A COMPARISON OF FISH COMMUNITIES IN RESTORED AND NATURAL SALT MARSHES IN TAMPA BAY, FLORIDA

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ABSTRACT

Four restored salt marshes and one natural marsh in Tampa Bay, Florida were sampled regularly for two years to compare fish colonization and community structure. Fifty-six species of fish (86,024 total individuals) representing 25 families were caught and released during the study period. The numerically dominant species (those species which individually comprised more than 5% of the overall catch) were Menidia beryllina (27-.), Anchoa mitchili (12%), Lucania parva (9%), Poecilia latipinna '(8-.), Cyprinodon variegatus (7%), Fundulus grandis (6%), Brevoortia smithi (6%), and Adinia xenica (5%). Peak densities typically occurred during early spring and late fall months, however, mean fish density did not change significantly over time. Marshresident species dominated the overall catch and were found in greater densities than transient and nursery species. We found no significant differences in fish density between restored and reference marshes, however, there were significant ($p < 0.05$) differences in numbers of species between sites. Species of economic importance including spotted seatrout (Cynoscion nebulosus), common snook (Centropomus undecimalus), red drum (Sciaenops ocellatus), spot (Leiostomus xanthurus), and striped mullet (Mugil cephalus) were typically found as juveniles in all marshes and in equal or greater densities at restored marshes than at the reference marsh.

INTRODUCTION

Extensive shoreline development has cost the Tampa Bay coastal ecosystem an estimated 45% of its natural salt marsh habitat over the last century. Concurrently, declines in the populations of recreationally and commercially important fish species have occurred due, in part, to the loss of critical nursery and foraging habitats which include intertidal marshes and mangrove-rimmed shorelines. These coastal communities are highly productive and valuable ecosystems since they are a source of primary and secondary productivity and provide structural refugia for resident, nursery, and transient fish and shellfish species (Gilmore et al., 1983; Rakocinski et al., 1992; Robertson and Duke, 1987; Shenker and Dean, 1979; Sheridan, 1992).

In the Tampa Bay area, coastal habitat restoration projects have been implemented since the early 1970's and continue to be constructed as part of an overall plan to restore the balance of ecosystems lost during the last decade (Tampa Bay National Estuary Program, 1997). In fact, more than 46 hectares (113 acres) of estuarine marsh have been restored or created by public agencies in the Tampa Bay area over the past five years (Treat, In press). Few studies, however, have addressed the impacts of habitat restoration, enhancement, or creation on estuarine fish communities. This study was conducted to evaluate the fish communities that colonized restored salt marshes and to compare these communities with those from a natural salt marsh system. Specifically, fish density, species diversity, and community similarity were compared between five different marshes in Tampa Bay.

MATERIALS AND METHODS

Study Locations

Tampa Bay is located in the east-central region of the Gulf of Mexico and is Florida's largest open water estuary with a surface area of approximately 1,040 km^2 (Figure 1). Historically, Tampa Bay has supported a complex and diverse

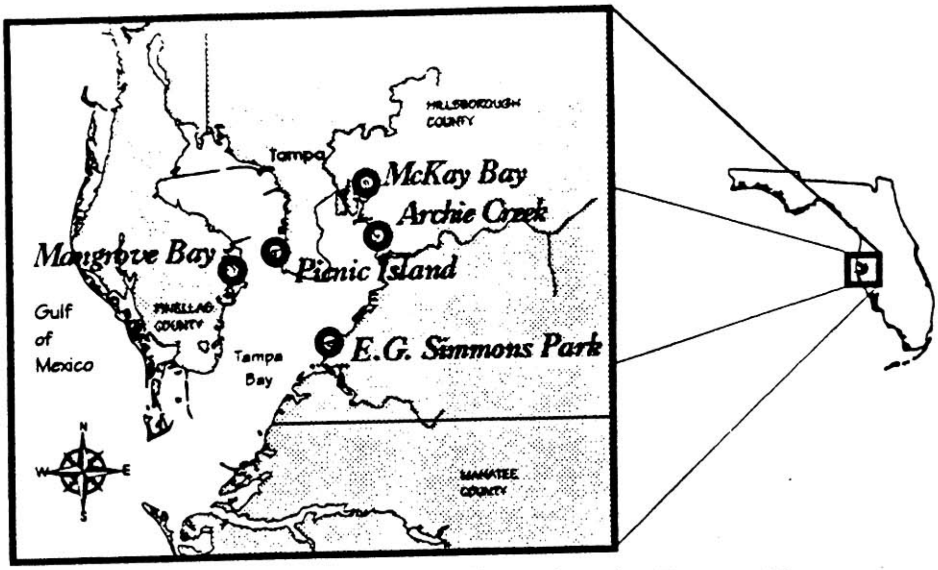

Figure 1. Locations of fish sampling sites in Tampa Bay.

