EFFECTS OF FRESHWATER DISCHARGE FROM FINGER CANALS ON ESTUARINE SEAGRASS AND MANGROVE ECOSYSTEMS IN SOUTHWEST FLORIDA

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ABSTRACT

The Cape Coral canal system has altered the natural sheet flow of freshwater into Matlacha Pass Aquatic Preserve (MPAP). A "spreader" waterway was constructed to re-establish sheet flow. However, we have found "breaks" in the Spreader which result in channelized flow of fresh to brackish water into MPAP. This input affects the physiochemical habitat of the saline wetlands and receiving waters of MPAP.

Salinity is an important factor affecting seagrass, Thalassia and Halodule, distribution and abundance in Matlacha Pass. The channelized discharge from Cape Coral may inhibit or affect seagrass growth in MPAP.

Cattail (Typha) has invaded the mangrove ecosystem along channelized flow paths which originate at breaks in the Spreader rim canal. Repair of these breaks and elimination of channelized freshwater discharge would inhibit Typha invasion and enhance re-establishment of saline wetland vegetation.

INTRODUCTION

Matlacha Pass, in Lee County, is one of 40 State Aquatic Preserves in Florida. Aquatic preserves are state-owned submerged lands of special natural resource value which are intended to be maintained in an essentially natural conditions. Matlacha Pass is identified as a sensitive area of particular concern within the Charlotte Harbor estuarine system because of its valuable natural resources, which include extensive mangrove and seagrass ecosystems, and vulnerability to upland development (Florida Department of Natural Resources, 1983). These resources are potentially threatened by, among other factors, channelized discharge of fresh and brackish water from the adjacent Cape Coral waterway system.

The City of Cape Coral extends along the entire eastern border of Matlacha Pass. The City is transected by over 650 km of man-made fresh and estuarine waterways. This extensive waterway system disrupted the

natural sheet flow of water into the saline wetlands of Matlacha Pass Aquatic Preserve (MPAP).

Attempting to mitigate this disruption, the Florida Department of Environment Regulation required the developer of Cape Coral to construct a "spreader" or "interceptor" waterway system at the border of MPAP and the Cape Coral canal system. The intended purpose of the Spreader system was to re-establish, as best as possible, the natural sheet flow of water through the saline wetlands of MPAP. This sheet flow would facilitate the gradual, widespread mixing of fresh and saltwater. The Spreader system also serves as a retention and pollutant assimilation area for upland stormwater runoff.

The little information available on the effectiveness of the Spreader system indicates that it is not functioning as intended. "Breaks" or "breaches" occurring along the Spreader-wetland boundary result in channelized flow of fresh or low salinity water into MPAP saline wetlands (Browder & Moore, 1981; Comp & Seaman, 1985). This channelized discharge may negatively affect mangrove and seagrass ecosystems in MPAP. Increased freshwater discharge has adversely affected estuarine ecosystems elsewhere in Florida (Tackney & Associates, 1981; LaRose, unpub. study). Cattail (Typha sp.) has invaded the saline wetlands. The extent of the Spreader system problems, and their potential environmental impacts on MPAP, have not been thoroughly investigated.

The study reported here is the first phase of a project to evaluate the function of the Spreader system, to investigate potential environmental impacts of discharge from Cape Coral into MPAP, and to develop and implement improvements of the Spreader system. The overall project goal is to minimize the environmental impacts of discharge from Cape Coral waterways into MPAP. The objectives of the present study are:

1. Attempt to assess the impact of channelized low-salinity flow on Matlacha mangrove and seagrass ecosystems. This objective is difficult to achieve because scientific data on these ecosystems before channelization occurred are lacking.

2. Obtain baseline data which will be used to evaluate the effectiveness of repairs to the Spreader system.

3. Provide basic scientific data on the Charlotte Harbor estuarine system, especially the seagrass ecosystem in Matlacha Pass and Pine Island Sound. The Charlotte Harbor system is the least studied major estuary in Florida (Mahadevan et al., 1984).

