A COMPARISON OF MARSH FISH COMMUNITIES USING THE WEGENER RING

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Abstract: Three marsh types (saline, brackish, and freshwater) in the Baratoria Basin were sampled with the Wegener Ring. Forty-four species were collected, representing 21 families. Overall species composition and within species abundance varied from saline to freshwater environments. Shannon-Weaver diversity and evenness diversity show a decreasing gradient from saline to freshwater marsh. Number of individuals collected had an opposite gradient. The order of sequence from highest to lowest for biomass was fresh, saline, and then brackish. The saline marsh had the highest species richness value, while freshwater marsh had a slightly higher value than the brackish marsh.

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The marshes of the Barataria Basin comprise a valuable natural resource. As much as 1/2 of the total primary production of estuaries may originate from surrounding marshes (Stowe et al. 1971, Teal 1962). In addition, it is well documented that marshes and estuaries serve as nursery grounds for fish and shellfish. As estimated 2/3 of the cash value of species harvested on the Atlantic and Gulf coasts are estuarine-dependent during part of their life cycle (McHugh 1966). Marsh fish communities also provide immense amounts of biomass important for energy flow in estuaries (Day et al. 1973, Nixon and Oviatt 1973). Shallow, heavily vegetated marshes are thus an intergral component of the estuarine and inshore Gulf ecosystem.

The community structure, species composition, abundance, and biomass of small, permanently-residing and juvenile seasonally-residing marsh fishes in Louisiana is virtually unknown. Shallow water, extremely soft substrate, and heavy vegetation render most sampling for marsh fish populations virtually useless. Comprehensive studies have been conducted on the saline marsh fish fauna of Florida (Kilby 1955, Reid 1954, Subrahmanyam and Drake 1975, Zilberberg 1966) and in Mississippi (Franks 1970). Little data, however, exist on Louisiana marsh fish communities. The objectives of this study were to identify species composition, species abundance, and biomass of fishes in different marsh types in the Barataria Basin using the Wegener Ring.

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METHODS

The Barataria Basin includes Barataria Bay proper and extends northward to Little Lake, Lake Salvador, Lake Cataouache and Lac Des Allemands (Fig. 1). For this study, 3 marsh types were selected according to Chabreck (1972): saline, brackish, and freshwater. The saline marsh area was on Grand Terre Island. This marsh is dominated by *Spartina alterniflora* with some *S. patens* and *Avicennia nitida* along canal edges. The saline marsh had less detritus and a harder bottom when compared to the brackish and freshwater areas. The brackish marsh site was on the southern and northern shores of Little Lake just east of Plum Point. *Spartina patens* and *S. alterniflora* were the dominant

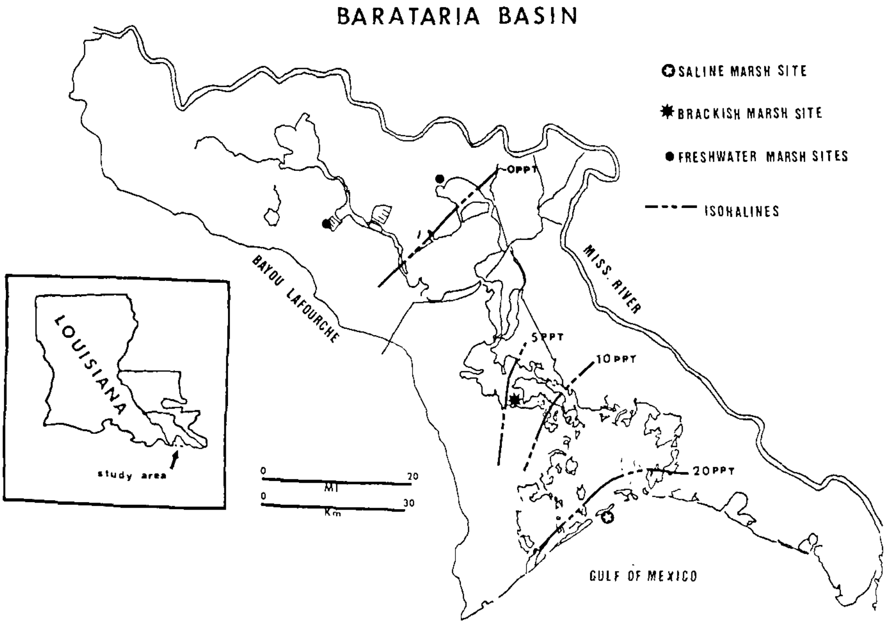

Fig. 1. Location of sampling sites in the Barataria Bay system (redrawn from Hopkinson 1979).