assemblage of coastal habitats including mangrove forests, salters, oligohaline and intertidal marshes, seagrass beds, mud flats, and hard bottom. In recent decades, dredge and fill activities prevalent along the western and northern shores of Tampa Bay have resulted in significant losses of natural habitat. In an attempt to reverse these declines, over twenty-five marsh restoration projects have been completed in Tampa Bay during the last decade.

Five marsh systems were sampled during this study and included four restored/created marshes and one natural marsh that served as a reference site (Table 1). All four restored marshes were located in the middle and upper Tampa Bay regions and had topographical and vegetative similar to the reference marsh. Each of the marshes was cooperatively constructed by the Improvement and Management (SWIM) Program of Florida Water Management District and one of government agencies including Hillsborough County, the City of St. Petersburg, and the City of Tampa.

Table 1. Descriptions of the five marsh sites in Tampa Bay.

Site	Year Completed	Size (ha)	Salinity Range (ppt)	Total Area Sampled (m^2)
Picnic Island	1993	3.2	11-31	1,377
McKay Bay	1991	1.6	0-26	258
Mangrove Bay	1991	5.3	8-30	754
E.G. Simmons Park	1990	5.7	15-33	1,094
Archie Creek (reference marsh)	Historic	>25	2-27	558

Experimental Design

Each of the five marsh sites described in Table 1 was sampled monthly from January 1994 to December 1994. Due to logistical constraints, Picnic Island and Mangrove Bay were sampled quarterly in 1995 while the remaining marshes continued to be sampled monthly. No samples were taken in March or December 1995 from any of the five sites. A 15.2 m wide by 1.2 m high bag seine with 0.6 cm mesh was used for sampling at restored and reference sites. To control for the effects of tidal height variability, every effort was made to sample each area at approximately 0.5 m above mean low tide (MLLW). At this tidal height, platform areas adjacent to sampling stations were usually drained of water, concentrating the fish in channels where they could be collected with the seine. Sampling at each marsh was performed at fixed stations in both open water and channel areas.

Fish were enumerated alive, identified to species and released. Large catches were held in five-gallon containers until they could be recorded and released. Species of economic importance such as snook (Centropomus undecimalus), red drum (Sciaenops ocellatus), spotted seatrout (Cynoscion nebulosus), and mullet (Mugil cephalus) were measured to the nearest centimeter total length. Salinity (ppt) and temperature (^{0}C) were recorded using a refractometer and mercury thermometer, respectively, during each sampling event.

Statistical Analysis

Overall trends in fish abundances and species are presented using untransformed data. For statistical comparisons between sites, fish density (i.e., catch per square meter) values were used since the total area and number of seine hauls differed between sites. Fish density values were calculated by combining data from all stations sampled within a site and dividing by the total area (ml) sampled. Fish density data were then normalized by log + 1 transformation to meet the normal distribution assumptions for parametric analysis. A general linear models procedure (PROC GLM, SAS Institute, 1989) was used since sample sizes differed among sites. Untransformed temperature and salinity data were analyzed separately using one-way ANOVA. A Student Newman Keuls (SNK) test was used for post-hoc analyses.

To compare and describe trends in fish community structure, species similar in their functional use of the marsh ecosystem were grouped into three separate guilds: nursery, resident, and transient. Nursery species were grouped as those using marsh habitat during an important early life history stage. Resident species were grouped as those using marsh habitat during most or all stages of their life history. Transient species were classified as using marsh habitats periodically for foraging or infrequently for refuge. Cluster analysis (nearest neighbor method) was used to generate a hierarchical tree, which identified the relative similarity among sites based on abundances of each of these three guilds.