STUDY AREA AND SITES

Matlacha Pass and Pine Island Sound (PIS) are part of the Charlotte Harbor estuarine system, located on the Gulf of Mexico in southwest Florida. Matlacha Pass is a narrow water body between Cape Coral and Pine Island. PIS is between Pine Island and the barrier islands. Matlacha

Pass and PIS are shallow; most of the subtidal area is <1.5 m deep (Estevez, 1986). Unvegetated sandy bottom and seagrass meadows are the most common benthic habitats in Matlacha Pass and PIS (Harris et al., 1983). Tropical seagrasses, Thalassia testudinum and Halodule wrightii, and subtropical red seaweeds are the predominate benthic vegetation.

The climate of the region is subtropical and humid. The mean annual air temperature is 23.3°C (1959-1988). Rainfall averages 136.5 cm annually (1959-1988). There are definite wet (mid-June through September) and dry (November through May seasons. About 64% of the annual rainfall occurs during the wet season.

The brackish water north and south Spreader waterway systems, which are separated by 4 km, are part of the 650 km of man-made canals and lakes in Capt Coral. Each system consists of the outer rim Spreader canal. The western bank of which borders MPAP wetlands, and a network of finger canals proceeding landward. The north and south systems have direct drainage basins of 15 km^2 and 22 km^2, respectively. The systems are separated from adjacent freshwater canals to the east by a series of weirs (dams). These canals discharge into the Spreader systems.

We established a non-linear transect of water quality stations extending from the Spreader; along channelized flow paths through Matlacha wetlands caused by the largest break in the south and north Spreader; in Matlacha Pass; and, in PIS, which served as the control for Matlacha sites because PIS receives little direct terrestrial runoff.

We established a series of seagrass monitoring sites in Matlacha Pass and PIS, starting at the mainland and progressing seaward and farther from the sources of freshwater input. The sites in Matlacha Pass adjacent to the mainland (MN-P1 and Oyster Creek) were the grass beds closest to the channelized discharge from Cape Coral. There were two sites (Givney Key and Marker 63) in central Matlacha Pass. The seagrass sites were also water quality monitoring stations.

MATERIALS AND METHODS

The following water quality parameters were sampled at least monthly at each station: temperature, salinity/conductivity, dissolved oxygen, pH, turbidity, ammonia, nitrate-nitrite, TKN, and total phosphorus. All analyses were performed using standard methods (Rand et al., 1981; U.S. Environmental Protection Agency, 1983).

Seagrass abundance data were collected quarterly at each site using 0.0625 m^2 (1/16 m^2) quadrats located randomly within the grass bed. For Thalassia, all shoots and blades in the 1/16 m^2 section were counted. When Halodule was sparse or moderate in abundance, all shoots in the 1/16 m^2 quadrate were counted. In Ruppia maritima and dense Halodule beds, 0.02 m^2 quadrats were used for shoot counts. After recording counts, seagrass and algal biomass within the 1/16 m^2 quadrat was harvested at ground level and brought back to the lab where it was sorted, cleaned of

epiphytes and epizoics, and dried at 60°C until a constant weight.

The invasion of Typha into the mangrove system and mangrove-cattail interactions are being monitored at two locations along the north Spreader break flow path. Both sites have a Typha dominated stand and a juvenile red mangrove (Rhizophora mangle) dominated stand, with a mixed Typha-mangrove transition area. We have established five 0.5 m^2 permanent plots in the transition area at each site. These quadrats and randomly located quadrats were sampled quarterly in 1989. Shoot and leaf densities for each species were recorded. Surface water and sediment pore water salinity and nutrients were measured at least monthly at each site.

Statistical Procedures

The t-test or its nonparametric equivalent, the Mann-Whitney U test, was used to test for significant ($P<0.05$) difference between two groups of data. Analysis of variance (ANOVA) or its nonparametric equivalent, the Kruskal-Wallis test, was used to test for significant difference among more than two data groups. Two-way ANOVA was used to compare PIS and Givney Key seagrass data. Two-way ANOVA without replication was used to compare the permanent plots in the Typha-mangrove study.