vegetation. This marsh has a large amount of detritus and a soft bottom. The freshwater marsh samples were taken in 2 locations: canals at Dufrene's Ponds adjacent to Bayou des Allemands and the Salvador Wildlife Refuge. Fresh marsh vegetation is predominantly *Sagittaria falcata*, *Eleocharis* Spp., *Panicum hemitomon*, although there were many other species. The water surface is often covered with *Lemna* spp., *Azola* spp., and *Eichornia crassipes*.

Salinity regimes in the Barataria Basin are extremely dynamic, depending upon tide, wind direction, local rainfall, and Mississippi River discharge. As a result, salinity values are constantly changing at a particular site. Average annual isohaline lines, however, provide a more realistic appraisal of the parameter. Grand Terre Island is near the 20 ppt line, Little Lake at the 5 ppt line, and Salvador Wildlife Refuge at the 0 ppt line (Dunham 1972). In our study, salinity at Grand Terre ranged from 2.5 to 15 ppt, Little Lake from 0 to 2 ppt, and Dufrene's Ponds and Salvador Refuge had a reading of 0 ppt.

Twenty samples were taken in each marsh type from May to August 1979. At the freshwater marsh 5 samples were taken in Dufrene's Ponds and 15 samples were taken in Salvador Wildlife Refuge. A variety of habitats were sampled in each area, small ponds, tidal channels, vegetation types, etc. Water temperature, air temperature, salinity, and depth were recorded at each site.

The area-density method provides the best numerical estimate of juvenile and/or small fishes in estuaries (Kjelson 1977). After reviewing the available quantitative sampling methods we selected the Wegener Ring (Wegener et al. 1973) for our study. It was originally developed to sample shallow, heavily vegetated margins of certain central Florida lakes but has also been used to study oyster reefs and spoil banks (Bass and Guillory 1979). The Wegener Ring is a cylinder of fine mesh netting suspended between a ring of strap steel on the bottom and ring of floatable hose on the top. The ring has a diameter of 2.26 m. This is a convenient size because it can be handled easily by 2 people and its area of 0.0004 ha allows for easy expansion of standing crop estimates to a larger scale.

The Wegener Ring was transported to the sampling site by boat and usually carried by hand to sampling sites further inland. On some occasions the ring was thrown directly from the boat because the soft substrate made walking almost impossible. All of the freshwater samples were obtained in this manner. Once thrown, the sampler was checked to make sure the metal ring was on the bottom and the hose was completely floating. Rotenone was then applied. Fish were collected with a 1/4-inch mesh dip net from the surface when they surfaced in distress or from the bottom after they sank.

Due to unavoidable circumstances, a 46 cm *Lepisostous oculatus* collected at the freshwater marsh was released without obtaining a weight. An approximate weight was obtained from data tabulated by Carlander (1969).

All fish were preserved in the field with 10 percent formalin. After a week they were washed in water and put in 50 percent isopropyl alcohol. They were then sorted to species, identified, and weighed.

Pooled data for each site was subjected to 3 diversity indices. The Shannon-Weaver diversity index (Shannon and Weaver 1963) was the first: $H'' = -\Sigma\, n/N \log_n n/N$, where n is the number of individuals of each species and N is the total number of individuals. This formula is sensitive to both species richness and evenness. Species richness diversity is sensitive to the number of species present in reference to total number of individuals. Species evenness measures dominance or how evenly numbers are allocated into species categories in reference to the calculated maximum where all species are equally abundant. The Margalef (1958) index for species richness was calculated according to the formula: $D = S\text{-}1/\log_{10} N$, where S is the number of species and N is the total number of individuals. The Pielou (1966a) formula for evenness was also used: $J = H/Hmax = H/\log_n S$, where H is the Shannon-Weaver index and S is the number of species.

