Fisheries Use Attainability Study for Pine Island Bayou (Segment 0607)

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Pine Island Bayou (Segment 0607) was sampled by Texas Parks and Wildlife Department (TPWD) Resource Protection Division staff as part of a use attainability analysis being prepared by the Texas Water Commission (TWC). The role of TPWD was to provide the TWC with a characterization of the fish community in this stream segment.

Study Site

Pine Island Bayou (Segment 0607) flows for 148 km through Hardin and Jefferson counties in southeast Texas before its confluence with the Neches River. The drainage area covers 1700 km², a portion of which is in the Big Thicket National Preserve. Flow is dependent on rainfall, and low flow periods normally occur during the summer months. No major impoundments have been constructed on the bayou, but the Lower Neches River Authority diverts water at a pumping station approximately 400 m upstream of US 69/96/287. Little Pine Island Bayou is a major tributary in the system.

Six stations were sampled during the survey (Figure 1). Flow was sluggish to nonexistent at most stations. The only site for which flow was measured was Little Pine Island Bayou below the Pinewood Estates wastewater treatment plant (0.02 m³/sec). The only other station at which flow was apparent was at Old Sour Lake Road on the main bayou. Discharge data were unavailable because of malfunctions in the United States Geological Survey data retrieval equipment.

Banks surrounding the bayou were heavily forested, and in many areas, canopy cover was extensive (Table 1). Terrestrial vegetation consisted mainly of cypress (***Taxodium***), pine (***Pinus***), oak (***Quercus***), sweetgum (***Liquidamber styraciflua***), and chinese tallow (***Sapium sebiferum***). Substrate consisted primarily of clay and sand. Stream width and depth (Table 1) at the two downstream stations (Black Creek and Village Slough) on Pine Island Bayou were much greater than at the upstream stations and those on Little Pine Island Bayou. Habitat for fishes in the form of snags and fallen timber was adequate.

Several major and minor wastewater plants discharge treated effluent into Pine Island and Little Pine Island bayous (Figure 1). Low dissolved oxygen levels have been reported in the bayou and have been attributed to the decay of organic material contributed from forested land surrounding the bayou or to those natural conditions in combination with wastewater discharges (Adsit and Hagen 1978).

Methods

Fish were collected August 4-6, 1987. Representative habitats were sampled by common sense seine at all sites, and by experimental gill nets and electrofishing at the two downstream stations on Pine Island Bayou (Black Creek and Village Slough). The seine measured 4.5 m in length, 1.2 m in depth, and was composed of 3.1 mm ace weave mesh. Gill nets were constructed of monofilament and were 60 m in length, 2.4 m in depth, and were composed of eight 7.5 m long panels varying in bar mesh size from 12.5 to 100 mm. Electrofishing was conducted from a boat equipped with a boom, a 5,000-watt electrical generator, and a converter box designed to produce pulsed DC current.

Each station was seined for three 5-minute periods. Weight (g) and total length (mm) were recorded for larger individuals. Twenty-five randomly chosen fish from each sample were examined for disease and other abnormalities. All fish were preserved in 10% formalin and transported to the laboratory for identification. Taxonomic references include Eddy and Underhill (1978), Hubbs (University of Texas unpublished 1970 manuscript), and Pflieger (1975).

One gill net was set for 16 to 18 hours at each station. Sets were made so that the period sampled included dawn, dusk, and evening periods, when fish are more active. Gill nets were set on the inside banks of meanders with the small mesh abutting the shoreline. Fish were identified, weighed, measured, and examined for disease and other abnormalities before their release.