RESULTS AND DISCUSSION

Thirteen breaks, ranging from 1.5 to 14 m wide and 0.3 to 1.5 m deep, were found in the north and south Spreader rim canal at the Spreader-wetland boundary. These breaks were caused by insufficient restoration of previous dredging, other human activity, e.g., destroying wetland vegetation, airboating, canoeing), and natural erosion.

Substantial volumes (as great at 2.7 m^3/s) of brackish to freshwater flow through these breaks into MPAP. This channelized flow reaches the receiving waters virtually unmixed and unfiltered in the wet season. This input affects the physiochemical habitat of the wetlands and receiving waters of MPAP. Drought conditions existed before and during the study. The cumulative rainfall deficit for 1988-89 was 59 cm. Thus, the volume of freshwater flowing through breaks during the study period was likely below average.

A gradient of increasing salinity proceeding from the Spreader system through Matlacha wetlands and back bays, into Matlacha Pass, to Pine Island Sound existed throughout the study period (Table 1). Salinity in Matlacha Pass was equivalent to that in Pine Island Sound only in the latter part of the dry season (April to mid-june); and even then, only during high tide at stations adjacent to the mainland (Oyster Creek, MN-P1).

Table 1. Salinity (ppt) ranges during the study (October 1988 through September 1989) at the water quality monitoring sites.

Location	Oct.-Dec.	Jan.-Mar.	Apr.-mid June	Late June-Sept.
Pine Island Sound	28-33	30-34	33-37	26-35
Matlacha Pass, Givney Key	22-26	22-32	32-35	19-27
Matlacha Pass, Oyster Creek	18-24	22-30	27-33	11-23
South Spreader, Break	3-19	7-24	9-29	5-18
South Spreader, Waterway	3-7	7-12	10-14	5-11
Matlacha Pass, North (MN-P1)	11-23	11-24	22-33	9-25
North Spreader, Break	1-20	4-20	7-24	0-19
North Spreader Waterway	1-4	4-6	7-14	0-7

Seagrass Ecosystems

MN-P1, the seagrass site nearest the location of greatest discharge from the Spreader, had the greatest seasonality in seagrass composition and abundance (Table 2). It experienced the lowest salinity of any seagrass site (Table 1). When first surveyed in November 1988, this grass bed was composed of *Ruppia maritima*, a brackish water plant. As salinity increased during the dry season *Halodule* replaced *Ruppia*; however, *Ruppia* did not return during the wet season. Oyster Creek, the other grass bed near channelized discharge, was composed of *Halodule*.

Halodule abundance at both sites (MN-P1 and Oyster Creek) varied seasonally ($P<0.05$; Table 2). *Halodule* abundance was clearly correlated with salinity. *Halodule* increased during the dry season with increasing salinity, reaching peak biomass in June at the end of the dry season. Abundance decreased, with decreasing salinity, during the summer wet season. Salinity was <23 ppt during the wet season. Low salinity at these nearshore sites may chronically stress *Halodule*. We could not

conclusively determine if reduced salinity had a negative impact on fish abundance in these nearshore grass beds (Morrison et al., 1989).

Table 2. *Halodule* abundance in north (MN-P1) and south (Oyster Creek) Matlacha Pass. Values are Means ±SE (N).

