The Contribution of Mangrove Swamps to Florida Fisheries

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INTRODUCTION

THE COASTAL MARGINS of southern Florida are characterized by a 700-square mile band of mangrove forests which received little public attention until recently. South Florida residents and visitors, while realizing that mangrove areas are good places in which to fish for snook, tarpon or mangrove snappers, have otherwise tended to dismiss them as mosquito-ridden wastelands, or, at best, as curiosities of dubious beauty. Land developers regard mangrove swamps as an impedence to the development of valuable waterfront properties, and the commercial fisherman rarely pays attention to mangroves unless he encounters an oyster-encrusted log in his net.

During the past decade there has been a growing recognition of the role played by south Florida's estuarine areas in the maintenance of commercial and sport fisheries, both in the immediate vicinity of land and further offshore in the Gulf of Mexico. Idyll (1965) points out that the pink shrimp, *Penaeus duorarum*, is dependent upon these mangrove-dominated estuaries as a nursery ground. One measure of the potential of such nursery areas is the volume of the commercial shrimp catches from the Dry Tortugas grounds. In 1965 its value exceeded 11 million pounds, worth over $10 million (Anon., 1966). Most, if not all, of these shrimp grew up in the estuarine regions of Everglades National Park and adjacent areas.

Several other commercially valuable species including mullet, grey snapper, red drum and blue crab use these estuaries as a nursery area and feeding ground (Idyll et al., 1968). Tabb (1966) has shown that at least one species of economic and recreational value (the spotted seatrout) appears to be dependent upon the estuary during the greater part of its life cycle.

The primary food source for aquatic organisms in many shallow estuaries, particularly those at lower latitudes, is not phytoplankton, but vascular plant detritus (W. E. Odum, 1970a). Schelske and E. P. Odum (1962) demonstrated that the high productivity of the Georgia salt marshes is based mainly upon cordgrass, *Spartina alterniflora*. The system is characterized by a large standing crop of resistant vegetation which is not heavily grazed by terrestrial herbivores. The result is a continual production of large amounts of plant debris which is utilized in a detritus-based food web. In south Florida a similar situation exists with the red mangrove, *Rhizophora mangle*, and turtle grass. *Thalassia testudinum*, sharing the role of dominant primary producer and source of detritus.

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In this paper we discuss the importance of mangrove swamps to the ecology of south Florida estuarine areas from the viewpoint of detritus production. Briefly, we describe the pathways by which the primary production of these plants is ultimately utilized by species of commercial value. The data upon which this discussion is based were gathered during 1967 and 1968 in the North River estuarine system of Everglades National Park, Florida. Information not presented in detail here can be found in Heald and Odum (1970) and Odum and Heald (1970a&b).

The North River arises as a poorly organized stream system near the edge of the sawgrass prairie and flows southwest into Whitewater Bay, about 14 km from its farthest traceable source. It drains an estimated 4,100 acres. The predominant drainage pattern is best described as a series of shallow, mud-lined ponds connected by meandering streams which eventually coalesce and enter the main river at various points.

The dominant cover vegetation is red mangrove, *Rhizophora mangle,* which borders all water areas and covers most of the land between them. In the upper reaches of the river the mangroves become progressively more restricted to its banks. Scattered marsh areas dominated by the black-rush, *Juncus roemerianus,* lie beyond these mangrove fringes.

The hydrography of the system is characterized by marked fluctuations of water level and salinity in response to the seasonal rainfall pattern of south Florida. In general the months of low rainfall are November to May when salinities rise to about 25 parts per thousand. The heavy summer rains normally begin in June, and freshwater conditions persist for most of summer and early fall.

Aquatic primary producers are nowhere abundant. Phytoplankton volumes were low throughout the study period, and benthic algae were not abundant. The bladderwort, *Utricularia lutea,* grows rapidly in shallow pools during the summer, but its contribution to the whole river system is very small.

OBJECTIVES AND PROCEDURES

Our investigations of the mangrove ecosystem determined the amount and ultimate fate of mangrove litter produced yearly. Rates of breakdown of litter under different environmental conditions were determined. Protein and caloric content during litter degradation was monitored. Measurements were made of the amount of mangrove detritus present in the river. A study of the food habits of all species of fish and invertebrates in the system was performed.