Stations were electrofished for 15 minutes. Fish

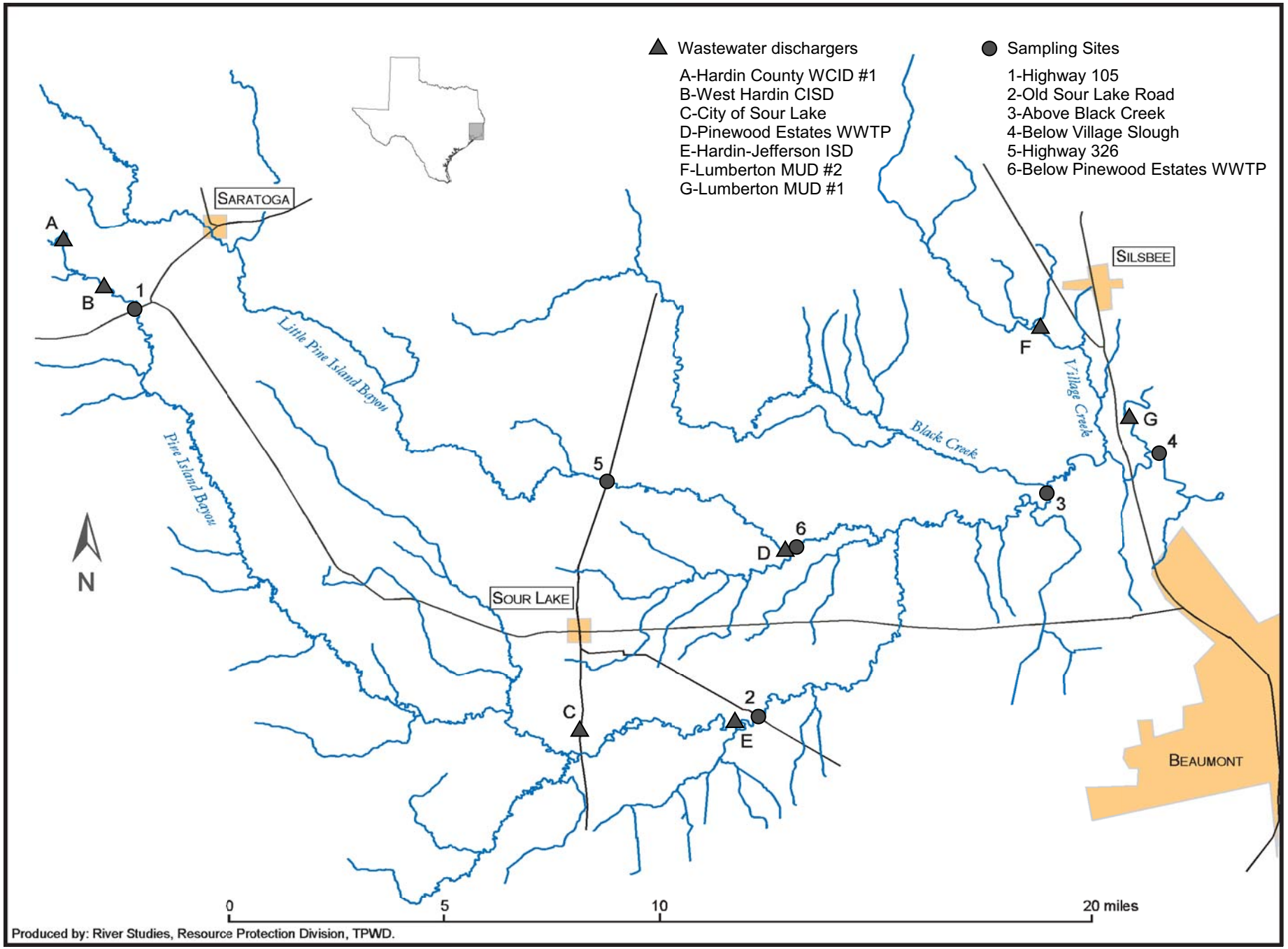

Figure 1. —Map of sampling area.

Table 1. Physical characteristics observed at Pine Island and Little Pine Island bayous, August 1987.