RESULTS

A total of 86,024 fish representing fifty-six species and twenty-five families were collected over the 24-month study period from the five marsh sites (Table 2). Dominant species (abundances >5% of the total population sampled), in order of greatest total abundance, were Menidia beryllina (27%), Anchoa mitchili (12%), Lucania parva (9%), Poecilia latipinna (8%), Cyprinodon variegatus (7%), Fundulus grandis (6%), Brevoortia smithi (6%), and Adinia xenica (5%). Mean number of species per sampling event was significantly different (df = 4, F = 19.96, p = 0.0001) among sites. Greatest mean number of species was found at Picnic Island (18.8 ±4.7 species) followed by E. G. Simmons Park (14.8 ±5.9), Mangrove Bay (11.1 ±3.3), Archie Creek (9.8 ±4.8), and McKay Bay (9.0 ±4.5).

Mean fish densities for all species combined were calculated from greatest to least as follows: McKay Bay (1.96 fish m^2) , Archie Creek (1.48 fish m^2), Mangrove Bay (1.29 fish m^2) , Picnic Island (0.89 fish m^2) , and E.G. Simmons Park (0.87 fish m^2) . These differences, however, were not significantly different between sites ($p > 0.05$). When data were segregated by guild, marsh resident fish densities were significantly greater than both transient and nursery fish densities (df = 2, F = 50.15, $p < 0.0001$) for data pooled from all sites.

For comparisons between marshes, mean densities of marsh resident fish were significantly greater ($p < 0.05$) at Mangrove Bay than Picnic Island. Mean densities of nursery species were greatest at McKay Bay (0.22 fish m^2) and least at Mangrove Bay (0.06 fish m^2) , however, differences between sites were not significant ($p > 0.05$). Densities of nursery species were significantly different among months (df = 11, F = 2.38, p = 0.01) with greatest densities occurring in February and March. Transient fish densities were significantly different among sites (df 4, F = 14.27, p 0.0001) and were greatest at Picnic Island (0.76 fish m^2) followed by McKay Bay (0.49 fish m^2) E. G. Simmons Park (0.07 fish m^2) , Archie Creek (0.02 fish m^2) and Mangrove Bay (0.0007 fish m^2) . Densities of transient fish differed significantly between months (df = 11, F = 14.27, p = 0.0001) and were greatest in April than any other month.

Data for economically important species were pooled among all sites to calculate mean total length values. A total of 204 snook, 491 red drum, 75 spotted seatrout, 2,576 spot, and 2,547 mullet were caught over the study period. Snook total length values ranged from 20-590 mm with a mean length of 99.3 mm (Figure 2). Total length values for red drum ranged from 20-210 mm with a mean of 59.4 mm. Spotted seatrout total lengths ranged from 40-120 mm with a mean of 74.5 mm. Total length values for mullet ranged from 10-210 mm with a mean of 28.3 mm.

Densities of economically important fish species were analyzed separately for comparisons between sites. Mean densities of snook were greatest at Mangrove Bay (0.0052 fish m^2) and least at the natural marsh at Archie Creek (0.0009 fish m^2) . However, snook densities were not statistically different between sites ($p > 0.05$) nor between months ($p > 0.05$). Mean densities of red drum were significantly greater at Archie Creek (0.018 fish m^2) than any other site (df = 4, F = 5.61, p = 0.001) (Figure 3). Red drum densities also differed significantly (df = 11, F = 4.58, p = 0.0002) between months with greatest densities occurring in December and January at both Archie Creek and McKay Bay. Mean densities for spotted seatrout were greatest at Archie Creek (0.0014 m^2) and least at Mangrove Bay (0.0002 fish m^2). Spotted seatrout densities were not statistically different ($p > 0.05$) between sites nor between months. Mean densities for mullet were significantly different (df= 4, F=2.94, p=0.03) between sites with greatest densities at McKay Bay (0.1682 fish m^2). No significant differences ($p > 0.05$) in mullet densities were found between months.