Litter production was measured monthly from catchment devices placed around selected trees. Details of the method are given by Heald (1969a). Breakdown rates of leaves were obtained from field experiments in which known weights of newly fallen leaves, placed in nylon mesh bags, were retrieved and weighed at monthly intervals. Chemical analyses included bomb calorimetry, micro-kjeldahl nitrogen determinations and fat extractions.

For the purpose of trophic studies, over 6,000 individuals representing approximately 90 species of fish, crustaceans, bivalves and insect larvae were captured by a variety of methods, and an analysis of stomach contents was made with conventional, phase and fluorescence microscopy. Capture methods and techniques of analysis are detailed by W. E. Odum (1970b).

From the data thus obtained we were able to reconstruct the biological pathways of energy flow in the community and assess the value of mangrove material to the ecosystem.

THE PROCESS OF DETRITUS PRODUCTION

Production of mangrove leaf material in the North River estuary exceeds 2.9 dry tons per acre per year or 800 dry grams per square meter per year. This means that about 10,000 tons (dry wt.) of leaves are shed each year by the mangroves of the North River drainage. Lesser amounts of litter are contributed by twigs, bark and leaf scales.

Less than 5% of the leaf material is consumed on the tree by terrestrial herbivores; most of it falls from the tree. Very little of this fallen leaf material remains permanently in the system. About half is consumed by bacteria, fungi and detritus feeders. Most of the remainder is eventually flushed out of the river system into nearby shallow coastal embayments where it is available as food to detritus consumers in those ecosystems. Only 1 or 2% in the form of peat is actually lost to the animal communities.

The rate at which mangrove leaf material enters the aquatic food chains depends largely upon where it falls. Leaves falling directly into the water soon acquire a flora of bacteria and fungi which utilize the leaf material as a physical substrate and as a nutrient source. After 2 or 3 months the breakdown of the leaf is further speeded by amphipods and the crab *Rhithropanopeus harrisii* which shred the leaf into smaller fragments. Within 6 months of leaf fall, over 30% of the leaf material has been removed by scavenging organisms. Three more months are sufficient for the leaf to be reduced to fragments no larger than 1 cm in width. This gradual degradation of the leaf is accompanied by an increase in the caloric content and the relative percentage of protein of the leaf particle, due to its covering of microorganisms. For this reason the particle becomes an increasingly valuable food source as it diminishes in size.

Leaves which fall on river banks and other elevated areas are initially unavailable and break down slowly. When subsequently washed into the river during the rise in water level which accompanies the onset of the summer rainy season, they break down rapidly and are utilized by detritus feeders. Under present conditions in the North River basin, almost all mangrove leaf litter is broken down and fragmented within a year. If flood control measures or other water diversions interfere with the seasonal influx of fresh water much more detrital material would accumulate within the mangrove forest. This in turn would lead to an increased deposition of forest soil culminating in conditions unfavorable to the mangroves and favorable to a willow and buttonwood community.

DETRITUS PRODUCTION: THE PRINCIPAL PATH OF ENERGY FLOW

The detailed structure of the important food chains in the North River system have been investigated (Odum and Heald, 1970a) and analyzed (Odum and Heald, 1970b) elsewhere. In summary, the animals of this estuarine system are dependent upon an input of energy in the form of vascular plant detritus originating from mangrove leaves. The production of phytoplankton and benthic algae provides a limited amount of energy for the primary consumers, but is of limited importance compared to the production of vascular plant detritus.

The first link in the food web is provided by bacteria and fungi which convert the relatively undigestible lignin and cellulose of vascular plant tissue into a protein source which can be digested by the organisms of the second link in the food web. This next link is composed of opportunistic omnivorous crustaceans such as amphipods, mysids, harpacticoid copepods, caridean and penaeid shrimp along with chironomid midge larvae and a few omnivorous fishes such as the striped mullet, *Mugil cephalus;* the sheepshead minnow, *Cyprinodon variegatus;* and the molly, *Poecilia latipinna.* All of these ingest large quantities of detritus particles with their loads of digestible microorganisms. These particles pass through the digestive tract essentially unaltered except for mechanical grinding and the partial removal of absorbed microorganisms. Once the particle is excreted as fecal material, the entire process (excreted particle→ colonized by fungi and bacteria→ ingested by detritus feeder→ fungi and bacteria digested off particle by detritus feeder→ excreted particle) commences again and may be repeated a number of times. A particle may be ingested by several different detritus feeders before it is completely broken down. Even when the particle becomes very small (less than 5 or 10 microns) it may combine with other small particles to form conglomerates which continue in the cycle.