Parameter	Pine Island				Little Pine Island	
	Hwy. 105	Old Sour Lake Road	Above Black Creek	Below Village Slough	Hwy. 326	Below Pinewood WWTP
Width (m)	7.2	8.0	33.0	33.6	3.0	4.2
Mean depth (m)	0.6	0.7	4.0	4.6	0.3	0.2
Maximum depth (m)	1.0	1.0	4.7	6.2	0.8	0.3
Canopy (%)	50	30	20	5	90	60

were identified, weighed, measured and examined as explained above.

Dissolved oxygen, pH, temperature, and conductivity were sampled in situ at each station using a Hydrolab Surveyor II. Water transparency was measured with a Secchi disk, and stream width was measured by tape and rangefinder. Discharge was calculated by the method of Orth (1983). Seine data were analyzed and compared among all sites. At the Black Creek and Village Slough stations, data collected by seine, gill net, and electrofishing were pooled and analyzed separately. Since the main intent of the study was to compare values among sites more than against literature values, the combination of collections was justified. Several methods were utilized in analyzing the data, as discussed below.

Species diversity was calculated according to the equation presented in Wilhm (1970):

$$\overline{H} = -\sum_{i-1}^{s} (n_i/n) \log_2 (n_i/n),$$

where $\overline{H}$ = species diversity, n_i = number of individuals in the i^{th} species, n = number of individuals in the sample, and S = number of species. Generally, values less than 1 indicate severely degraded conditions, 1 - 3 indicate moderately polluted streams, and greater than 3 indicate clean water streams (Wilhm and Dorris 1968).

Index of similarity, a measure of the degree of resemblance in species composition between two sites, was calculated according to the equation presented in Odum (1971)

$$S = 2C/A + B,$$

where S = index of similarity, A = number of species in sample A, B = number of species in sample B, and C = number of species common to both samples. Values can range from 0, meaning the sites are dissimilar, to 1.0, indicating the two sites are the same.

Condition factors, a measure of the well-being or plumpness of a fish, were calculated according to the equation presented in Carlander (1969, 1977):

$$K = W10^5/L^3,$$

where K = condition factor, W = weight in grams, L = length in millimeters, and 10^5 is a factor to bring the value of K near unity. K-factors were calculated only for species for which Carlander (1969, 1977) presents comparative data. In selecting values for comparisons, an effort was made to find data in Carlander (1969, 1977) for fish from a similar geographical area and of a similar size to that collected in this study. K-factors vary with species and size, but generally, larger values are indicative of better fish condition.

Index of biotic integrity (IBI) was calculated according to Karr ***et al***. (1986), though the scoring criteria were modified to rate Pine Island Bayou (Table 2). Pine Island Bayou at Highway 105 was estimated to be a third order stream as was Little Pine Island Bayou at both stations. Pine Island Bayou at Old Sour Lake Road was a fourth order stream, while above Black Creek, it was a fifth order stream. Below Village Slough, it was a sixth order stream. Scoring criteria for total number of fish species was based on work performed by Karr ***et al***. (1986) on midwestern streams. The values for that study, in which stream order was regressed against total number of species, are roughly comparable to work on the Plum Creek drainage basin of south-central Texas and the Otter Creek drainage of north-central Oklahoma. In Plum Creek, a maximum number of 12 fish species were found in third through fifth order streams (Whiteside and McNatt 1972). Harrell ***et al***. (1967) found that the maximum number of species collected from third, fourth, fifth, and sixth order streams in the Otter Creek drainage were five, 11, 13, and 13, respectively.

Other modifications to the IBI included substituting the proportion of individuals as tolerants for occurrences of green sunfish (***Lepomis cyanellus***) to make the index less susceptible to the presence or absence of a single species. Green sunfish and mosquitofish (***Gambusia affinis***) were considered tolerant species. As suggested by Karr et. al. (1986), the proportion of individuals as insectivores was substituted for insectivorous cyprinids. IBI integrity class scores and attributes are listed in Appendix A. Proportions mentioned in the text refer to IBI metrics listed in Table 2.