Salinity values were significantly different between sites (df=4, F=37.75, $p < 0.05$) and ranged from 0.0 - 33.0 ppt for all sites combined. Lowest salinities

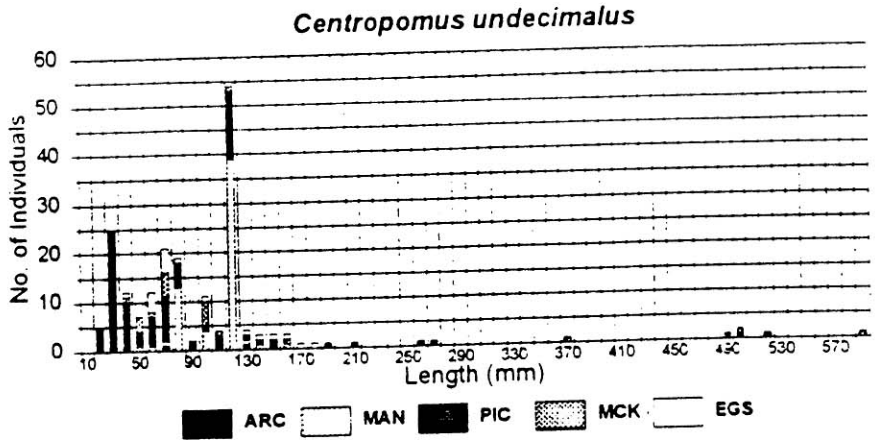

Figure 2. Length frequency distribution of snook at the five study marshes in Tampa Bay (ARC = Archie Creek, MAN = Mangrove Bay, PIC = Picnic Island, MCK = McKay Bay, EGS = E. G. Simmons Park).

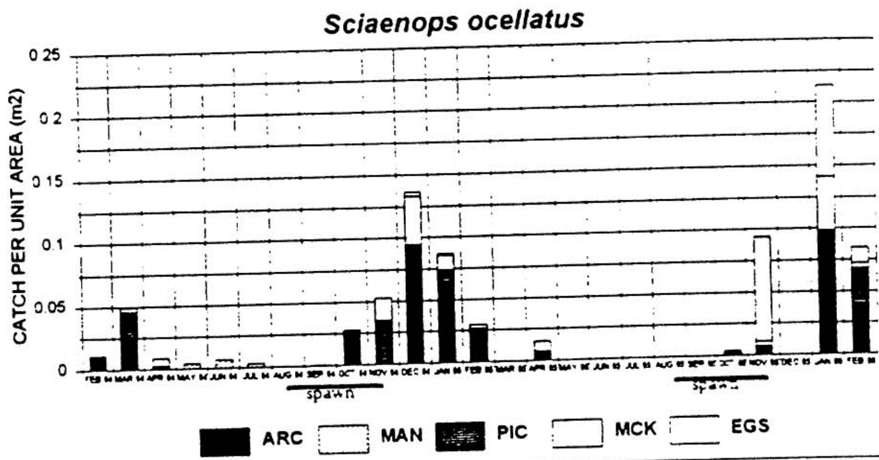

Figure 3. Mean densities of red drum at the five study marshes in Tampa Bay.

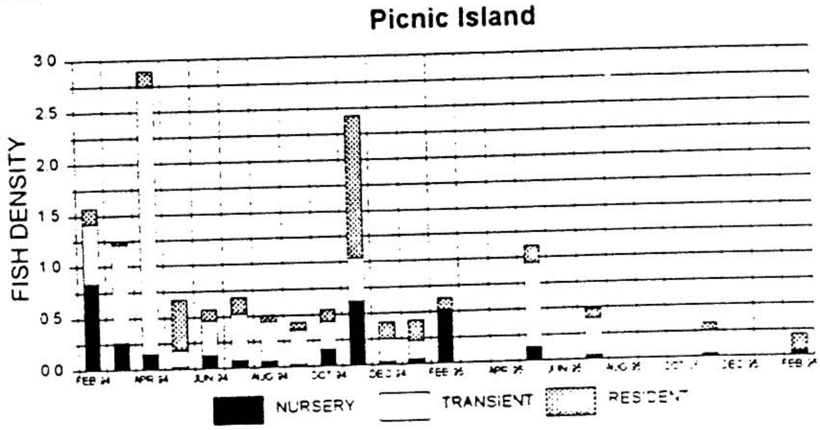

Figure 4. Mean monthly fish densities by guild for Picnic Island.

occurred at McKay Bay, followed by Archie Creek, Mangrove Bay, E.G. Simmons Park, and Picnic Island. Temperatures throughout the study area ranged between 15 - 38 'C and were not significantly different between sites during any given month (df=4, F=0.28, $p = 0.89$) .