	November 1988	March 1989	June 1989	October 1989
Oyster Creek				
Shoot Density (No/m)	1201±123 (13)	1691±130 (26)	1400±176 (22)	424±85 (28)
Biomass (g/m)	29.9±5.0 (10)	31.4±4.4 (14)	32.0±5.0 (17)	5.1±1.2 (19)
MN-P1				
Shoot Density (No/m)	0±0 (15)	930±218 (17)	832±158 (20)	511±111 (24)
Biomass (g/m)	0±0 (15)	10.9±3.3 (17)	13.8±3.3 (16)	4.4±1.2 (17)

The grass beds in central north Matlacha Pass were a mixture of *Thalassia* and *Halodule*. Salinity here (Marker 63) was lower than in central south Matlacha, but higher than at sites adjacent to the mainland. *Thalassia* abundance at Marker 63 declined considerably during the wet season (mean shoots/m^2: June=215, N=16; October=66, N=25; $P<0.05$). *Halodule* mean shoot density increased 50% between June (1973 shoots/m^2, N=16) and October (1465 shoots/m^2, N=25) ($P<0.05$).

The grass beds at Givney Key (GK), in central south Matlacha Pass, and Pine Island Sound (PIS) were composed primarily of *Thalassia*. *Thalassia* abundance varied seasonally at both sites (Table 3), but the patterns differed between sites (2-way ANOVA interaction term $P<0.01$). *Thalassia* and salinity seasonality were greater at GK. Biomass and shoot density increased significantly at GK, but not PIS, from December 1988 to March 1989. Shoot density decreased significantly at GK, but not PIS, during the wet season. Biomass decreased significantly at both sites during the wet season, but the magnitude was significantly greater at GK. Salinity at GK was lower than at PIS during the wet season. Salinity at GK was frequently below the range optimal for *Thalassia* growth, 24-35 ppt (Zieman, 1982), from June to November. Lowered salinity during the wet season may chronically stress *Thalassia* in Matlacha Pass.

Table 3. *Thalassia* abundance in Pine Island Sound and Givney Key, Matlacha Pass. Values are Means ±SE (N).

	December 1988	March 1989	June 1989	October 1989
Pine Island Sound				
Shoot Density (No/m)	233±17 (16)	245±13 (20)	278±16 (23)	292 18 (21)
Blade Density (No/m)	607±52 (16)	740±39 (20)	967±50 (23)	790 53 (21)
Biomass (g/m)	75±8 (15)	89±8 (20)	139±10 (18)	94 6 (17)
Givney Key				
Shoot Density (No/m)	357±32 (20)	713±40 (15)	734±35 (20)	548 38 (19)
Blade Density (No/m)	891±71 (20)	2028±124 (15)	2286±80 (17)	1314 96 (19)
Biomass (g/m)	49±5 (15)	89±6 (15)	145±6 (16)	57 5 (16)

Salinity is an important factor affecting seagrass abundance, distribution, and seasonality in Matlacha Pass. In fact, it may have been the most important physiochemical factor affecting seasonality during the study, even though rainfall was below average. Seagrass abundance in Matlacha Pass increased from December to March with increasing salinity, even though temperature is lowest during this period. However, seagrass abundance (and salinity) did not increase significantly from December to March in Pine Island Sound. Generally, in south Florida, seagrass abundance is lowest in winter (February-March) (Zieman, 1982; Virnstein & Carbonara, 1985).

Previous seagrass data for Matlacha Pass are limited and qualitative. Thus, it is difficult to assess the long term effects of freshwater discharge from Cape Coral on seagrass distribution and abundance. According to 1982 Florida DNR aerial surveys, the north Matlacha grass beds nearest the channelized discharge were "dense" in abundance (Harris et al., 1983). Our 1989 field surveys and 1990 aerial photographs revealed that seagrass abundance was "sparse" in this area. Salinity in this area is lower much of the year than in adjacent areas where seagrass abundance is still "dense." Perhaps, the decreased seagrass abundance from 1982 to 1989-90 is due to Spreader channelized discharge.

