portion which has ceased growing. This area of the leaf is senescent, but is often heavily colonized with

epiphytic organisms with high food value.

DETRITAL FOOD WEB IN GRASSBEDS

The detrital web within grassbeds has long been considered the dominant pathway of energy flow, and in many grassbeds is the only quantitatively significant path. This pathway consists of three primary processes: (1) the initial rapid loss of soluble organic compounds, (2) the colonization of the leaf substrate by bacteria, fungi, and protozoans, and (3) physical and biological breakdown and fragmentation. This process was described in detail by Odum et al. (1973). This pathway is common to seagrasses, mangroves, and marshes (Odum et al. 1973, Thayer et al. 1978).

Mixed in with the decaying grasses and their attendant decomposers are also a complex community of microalgae, amphipods, rotifers, copepods, and many other small organisms which form the basis of a microcarnivore food chain for a variety of juvenile fishes which use the beds as nurseries.

Because of the mode of growth of the seagrasses, the leaves emerge from the short shoots clean and fresh. As the leaves grow, they become colonized by epiphytes from the oldest part of the leaf (the tip), downward, and the epiphytic community develops. As the leaves become senescent, fall over and detach, this flourishing microcommunity becomes part of the litter layer.

Organisms that feed on this rich mixture may show some degree of selectivity in feeding, but are difficult to place into a conventional trophic scheme (Odum and Heald 1975). Recent published articles and work in progress continue to reinforce the position that

this is the dominant pathway of energy conversion in seagrass beds.

DETRITAL FOOD WEB EXPORTED FROM SEAGRASS

The function of seagrasses in the vicinity of the grassbeds, as discussed, has been described and elaborated upon since the studies of Petersen (1918). What has most recently been realized is the amount of seagrass export from the beds and the potential importance of these leaves as food at distances and depths quite remote from the source grassbeds. Leaves and fragments of Thalassia were collected by Menzies et al (1967) in 3,160 m of water off the North Carolina coast. Leaves were found at densities of up to 48 blades per photograph, although the nearest source was 500 to 1,000 km distant. In the region of the Virgin Island basin, Roper and Brundage (1972) observed seagrass blades in nearly all of 5,000 photographs taken at an average depth of 3,900 m.

Greenway (1976) estimated that about 10 percent of the weekly production of Thalassia drifted out from Kingston Harbor, Jamaica, after having been detached by urchin grazing.

The primary causes of detachment are grazing by herbivores, and wave induced severing of leaves which are becoming senescent. In addition, storm waves tear out healthy blades and rhizomes. Because of the differences in the shape of Thalassia and Syringodium leaves, the effects of direct herbivory on the two species are quite different.

Thalassia leaves are broad (typically 7-12 mm) and straplike, while Syringodium leaves are narrow (1-1.5 mm) and cylindrical. When a parrotfish or urchin bites a Thalassia blade, it only removes a

portion and the blade usually remains attached. However, the same bite on a Syringodium blade will always sever the blade, and the portion above the bite (commonly 2-4 cm) will float to the surface and drift away. Thus the direct grazing of a relatively small amount of leaf material releases a proportionately large amount of leaf material for export. Because of this mechanism, Zieman et al. (1979), found that in Tague Bay, St. Croix, 60 to 100 percent of the daily production of Syringodium is exported from the system in which it is produced.

In contrast, only a small portion of Thalassia is detached before senescence. The senescent turtle grass leaves normally remain in the bed in which they were formed and decompose. In Tague Bay, only about 1 percent of the Thalassia production is exported, and this material moves primarily by bedload transport as opposed to floating.

This shows a quite different ecological function for the two dominant tropical seagrasses. Thalassia, which is the mature, climax species, promotes recycling of carbon and nitrogen within the grassbed, enhancing sediment development. Syringodium, which is not a climax species, does not contribute to the recycling and further development of the litter layer and its attendant organisms. Evidence indicates that in temperate systems, Zostera functions most closely to Thalassia in this respect.

HIGHER ORDER FEEDING RELATIONSHIPS

The organisms involved in the food webs previously described provide a rich source of food for carnivores capable of exploiting the grassbeds. The primary restraint

on these small carnivores is the lack of shelter within the grassbeds. For this reason much of the predation within grassbeds occurs at night. Vast schools of snappers (Lutjanidae) in Florida, and grunts (Pomadasyidae) and squirrelfishes (Holocentridae) in the Virgin Islands, rest in the shelter of reefs by day and at night migrate large distances (1 km or further) out onto adjacent Thalassia beds to feed (Ogden and Zieman 1977, Starck 1969). The resting schools form into large streams at specific assembly points on the reef edge. They then migrate onto the grassbed along routes that remain constant for several years. As the distance from the reef increases, the individual fish leave to feed alone in the grassbeds, returning along the same routes at dawn (Ogden and Zieman 1977).

The other identifiable group of organisms is the large often pelagic top carnivores such as the jacks, tarpon, and barracuda. Of the top carnivores, only the barracuda tends to be resident in a specific location, while most others roam over large distances in search of prey in the grassbeds and over the reef.

SUMMARY

The earliest studies on seagrass ecosystems indicated that the dominant pathway of energy utilization was through the detrital food web. Recent studies and research in progress confirm that this is indeed the primary pathway for utilization of seagrass carbon, but that other pathways, notably direct herbivory and export of material from grassbeds for remote utilization, are often significant also. In addition, energy is exported from seagrass beds via utilization by

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