Total fish densities (all species combined) were not significantly correlated with temperature but were positively correlated with salinity ($r^2 = 0.16$, $p = 0.0001$) Densities of red drum, trout, and mullet were not significantly correlated with temperature. Snook densities were positively correlated with temperature ($r^2 = 0.15$, p 0.05) and spotted seatrout densities were negatively correlated with salinity ($r^2 = 0.21$, $p = 0.04$).

Fish community similarity was measured using cluster analysis and was used to group the most similar sites based on mean monthly densities of the three guilds (nursery, resident, transient) at each site. Nearest-neighbor (Euclidean distance) values were shortest between Mangrove Bay and Archie Creek indicating that these sites were most similar in guild composition. Picnic Island and E.G. Simmons Park also were relatively similar while McKay Bay ranked between both of these two clusters.

DISCUSSION

Previous studies of natural marshes in the Gulf of Mexico have established considerable descriptions and species lists of fish communities (Subrahmanyam and Drake 1975; Subrahmanyam and Coultas 1980; Peterson and Ross 1991; Rakocinski et al. 1992). We observed similar dominant species and overall fish community structure as those found in other west Florida marshes in both the restored and natural marshes we sampled in Tampa Bay. However, we also found significant differences in the proportions of resident, nursery, and transient species among the five study sites.

Marsh resident species comprised more than 50% of the total catch at three of the four restored marshes (Mangrove Bay, E. G. Simmons Park, and McKay Bay) and the reference marsh. These four sites are all located in relatively protected, quiescent (low wave energy) areas away from the open waters of Tampa Bay; conditions typically favored by many marsh resident species.

Conversely, Picnic Island is located in the middle reaches of the bay and is exposed to large-scale, semi-diurnal tidal currents that are capable of transporting a wide variety of larval and juvenile fish species into the bay from offshore spawning areas in the Gulf of Mexico. Transient fish densities comprised approximately 55% of the catch at Picnic Island (Figure 4). We believe that the reason Picnic Island had significantly greater numbers of species and greater densities of transients than the other marshes was a result of its geographic location with respect to this tidal transport phenomenon.

Cluster analysis further suggested that sites most similar in fish guild composition were also most similar in salinity regime and proximity to the open waters of the Bay (Figure 5). Sites were clustered according to similarity in their densities of resident, transient, and nursery fish species. Mangrove Bay and Archie Creek appeared to be the most similar (had shortest Euclidean distances), had nearly identical mean salinities (mesohaline), and were both relatively protected marsh systems located several hundred meters from the open waters of Tampa Bay. Picnic Island and E. G. Simmons Park had consistently higher mean salinities with little to no freshwater influence entering either marsh system. McKay Bay had a relatively low mean salinity value and fell between these two distinct pairs (clusters) of sites.

Despite an apparent clustering of sites with similar salinity regimes, only a weak, positive trend was observed between total fish abundance and salinity. No significant trends were observed between total fish abundance and temperature. The lack of significant correlations with either salinity or temperature suggests that many species within the fish community may be more influenced by seasonal emigration and immigration patterns than by physicochemical factors. Examples of this phenomenon occurred with snook, red drum, seatrout, and mullet whose abundances were either unrelated or only weakly correlated with trends in temperature or salinity. Earlier observations by Subrahmanyam and Coultas (1980) in north Florida marshes suggest that breeding patterns, recruitment, and seasonal succession of dominant species have a more profound influence on seasonal changes in fish community structure than do physical factors. Similar findings were described by Potter et al. (1986) in an estuarine fish assemblage in the United Kingdom.

Economically important species such as juvenile snook are colonizing and

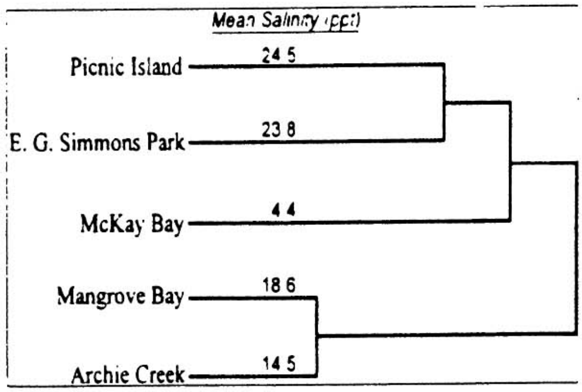

Figure 5. Cluster diagram and mean salinities of five marsh sites in Tampa Bay.