Species richness and index of biotic integrity were emphasized in characterizing the fishery. A gauge of system health is the number and types of species present, with a greater number of species typically suggesting a more stable and healthy system. This reasoning must be used with care, but as Young ***et al***. (1973) point out, the presence of some fish species upstream of an entry point of waste and their

Table 2. Scoring criteria used for rating the index of biotic integrity for Pine Island and Little Pine Island bayous.

Category		Metric	Scoring criteria 5	3	1
Species richness and composition	1.	Total number of fish species			
		third order stream	≥9		0-3
		fourth order stream	≥12		0-5
		fifth order stream	≥14		0-6
		sixth order stream	≥18		0-7
	2.	Total number of darter species	≥3	1-2	0
	3.	Total number of sunfish species	≥2		0
	4.	Total number of sucker species	≥2[4-8]	[6-11]	0
	5.	Total number of intolerant species	≥3[7-13]	1-2	0
	6.	Proportion of individuals as tolerants	<5%[8-17]	5-20%	>20%
Trophic composition	7.	Proportion of individuals as omnivores	<20%[1]	20-45%	>45%
	8.	Proportion of individuals as insectivores	>80%[1]	40-80%	≤40%
	9.	Proportion of individuals as piscivores	>5%	1-5%	<1%
Fish abundance and condition	10.	Number of individuals in sample	>200	>50-200	≤50
	11.	Proportion of individuals as hybrids	0%	>0-1%	>1%
	12.	Proportion of individuals with disease or other anomaly	<2%	>2-5%	>5%

absence downstream of that point suggests the waste is limiting their occurrence. In addition, the index of biotic integrity provides a means of assigning a score to a stream station by integrating information from individual, population, community, zoogeographic, and ecosystem levels into a single ecologically based index. Together, these two methods provide a sound characterization of the fishery.

Less emphasis was placed on species diversity, similarity indices, and condition factors. They are not reliable indicators in themselves, but when used in conjunction with other methods can provide additional information for characterizing the system.

Results and Discussion

Water Quality Parameters

Dissolved oxygen readings (Table 3) at the shallow, upstream stations (Highway 105 and Highway 326) were below 4.0 mg/L. High water temperatures, sluggish flow, and organic loading from leaf litter and treated sewage effluent probably all contributed to the low dissolved oxygen levels. The D.O. reading below the Pinewood Estates Wastewater Treatment Plant was further depressed when compared to that upstream of Highway 326, possibly due to wastewater influence or diel variability. In the deeper (downstream) portion of Pine Island Bayou, oxygen stratification was observed (Table 3). Surface readings were at a supersaturation level in early evening, while at approximately 3 m of depth, readings dipped below 2.0 mg/L. Downstream of Village Slough, bottom readings indicated nearly anoxic conditions. The same factors contributing to the low dissolved oxygen levels upstream were undoubtedly at work in the nearly lentic lower bayou. A Texas Water Quality Board waste load evaluation prepared in 1974 (TWQB 1974) concluded that wastewater discharges could not account for low dissolved oxygen levels in the bayou. Adsit and Hagen (1978) suggested that wastewater discharges from the Sour Lake and Pinewood Estates plants may have a detrimental impact of water quality, but also recognized the aforementioned natural factors.

Fisheries Parameters

Thirty two fish species (Table 4, 5, 6) were collected from Pine Island and Little Pine Island bayous during this survey. Species richness was highest above Black Creek and below Village Slough (Table 7); however, those two stations were exposed to greater sampling effort and have considerably more available habitat. Species richness for the bayou as a whole was similar to that found by Seidensticker (1982), who collected 34 species (Table 8) when sampling nearly the same areas (See Table 8 for modifications).

Six species considered pollution intolerant (Karr ***et al***. 1986; USEPA 1983) were collected during the survey: pugnose minnow (***Notropis emiliae***), mimic shiner (***Notropis volucellus***), spotted sucker (***Minytrema melanops***), longear sunfish (***Lepomis megalotis***), tadpole madtom (***Noturus gyrinus***), and dusky darter (***Percina sciera***). Seidensticker (1982) found five species considered intolerant: pugnose minnow, spotted sucker, palid shiner (***Notropis amnis***), blacktail redhorse (***Moxostoma poecilurum***), and longear sunfish.