A drawback of species diversity indices, when used alone, is that they are insensitive to shifts in species composition and relative abundance along habitat gradients. For this reason, 2 methods of measuring the similarity of the biota at different stations were utilized.

The first method was based on Sander's (1960) index (S) which is sensitive to the cumulative differences in the relative abundance of species in 2 localities: $S = \Sigma\, \mathrm{Min}(r_a, r_b)$, where r_a and r_b are the relative abundance (in terms of percent composition) of species i at stations a and b, respectively. Values of S may range from 0.0 to 100, with 100 reflecting equal abundance of all species at stations a and b, and values less than 100 indicating varying degrees of similarity in the comparative abundance of all species between the 2 stations.

The second method was Long's (1963) faunal resemblance index (R) in which similarity between 2 localities is calculated: $R = C(N_1 + N_2) \times 100 / 2N_1N_2$, where C is the number of species common to stations 1 and 2, and N_1 and N_2 are the number of species found at stations 1 and 2, respectively. Values of R range from 0.0 to 100, where 100 reflects a situation where all species at stations 1 and 2 are identical and 0.0 results when stations 1 and 2 have no species in common.

RESULTS

Number, weight, and frequency of occurrence of each species in each marsh type is presented in Table 1. In the saline marsh the cyprinodonts comprised about 60 percent and gobiids and 15 percent of the total numerically. The most common species included, in order of abundance, *Cyprinodon variegatus*, *Fundulus grandis*, *Adinia xenica*,

Table 1. Number (No.), weight in grams (Wt.), and frequency of occurrence (F) of fishes collected in saline, brackish, and fresh marshes in the Barataria Bay system in 20 (per site) Wegener Ring samples.

	Saline			Brackish			Fresh		
	No.	Wt.	F.	No.	Wt.	F.	No.	Wt.	F.
Lepisosteus oculatus (Spotted gar)	-	-	-	-	-	-	1.00	320.00	1.00
Lepisosteus spatula (Alligator gar)	-	-	-	-	-	-	1.00	1.27	1.00
Elops saurus (Ladyfish)	1.00	0.13	1.00	-	-	-	-	-	-
Anguilla rostrata (American eel)	-	-	-	2.00	19.93	2.00	-	-	-
Myrophis punctatus (Speckled worm eel)	35.00	12.85	12.00	63.00	18.19	6.00	1.00	2.06	1.00
Anchoa mitchilli (Bay anchovy)	1.00	0.49	1.00	3.00	1.78	1.00	223.00	148.95	6.00
Notemigonus crysoleucas (Golden shiner)	-	-	-	-	-	-	75.00	110.52	4.00
Ictalurus natalis (Yellow bullhead)	-	-	-	-	-	-	3.00	11.63	2.00
Ictalurus punctatus (Channel catfish)	-	-	-	-	-	-	1.00	20.90	1.00
Gobiesox strumosus (Skilletfish)	9.00	6.54	2.00	1.00	0.17	1.00	-	-	-
Adinia xenica (Diamond killifish)	48.00	39.14	5.00	78.00	10.22	4.00	-	-	-

Table 1. Cont.

	Saline			Brackish			Fresh		
	No.	Wt.	F.	No.	Wt.	F.	No.	Wt.	F.
Cyprinodon variegatus (Sheepshead minnow)	288.0	426.95	8.00	473.00	233.18	7.00	3.00	0.65	1.00
Fundulus chrysotus (Golden topminnow)	-	-	-	-	-	-	16.00	6.12	7.00
Fundulus grandis (Gulf killifish)	136.00	226.53	11.00	49.00	26.26	9.00	-	-	-
Fundulus pulvereus (Bayou killifish)	5.00	7.78	2.00	15.00	6.03	6.00	-	-	-
Fundulus similis (Longnose killifish)	12.00	25.69	5.00	-	-	-	-	-	-
Lucania parva (Rainwater killifish)	-	-	-	3.00	0.43	3.00	37.00	7.27	5.00
Gambusia affinis (Mosquitofish)	-	-	-	-	-	-	1071.00	172.84	15.00
Heterandria formosa (Least killifish)	-	-	-	-	-	-	110.00	12.67	14.00
Poecilia latipinna (Sailfin molly)	3.00	14.39	1.00	-	-	-	16.00	3.61	3.00
Menidia beryllina (Tidewater silverside)	23.00	4.88	4.00	92.00	23.52	9.00	63.00	36.89	4.00
Syngnathus scovelli (Gulf pipefish)	-	-	-	37.00	12.81	7.00	9.00	1.21	4.00