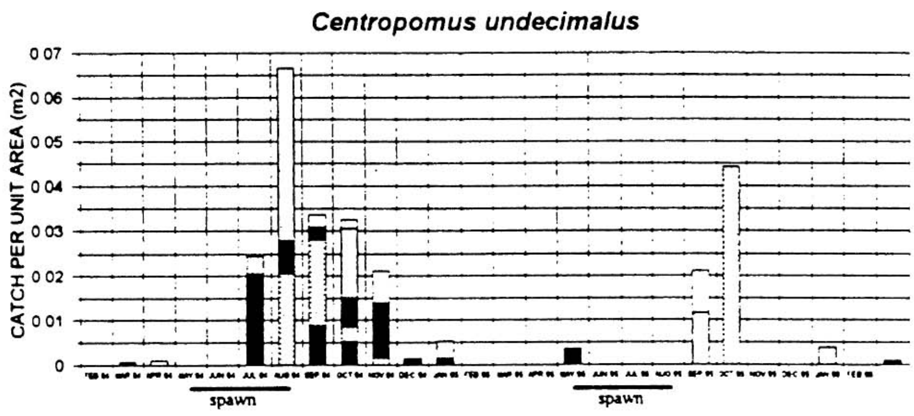

Figure 6. Mean monthly snook densities at the five study marshes in Tampa Bay.

residing in both restored and natural marshes during periods following peak spawning activity (Figure 6). Snook appear to reside in the marshes we studied for a duration of approximately 2-7 months. Similar observations were made by Gilmore et al. (1983), who found juvenile snook ranging in size between 10-174 mm with residence times ranging from 2-5 months in salt marsh habitat on the east coast of Florida. Peak snook densities in both restored and natural marshes at our study sites occurred between July and November following reported peak spawning periods between May and August. Based on age estimates developed by McMichael et al. (1989) for snook in Tampa Bay, snook entering the restored marshes in this study appear to range in age from approximately 27 days to 8 months. The average age of snook for the five marshes we sampled would be approximately 6 months based on an average measured length of 99.3 mm.

Juvenile red drum densities were greatest in December and January and followed reported spawning periods which typically occur between August and November (Peters and McMichael, 1987). These authors found high percentages of juvenile red drum in backwater areas (compared to seagrass beds); habitats which were similar to the tidal creeks created at many of the restored marshes in our study. Peters and McMichael (1987) also reported that peak abundances of juvenile red drum in backwater areas occurred at sizes between 30 to 60 mm. We observed similar peaks in abundance for red drum ranging in length from 20 to 70 mm. Spotted seatrout densities peaked between May and November following a spawning period that typically occurs between May and July.

Other comparisons of restored (or mitigated) and natural marshes have not always been favorable. A study by Chamberlain and Barnhart (1993) found that fish use of a mitigation salt marsh in Humboldt Bay, California was not similar to a nearby reference marsh. Moy and Levin (1991) found fewer Fundulus abundances, lower organic content, and lower Spartina stem densities in man-made marshes than in natural marshes. Even though the average age of the four restored marshes we sampled was less than 3 years old, we found significantly greater numbers of fish species at two of the four restored marshes than at the natural marsh and no significant differences in fish density between restored and natural marshes. Our observations of greater numbers of species at restored marshes suggest that these created habitats are serving as a functional resource to the local fish community. Several authors (LaSalle et al. 1991; Rulifson 1991; Whitman and Gilmore 1994) have reported similar findings.

We believe that the rapid and consistent presence of resident, nursery, and transient fish species at these four restoration sites provides strong evidence that salt (and oligohaline) marshes are a limited and critical habitat in the Tampa Bay ecosystem. The colonization of created marshes by a wide variety of juvenile fish also suggests that these sites are capable of attracting and supporting early life history stages of economically important species. Continued efforts to create, restore, and enhance coastal marsh habitats should have a measurable' positive effect on stressed fisheries' species in the Tampa Bay ecosystem.

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