Highway 105

Nine species (Tables 4, 5, 6) were found at this station. This falls in the upper range of values found in other third order streams (Harrell ***et al***. 1967; Whiteside and McNatt 1972; Karr ***et al***. 1986). Seidensticker (1982) collected eight species at this site (Table 8). One pollution intolerant species (pugnose minnow) was collected near Highway 105, both in this study and in the one by Seidensticker (1982). The species diversity index (Table 7) at Highway 105 was the second lowest in this study and in the range considered indicative of moderately polluted water ($\overline{H}$ of 1 to 3; Wilhm and Dorris 1968).

Comparison of condition factors (Table 9) with values from Carlander (1977) indicated a high value for bluegill sunfish, suggesting an abundant invertebrate food base for sunfish to utilize. However, since only one fish was collected natural variability could account for the high value.

The largest number of individuals (Table 5) collected in seine samples was found at this site. The index of similarity (Table 10) indicated this station was most like Old Sour Lake Road, the next downstream site. This station was least similar to stations at Black Creek and Little Pine Island Bayou at Highway 326.

Highway 105 was assigned a rating of fair (Table 11; Appendix A) based on the IBI (Karr ***et al***. 1986).

Table 3. Water quality parameters measured at Pine Island and Little Pine Island bayous, August 1987.

Parameter	Pine Island						Little Pine Island	
	Hwy. 105	Old Sour Lake Road	Above Black Creek		Below Village Slough		Hwy. 326	Below Pinewood WWTP
Date	8/6/87	8/6/87	8/4/87	8/5/87	8/4/87	8/5/87	8/6/87	8/6/87
Time	1455	1049	2000	0850	1910	1100	1307	0855
Dissolved oxygen (mg/L)								
Surface	2.25	4.45	10.18	6.35	8.13	6.61	3.84	2.71
1 m			3.24	2.51	6.00	6.20		
2			2.46	1.71	3.34	5.59		
3			1.84	1.12	1.37	1.47		
4			1.48	1.26	0.65	0.50		
5					0.18	0.26		
Conductivity (mhos)								
Surface	309	234	235	237	160	160	267	544
1 m			232	233	158	158		
2			236	238	179	162		
3			241	238	224	215		
4			242	238	219	212		
5					163	192		
pH (pH units)								
Surface	6.53	6.58	7.83	6.62	7.37	6.65	6.20	6.70
1 m			6.44	6.34	6.49	6.58		
2			6.38	6.31	6.28	6.48		
3			6.34	6.29	6.26	6.24		
4			6.30	6.28	6.21	6.20		
5					6.10	6.16		
Temperature (°C)								
Surface	31.56	28.11	32.40	30.28	34.36	31.17	29.50	28.23
1 m			29.96	29.75	30.50	30.57		
2			29.58	29.38	30.50	30.52		
3			29.31	29.19	29.26	29.55		
4			29.14	29.12	28.80	28.91		
5					27.83	28.37		
Secchi Transparency (m)	0.300	0.275	0.325	0.325	0.300	0.275	>0.300	>0.300

Table 4. Checklist of fishes collected by all methods from Pine Island and Little Pine Island bayous, August 1987.