Table 1. Cont.

	Saline			Brackish			Fresh		
	No.	Wt.	F.	No.	Wt.	F.	No.	Wt.	F.
Elassoma zonatum (Banded pygmy sunfish)	-	-	-	-	-	-	1.00	0.11	1.00
Lepomis macrochirus (Bluegill)	-	-	-	-	-	-	22.00	48.81	8.00
Lepomis megalotis (Longear sunfish)	-	-	-	-	-	-	1.00	1.15	1.00
Lepomis punctatus (Spotted sunfish)	-	-	-	-	-	-	13.00	55.35	5.00
Lepomis symmetricus (Bantam sunfish)	-	-	-	-	-	-	1.00	1.30	1.00
Micropterus salmoides (Largemouth bass)	-	-	-	1.00	1.15	1.00	4.00	259.83	3.00
Trachurus lathami (Rough scad)	1.00	0.08	1.00	-	-	-	-	-	-
Lutjanus griseus (Gray snapper)	1.00	0.74	1.00	-	-	-	-	-	-
Eucinostomus gula (Silver jenny)	1.00	0.73	1.00	-	-	-	-	-	-
Archosargus probatocephalus (Sheepshead)	2.00	0.78	1.00	3.00	13.33	2.00	-	-	-
Lagodon rhomboides (Pinfish)	1.00	0.38	1.00	-	-	-	-	-	-

Table 1. Cont.

	Saline			Brackish			Fresh		
	No.	Wt.	F.	No.	Wt.	F.	No.	Wt.	F.
Bairdiella chrysura (Silver perch)	2.00	0.78	1.00	11.00	22.30	3.00	-	-	-
Cynoscion nebulosus (Spotted seatrout)	-	-	-	2.00	1.95	2.00	-	-	-
Pogonias cromis (Black drum)	10.00	0.38	1.00	1.00	8.02	1.00	-	-	-
Mugil cephalus (Striped mullet)	1.00	1.69	1.00	1.00	3.65	1.00	-	-	-
Evorthodus lyricus (Lyre goby)	33.00	47.74	8.00	1.00	6.17	1.00	-	-	-
Gobionellus boleosoma (Darter goby)	28.00	5.95	8.00	-	-	-	-	-	-
Gobionellus hastatus (Sharptail goby)	-	-	-	1.00	2.42	1.00	-	-	-
Gobiosoma bosci (Naked goby)	36.00	14.92	5.00	77.00	26.17	6.00	1.00	1.89	1.00
Microgobius gulosus (Clown goby)	-	-	-	-	-	-	1.00	1.35	1.00
Citharichthys spilopterus (Bay whiff)	9.00	2.72	1.00	-	-	-	-	-	-
Symphrus plagiusa (Blackcheek tonguefish)	2.00	0.56	2.00	-	-	-	-	-	-
Total	688.00	856.33		914.00	437.18		1674.00	1226.41	

Gobiosoma bosci, *Myrophis punctatus*, and *Evorthodus lyricus*. The first 2 and the last species contributed the most biomass. The most common fishes numerically in the brackish marsh were *C. variegatus*, *Menidia beryllina*, *A. xenica*, *G. bosci*, *M. punctatus*, and *F. grandis*. The cyprinodonts accounted for approximately 60 percent of all fishes, while *M. beryllina*, *G. bosci*, and *M. punctatus* each comprised from 7 to 10 percent of the total. *Cyprinodon variegatus* contributed 8 times more biomass than the second and third ranked species (*G. bosci* and *F. grandis*). In order of numerical abundance, the most common fishes from the freshwater marsh included *Gambusis affinis*, *Heterandria formosa*, *Anchoa mitchilli*, *Notemigonus chrysoleucas*, *M. beryllina* and *Lucania parva*. Collectively, the poecilids accounted for approximately 70 percent of the total number collected. *Lepisosteus occulatus* and *Micropterus salmoides*, although infrequent in samples, yielded the most biomass.