Typha Invasion of Mangrove Ecosystem

Typha has invaded MPAP saline wetlands through Spreader breaks and along the resultant channelized flow paths. Using Lee County Government aerial photographs, we estimate that Typha began invading the MPAP wetlands in 1983-84. Typha occurs as far as 2 km into the wetlands, nearly to Matlacha Pass (as of March 1990). Currently, the invasion is mainly restricted to the immediate vicinity of the banks of the flow paths--tidal creeks. Typha is also invading areas of mangrove seedlings and juveniles (<1 m shoot height) near the flow paths. The invading Typha occurs in patches or stands which range in size from 5 m^2 to about 1000 m^2. Typha distribution was correlated with sediment and surface water salinities (Morrison et al., 1989).

Typha abundance varied seasonally ($P<0.05$) in the Typha dominated stands at the mangrove-cattail monitoring sites (Table 4). Abundance increased during the wet season and peaked in November. Typha then declined throughout the dry season. Typha seasonality was most closely correlated with sediment salinity, and secondarily with surface water salinity (Morrison et al., 1989).

Table 4. Typha shoot and leaf densities (No./m^2) in the Typha dominated stand at Mangrove-Typha monitoring site B. Values are means ±SE N=10).

	Feb. 1989	May 1989	Aug. 1989	Nov. 1989	Feb. 1990
Shoot Density	28.4±3.7	7.0±1.0	18.7±3.7	31.0±5.4	9.0±1.1
Leaf Density	103±17	15±2	140±31	208±40	53±34

Typha in the mangrove-cattail transition zone exhibited the same seasonal pattern as in the Typha dominated stands (Table 5). The seasonal die-back during the dry season likely reduced the rate of Typha invasion into the mangroves.

Nevertheless, Typha extended its range at both study sites. From August to November 1989 at Site A, the Typha stand expanded 3-4 m along the creek bank into an area occupied previously only by mangroves. This invasion continued during the dry season, with a one meter expansion from November 1989 to February 1990, even though the main stand was undergoing die-back. Rhizophora abundance in the Site A transition zone declined significantly ($P<0.05$) during the study (Table 6), while Typha was expanding its range. Rhizophora shoot density in February 1990 was one-third that in February 1989.

Table 5. Typha shoot and leaf densities (No./m²) in permanent transition zone plots in mangrove-Typha site. Values are means ±SE (N=5).

	Feb. 1989	May 1989	Aug. 1989	Nov. 1989	Feb. 1990
Site A					
Shoot	5.5±3.0	1.0±0.9	2.0±0.7	7.0±1.7	5.5±2.8
Leaf	21±12	1±1	9±4	42±10	18±9
Site B					
Shoot	14.0±6.3	1.2±0.7	9.6±2.8	15.6±5.2	17.2±3.5
Leaf	56±19	3±1	75±20	97±29	62±14

Table 6. Rhizophora shoot and leaf densities (No./m²) in permanent transition zone plots at mangrove-Typha sites. Values are means ±SE (N=5).

	Feb. 1989	May 1989	Aug. 1989	Nov. 1989	Feb. 1990
Site A					
Shoot	11.7±2.4	10.0±0.3	6.0±1.5	6.0±1.5	4.0±2.0
Leaf	258±102	125±45	103±26	92±43	79±40
Site B					
Shoot	52.8±7.5	54.0±6.5	46.0±5.1	49.2±6.6	46.0±6.1
Leaf	649±140	696±109	887±102	884±152	641±194

The Typha stands at both study sites also expanded by about one meter during the study due to new habitat creation. The physiography of the tidal creek changed during the 1989 wet season; the creek banks expanded. This was due to the deposition of sediment transported down the channelized flow path from the Spreader system. Thus, new habitat was formed and Typha has colonized it. Apparently, Typha opportunistically colonizes habitat that is altered or recently created by the low-salinity channelized discharge from the Spreader system.

Rhizophora exhibited no significant ($P>0.05$) seasonality in either the Typha dominated stands or the transition zones in 1989 (Tables 6 & 7). This suggests that the three to four months of low Typha abundance are insufficient time for a substantial increase in the abundance of the slower growing Rhizophora. Leaf density decreased by about 25% from November 1989 to February 1990 ($P<0.05$) due to freeze damage in late December 1989 (Table 6).