This group of detritus consumers also ingests other materials which include live benthic microalgae, animal material and fine inorganic particles which probably contain absorbed dissolved organic substances. The live microalgae, although usually present in relatively small volumes, appear to be necessary for adequate growth.

In the North River the critical detritus feeding link is composed of relatively few species: one xanthid crab, *Rhithropanopeus harissii;* four mysids; four amphipods; one penaeid shrimp; two caridean shrimps; one snapping shrimp; three small forage fishes; and an undetermined number of harpacticoid copepod, isopod and chironomid midge larval species. Feeding on these detritus consumers are a large group of fishes including all of the juvenile game fishes.

THE PRODUCTION OF GAME FISH AND FOOD FISH

A number of gamefish depend upon the Everglades mangrove estuary for varying periods of their juvenile lives. Tarpon, *Megalops atlanticus;* snook, *Centropomus undecimalis;* and ladyfish, *Elops saurus,* utilize the mangrove belt from the time they reach the estuary as post-larvae. Grey snapper, *Lutjanus griseus;* sheepshead, *Archosargus probatocephalus;* spotted seatrout, *Cynoscion nebulosus;* and red drum, *Sciaenops ocellata,* spend the first few weeks of their lives in the grass beds of Florida and Whitewater Bays and then move into the mangrove habitat for the next several years. Of this group, the grey snapper is the most dependent upon the mangrove environment. Finally, there are other gamefish which are found in the mangrove zone and other areas: the crevalle jack, *Caranx hippos;* the gafftopsail catfish, *Bagre marinus;* and the jewfish, *Epinephelus itajara.*

All of these gamefish feed on detritus feeders. The young fish eat amphipods, mysids and chironomid larvae. As the fish grow larger they consume caridean and penaeid shrimp, snapping shrimp, crabs and detritus-consuming fish along with forage fishes such as the tidewater silver sides, *Menidia berylina;* the silver jenny, *Eucinostomus gula;* and the rainwater killifish, *Lucania parva,* which in turn feed on detritus feeders.

The value of these nursery areas to the commercial shrimp fishery has already been referred to. It need only be added that shrimp are opportunistic feeders, incorporating large amounts of detritus in their diet. Other commercially valuable species, such as spotted seatrout, red drum, striped mullet, *Mugil cephalus,* and blue crab, *Callinectes sapidus,* are equally dependent upon the estuarine detritus food-chain system. Catches of these species from a single Bureau of Commercial Fisheries statistical area extending from Naples to western Florida Bay can be cited as an indication of potential productivity. In 1965 this area yielded over 2.5 million lbs. of striped mullet, 164,000 lbs. of spotted seatrout, 30,000 lbs. of blue crabs and almost 40,000 lbs. of red drum (Heald, 1969b).

From the foregoing discussion it should be apparent that the production of game and food fish from mangrove systems such as the North River is directly linked to the production of the detritus feeders and ultimately to the production of vascular plant detritus in the form of decaying mangrove leaves, roots, bark and wood. If mangrove estuarine systems are destroyed, a valuable protective habitat for juvenile fishes will be lost. More importantly it will cut off the input of mangrove organic material which is largely contributed in leaf fall. The leaf fall supports the detritus based food webs, a large population of detritus feeders and their predators. The production of phytoplankton and benthic and epiphytic algae in such an area is so much less than the production of detritus of a mangrove origin that the yield of gamefish must decline in proportion to mangrove destruction.

The situation is somewhat different in more open areas such as Florida and Biscayne Bays where there is a significant detritus production from seagrasses (discussed by Wood et al., 1970) and benthic macroalgae. Nevertheless, the wholesale removal of mangrove swamps, even from these more diverse areas, will result in a reduced production of detritus feeders and the commercial and sports fish which consume them.

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