Species	Common name	Pine Island				Little Pine Island	
		Hwy. 105	Old Sour Lake Road	Above Black Creek	Below Village Slough	Hwy. 326	Below Pinewood WWTP
Lepisosteus occulatus	Spotted gar			X	X		
Dorosoma cepedianum	Gizzard shad			X	X		
Dorosoma petenense	Threadfin shad			X	X		
Anchoa mitchelli	Bay anchovy			X			
Elops saurus	Ladyfish				X		
Notropis emiliae	Pugnose minnow	X	X	X			X
Notropis fumeus	Ribbon shiner	X	X	X	X	X	X
Notropis texanus	Weed shiner	X	X	X	X	X	X
Notropis venustus	Blacktail shiner					X	
Notropis volucellus	Mimic shiner				X		
Pimephales vigilax	Bullhead minnow			X	X	X	X
Carpiodes carpio	River carpsucker			X			
Ictiobus bubalus	Smallmouth buffalo				X		
Minytrema melanops	Spotted sucker				X		
Ictalurus furcatus	Blue catfish			X			
Pylodictis olivaris	Flathead catfish			X			
Noturus gyrinus	Tadpole madtom						X
Fundulus notatus	Blackstripe topminnow	X	X	X	X	X	X
Gambusia affinis	Mosquitofish	X	X	X	X	X	X
Labidesthes sicculus	Brook silverside		X	X		X	
Micropterus punctulatus	Spotted bass			X	X		
Micropterus salmoides	Largemouth bass			X	X		X
Lepomis gulosus	Warmouth	X	X	X	X		
Lepomis cyanellus	Green sunfish	X	X				X
Lepomis microlophus	Redear sunfish				X		X
Lepomis macrochirus	Bluegill	X	X	X	X		
Lepomis megalotis	Longear sunfish		X	X	X		X
Pomoxis annularis	White crappie		X	X	X		
Percina sciera	Dusky darter						X
Etheostoma chlorosomum	Bluntnose darter		X		X	X	
Etheostoma procliere	Cypress darter	X			X	X	X
Aplodinotus grunniens	Freshwater drum			X			
Total # of species		9	12	21	21	9	13

Table 5. Fishes collected by common sense seine from Pine Island and Little Pine Island bayous, August 1987.

Species	Common name	Pine Island				Little Pine Island	
		Hwy. 105	Old Sour Lake Road	Above Black Creek	Below Village Slough	Hwy. 326	Below Pinewood WWTP
Notropis emiliae	Pugnose minnow	32	9				13
Notropis fumeus	Ribbon shiner	19	77	1	39	264	291
Notropis texanus	Weed shiner	166	54	46	153	41	166
Notropis venustus	Blacktail shiner					13	
Pimephales vigilax	Bullhead minnow			26	8	15	9
Noturus gyrinus	Tadpole madtom						1
Fundulus notatus	Blackstripe topminnow	29	8	13	8	6	6
Gambusia affinis	Mosquitofish	351	71	30	18	154	14
Labidesthes sicculus	Brook silverside		2			2	
Micropterus salmoides	Largemouth bass				1		2
Lepomis gulosus	Warmouth	1	2				
Lepomis cyanellus	Green sunfish	1	4				1
Lepomis microlophus	Redear sunfish				1		2
Lepomis macrochirus	Bluegill	10	10		13		
Lepomis megalotis	Longear sunfish		1	10	1		1
Pomoxis annularis	White crappie		2				
Percina sciera	Dusky darter						1
Etheostoma chlorosomum	Bluntnose darter		1		3	2	
Etheostoma proeliere	Cypress darter	1			1	1	1
Total # of individuals		610	241	126	246	498	508

Table 6. Fishes collected by gill net and electrofishing from Pine Island Bayou, August 1987.