A rather pronounced shift in species composition of the marsh fauna also occurred between sites. Only 5 species (*A. mitchilli*, *M. punctatus*, *C. variegatus*, *M. beryllina*, *G. bosci*) were common to all 3 areas. *Elops saurus*, *Fundulus similis*, *Trachurus lathami*, *Lutjanus griseus*, *Eucinostumus gula*, *Lagodon rhomboides*, *Citharichthys spilopterus*, and *Symphurus plagiusa* were collected only in the saline marsh. Three species (*Anguilla rostrata*, *Cynoscion nebulosus*, *Gobionellus hastatus*) were observed only from the brackish marsh. Species restricted to the freshwater marsh included *Lepisosteus spatula*, *L. oculatus*, *Fundulus chrysotus*, *Notemigonus crysoleucas*, *Ictalurus natalis*, *I. punctatus*, *G. affinis*, *H. formosa*, *Elassoma zonatum*, *Lepomis macrochirus*, *L. megalotis*, *L. punctatus*, *L. symmetricus*, and *Microgobius gulosus*. Fourteen species were shared by the saline/brackish marshes, 8 by the fresh/brackish marshes, and 5 by the saline/fresh marshes.

To quantify the shifts in overall species composition and abundance of individual species along the saline-brackish-fresh marsh gradient, 2 coefficients of similarity were applied to the data (Table 2). As might be expected, both Long's index (based on shared species) and Sander's index (based on abundance of species) reflect the highest degree of faunal resemblance between the saline and brackish marshes. The fresh marsh fauna, on the other hand, was the most distinct and appeared to be equally discrete from the brackish and saline marsh fish communities. Thus, for the marsh fish fauna, the most drastic replacements of species and concurrent shifts in abundance of shared species took place as the fresh marshes were encountered.

Various summary data and species diversity indices also reveal some interesting observations and trends along the marsh gradient (Table 3). Each area was approximately equal in number of species: 24 in the saline marsh, 20 in the brackish marsh, and 23 in the fresh marsh. However, there was a trend in Shannon-Weaver diversity from the saline (1.99) to brackish (1.71) to fresh (1.37) marshes. The evenness index values paralled the above. As pointed out by Pielou (1966b), Shannon-Weaver diversity is influenced more by the evenness rather than the richness component. However, using the species richness index values, the saline marsh had the highest value (3.52), whereas the brackish and

Table 2. Results of Long's and Sander's indices of resemblance between pooled Wegener Ring data for each marsh type.

	Long's	Sander's
Saline vs Brackish	64.2	69.8
Saline vs Fresh	37.4	4.2
Brackish vs Fresh	25.5	5.4

Table 3. Summary data for each marsh type (95% confidence limits with 19 d.f. are included).

	Saline	Brackish	Fresh
Total Species	24	20	23
Species per Sample	4.40 + 1.03	3.70 + 0.92	4.50 + 1.42
Number per Sample	34.40 + 22.01	45.70 + 34.49	83.70 + 64.36
Biomass (g) per Sample	42.80 + 40.65	21.90 + 14.09	61.30 + 43.83
Shannon-Weaver Diversity	1.99	1.71	1.37
Species Richness Diversity	3.52	2.79	2.96
Evenness Diversity	.63	.57	.44

fresh marshes had similar values of 2.79 and 2.96, respectively. A well defined gradient in number of fishes existed from fresh to brackish to saline—83.7, 45.7, and 34.4 individuals per sample, respectively. With respect to biomass, the fresh marsh samples had the highest value, followed by the saline and brackish samples.