Table 7. Rhizophora leaf densities (No./m^2) in the Typha dominated stand at mangrove-Typha monitoring site B. Values are means ±SE (N=10).

	Feb. 1989	May 1989	Aug. 1989	Nov. 1989	
Leaf Density	310±192	526±206	391±218	571±241	$P>0.05$

CONCLUSIONS

Salinity is an important factor affecting seagrass abundance, distribution, and seasonality in Matlacha Pass. Channelized discharge may inhibit or affect seagrass growth in the immediate receiving waters and perhaps at nearshore areas on the tidal flow path from the receiving waters (e.g., MN-P1). Only monitoring after the breaks are repaired and channelized flow is eliminated or reduced will confirm our speculation.

Typha has invaded the saline wetlands along channelized flow paths which originate at breaks in the Spreader rim canal. Repair of these breaks and elimination of channelized freshwater discharge would inhibit Typha invasion and enhance re-establishment of saline wetland vegetation.

The breaks must be repaired as soon as possible. The goal is to eliminate channelized discharge and re-establish sheet flow. An engineering project is underway to repair known breaks. Ecological monitoring must continue to assess the effectiveness of repairs to the Spreader waterway; to determine changes (improvements) in the MPAP ecosystems following the anticipated reduction in channelized discharge from Cape Coral; and, to ascertain the need for additional management actions to restore damaged ecosystems. Additional breaks in the Spreader will likely occur in the future. Thus, a long term maintenance program for the Spreader needs to be instituted.

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LITERATURE CITED

Browder, J., and D. Moore. 1981. A new approach to determining the quantitative relationship between fishery production and the flow of freshwater to estuaries. In R. Cross and D. Williams (eds.), Proceedings of the National Symposium on Freshwater Inflows to Estuaries (pp. 403-420). U.S. Fish Wild. Surv., Off. Biol. Serv. FWS/OBS-81-04.

Comp, G. S., and W. Seaman, Jr. 1985. Estuarine habitat and fishery resources of Florida. In W. Seaman (ed.), Florida Aquatic Habitat and Fisher Resources (pp. 337-435). Florida Chapter Amer. Fishery Society.

Estevez, E. E. 1986. In faunal macroinvertebrates of the Charlotte Harbor estuarine system and surrounding inshore waters, Florida. U.S. Geol. Survey, Water Resources Investigations Rep. 85-4260.

Florida Department of Natural Resources. 1983. Charlotte Harbor Aquatic Preserves Management Plan.

Harris, B. A. et al. 1983. Assessment of fisheries habitat: Charlotte Harbor and Lake Worth, Florida. Florida DNR. 211 pp.

LaRose, H. U.S. Geological Survey. Unpublished study.

Mahadevan, S. eat al. 1984. Review and annotated bibliography of benthic studies on coastal and estuarine areas in Florida. Florida Sea Grant College Report No. 66. 576 pp.

Morrison, D. et al. 1989. Impact of freshwater discharge from Cape Coral Waterways on Matlacha Pass State Aquatic Preserve. Final report. FDER Contract CM-230. City of Cape Coral, Florida. 42 pp.

Rand, M. et al. (eds.). 1981. Standard methods for examination of water and wastewater. 15th ed. Amer. Public Health Assoc., Washington, D.C.

Tackney and Associates. 1982. Cape Coral spreader waterway monitoring report to Avatar Properties.

U.S. Environmental Protection Agency. 1983. Manual of methods for chemical analysis of water and wastes. Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. EPA-600/4-79-020.

Virnstein, R. W., and P. A. Carbonara. 1985. Seasonal abundance and distribution of drift algae and seagrasses in the mid-Indian River Lagoon, Florida. Aquat. Bot. 23:67-82.

Zieman, J. C. 1982. The ecology of seagrasses of south Florida: A community profile. U.S. Fish Wildlife Serv., Off. Biol. Serv. FWS/OBS-82-25. 158 pp.