Species	Common name	Gill net		Electrofishing	
		Above Black Creek	Below Village Slough	Above Black Creek	Below Village Slough
Lepisosteus occulatus	Spotted gar		3	3	2
Dorosoma cepedianum	Gizzard shad		11	3	3
Dorosoma petenense	Threadfin shad		2	1	9
Anchoa mitchelli	Bay anchovy			1	
Elops saurus	Ladyfish		1		
Notropis emiliae	Pugnose minnow			2	
Notropis fumeus	Ribbon shiner				1
Notropis texanus	Weed shiner			2	2
Notropis venustus	Blacktail shiner		1		
Notropis volucellus	Mimic shiner				5
Pimephales vigilax	Bullhead minnow			7	10
Carpiodes carpio	River carpsucker	1			
Ictiobus bubalus	Smallmouth buffalo		3		
Minytrema melanops	Spotted sucker				1
Ictalurus furcatus	Blue catfish			1	
Pylodictis olivaris	Flathead catfish			2	
Fundulus notatus	Blackstripe topminnow			1	
Labidesthes sicculus	Brook silverside			1	
Micropterus punctulatus	Spotted bass			3	1
Micropterus salmoides	Largemouth bass			5	5
Lepomis gulosus	Warmouth			2	2
Lepomis microlophus	Redear sunfish				1
Lepomis macrochirus	Bluegill	1		54	103
Lepomis megalotis	Longear sunfish			16	49
Pomoxis annularis	White crappie	2			5
Aplodinotus grunniens	Freshwater drum	1			
Total # of individuals		5	21	104	199

Table 7. Community indices for Pine Island and Little Pine Island bayous (August 1987).

Sampling location	Species Richness	Species Diversity
Pine Island at Hwy. 105	9	1.70
Pine Island at Old Sour Lake Road	12	2.40
Pine Island above Black Creek	6[a]	2.18[a]
Pine Island above Black Creek	21[b]	3.13[b]
Pine Island below Village Slough	11[a]	1.88[a]
Pine Island below Village Slough	21[b]	2.95[b]
Little Pine Island at Hwy. 326	9	1.75
Little Pine Island below Pinewood WWTP	13	1.60

[a]seine samples only

[b]all collection methods combined

Table 8. Checklist of fishes collected at Pine Island and Little Pine Island bayous by Seidensticker (1982).

Species	Common name	Pine Island				Little Pine Island
		Hwy. 105	Hwy. 326	Above Hwy. 96 Black Creek Area	Village Slough Area	Hwy. 326
Lepisosteus occulatus	Spotted gar			X	X	
Lepisosteus osseus	Longnose gar			X		
Lepisosteus spatula	Alligator gar			X		
Elops saurus	Ladyfish				X	
Dorosoma cepedianum	Gizzard shad			X	X	
Dorosoma petenense	Threadfin shad			X		
Cyprinus carpio	Common carp			X		
Notropis amnis	Pallid shiner		X			
Notropis emiliae	Pugnose minnow	X				
Notropis fumeus	Ribbon shiner	X	X			
Notropis venustus	Blacktail shiner		X			
Hybognathus nuchalis	Mississippi silvery minnow					X
Pimephales vigilax	Bullhead minnow					X
Ictiobus bubalus	Smallmouth buffalo			X	X	
Moxostoma poecilurum	Blacktail redhorse			X		
Minytrema melanops	Spotted sucker			X		
Ictalurus furcatus	Blue catfish			X		
Ictalurus natalis	Yellow bullhead					X
Aphredoderus sayanus	Pirate perch				X	X
Fundulus chrysotus	Golden topminnow	X				
Fundulus notatus	Blackstripe topminnow	X				X
Gambusia affinis	Mosquitofish	X	X			X
Elassoma zonatum	Banded pygmy sunfish					X
Micropterus punctulatus	Spotted bass				X	X
Micropterus salmoides	Largemouth bass	X				X
Lepomis gulosus	Warmouth					X
Lepomis macrochirus	Bluegill	X		X	X	X
Lepomis megalotis	Longear sunfish			X	X	X
Lepomis microlophus	Redear sunfish			X	X	
Pomoxis annularis	White crappie	X		X	X	
Pomoxis nigromaculatus	Black crappie			X	X	
Etheostoma gracile	Slough darter					X
Aplodinotus grunniens	Freshwater drum				X	
Mugil cephalus	Striped mullet			X		
Total # of species		8	4	16	11	13

Table 9. Comparison of condition factors calculated for fish collected at Pine Island and Little Pine Island bayous (August 1987) with values found in Carlander (1969, 1977). Values in parentheses indicate numbers of fish. Standard deviations are listed when three or more individuals of a species were collected at a site.