DISCUSSION

The Wegener Ring proved to be an adequate method to obtain quantitative samples in shallow, heavily vegetated marsh habitats. The main drawback of this method is that the standing crop is underestimated because some fishes, especially larger and/or fast-swimming forms, are frightened by movement of the operators. Despite this fault, the Wegener Ring is more accurate than unrestricted poison samples where the poisoned area can be changed drastically by currents, tides, or wind. The small unit area covered by the ring also allows repetitive sampling at a given station so that confidence limits may be derived for statistical comparisons. Moreover, more conventional sampling devices such as gill nets, trawls, or seines cannot be used in most marshes because of the shallowness, heavy vegetation, and soft substrates, which hinder both walking and boating. The Wegener Ring is also portable for sampling in hard-to-reach places. It can be handled by 2 workers. However, the Wegener Ring is still cumbersome when it must be carried, along with field gear, over marshy areas.

We generated expended standing crop estimates of fishes on a per hectare basis as follows: 206,740 individuals and 151.45 kg., 112880 individuals and 53.99 kg., and 84,970 individuals and 105.75 kg. for the fresh, brackish, and saline marshes, respectively. Day et al. (1973) obtained standing crop estimates from 2 brackish ponds in the Barataria Bay system and presented the following: 73,541 individuals and 460.03 kg. per ha in an isolated pond, and 5,435 individuals and 137.88 kg. per ha in a connected pond. They concluded that probably only about 1/4 of the fishes present were collected; consequently, their figures, like our data, represent minimum standing crop estimates. Thus, considering both our data and that generated by Day et al. (1973), the production of fishes in large tracts of marsh habitat is undeniably large.

A number of parameters, including temperature, degree of inundation, substrate, salinity, food, predation, and gross biotic relationships, affect the zonation of marsh fauna (Daiber 1977, Kirby 1955, Reid 1954). However, it is rarely possible to determine which factor is of greatest importance. A tidal marsh is a dynamic ecosystem characterized by constantly changing physical, chemical, and edaphic factors. Most of these factors are inseparable, each playing a significant role in forming a specific habitat.

Moreover, the relationship between habitat features and distribution and abundance of marsh fishes is obscured by the lack of data on the environmental tolerances and responses of various species and on the range of environmental conditions in each habitat. However, realizing the above shortcomings, the distribution and abundance of species and overall species composition of marsh fishes may be broadly correlated with salinity. As presented earlier in the description of the study area, the 20 ppt isohaline line was at the saline marsh site, the 5 ppt isohaline line at the brackish marsh station, and the 0 ppt isohaline line at the fresh marsh. The saline marsh fauna included typical marine inshore and estuarine species. The fresh marsh fauna was predominantly freshwater in species composition (about 65%) and in overall numerical abundance (about 80%). The freshwater marsh fish community was largely comprised of species which typically invade low salinity waters. The brackish marsh fauna included a single species of *M. salmoides* and 2 individuals of *Anguilla rostrata*. The remaining species were predominantly typical estuarine species. As demonstrated by the above generalizations, and earlier quantified by the similarity indices, the saline and brackish fish fauna were fairly similar while the fresh marsh fish community was the most distinct. Salinity also has an important influence on the total number of species. Gunter (1961) presented many examples showing that over a salinity gradient the number of species is directly related to salinity.However, our samples from the marshes showed no such gradient—the number of species collected per site ranged from 20-24. This disparity may be related to the selectivity of the Wegener Ring towards smaller fish; alternately, the total number of species of marsh dwelling fishes may not be related to salinity in the same manner as the open-water fish populations illustrated by Gunter (1961).

Studies on the marsh fish fauna are sparse and, in most cases, little is known about their ecology and life histories. We hope this paper will stimulate other investigations of basic marsh ecology and fauna. The deterioration of Louisiana's marshlands, due to local subsidence, erosion, canalization, and filling, may (or should) be the most critical topic in coastal zone management today. The protection and preservation of these marshes has proven difficult because, among other reasons, there are deficiencies in the scientific data on these marshes.

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