Species	Pine Island				Little Pine Island		
	Hwy. 105	Old Sour Lake Road	Above Black Creek	Below Village Slough	Hwy. 326	Below Pinewood WWTP	Carlander
Dorosoma cepedianum			0.87 (3) ±0.11	0.84 (13) ±0.12			0.99
Carpiodes carpio			1.52 (1)				1.11 - 1.45
Ictiobus bubalus				2.03 (3) ±0.16			1.53
Ictalurus furcatus			0.90 (1)				0.92
Lepomis gulosus			1.90 (2)	1.87 (3) ±0.13			2.12
Lepomis macrochirus	2.16 (1)		1.82 (25) ±0.27	1.89 (25) ±0.20			1.27 - 1.94
Lepomis megalotis			1.96 (18) ±0.45	2.04 (28) ±0.40		1.73 (1)	1.93
Lepomis microlophus				1.96 (1)		1.60 (1)	1.41 - 1.83
Micropterus salmoides			1.35 (5) ±0.009	1.35 (6) ±0.37		1.28 (4) ±0.16	1.19 - 1.83
Pomoxis annularis		1.04 (2)	1.02 (2)				1.06 - 1.52
Pylodictus olivaris			1.01 (1)				0.90

Table 10. Index of similarity for stations on Pine Island and Little Pine Island bayous (August 1987). Only seine samples were used for calculation.

	Pine Island				Little Pine Island	
	Hwy. 105	Old Sour Lake Road	Above Black Creek	Below Village Slough	Hwy. 326	Below Pinewood WWTP
Hwy. 105	..					
Old Sour Lake Road	0.76	..				
Above Black Creek	0.53	0.56	..			
Below Village Slough	0.60	0.61	0.70[a]	..		
Hwy. 326	0.56	0.57	0.67	0.70	..	
Below Pinewood WWTP	0.64	0.56	0.67	0.75	0.54	..

[a]when data from all collection methods were used, the index was 0.67.

Table 11. Summary worksheet for index of biotic integrity for Pine Island and Little Pine Island bayous (August 1987). Values are followed by IBI metric ratings in parentheses.

Data Classification	Pine Island						Little Pine Island	
	Hwy. 105	Old Sour Lake Road	Above Black Creek		Below Village Slough		Hwy. 326	Below Pinewood WWTP
Number of species as:								
Total	9 (5)	12 (5)	6 (1)[a]	21 (5)[b]	11 (3)[a]	21 (5)[b]	9 (5)	13 (5)
Darters	1 (3)	1 (3)	0 (1)	0 (1)	2 (3)	2 (3)	2 (3)	2 (3)
Sunfishes	2 (5)	4 (5)	1 (3)	4 (5)	3 (5)	5 (5)	2 (5)	2 (5)
Suckers	0 (1)	0 (1)	0 (1)	1 (3)	0 (1)	2 (5)	0 (1)	0 (1)
Intolerants	1 (3)	2 (3)	1 (3)	2 (3)	1 (3)	2 (3)	0 (1)	4 (5)
Proportion of individuals as:								
Tolerants	58% (1)	31% (1)	24% (1)	13% (3)	7% (3)	4% (5)	31% (1)	3% (5)
Omnivores	0% (5)	0% (5)	21% (3)	16% (5)	3% (5)	10% (5)	3% (5)	<2% (5)
Insectivores	99% (5)	97% (5)	79% (5)	76% (3)	96% (5)	88% (5)	97% (5)	97% (5)
Piscivores	<1% (1)	3% (3)	0% (1)	8% (5)	<1% (1)	4% (3)	0% (1)	<1% (1)
Hybrids	0% (5)	0% (5)	0% (5)	0% (5)	0% (5)	0% (5)	0% (5)	0% (5)
Diseased	1% (5)	0% (5)	0% (5)	4% (3)	0% (5)	<2% (5)	0% (5)	<2% (5)
Total number of individuals in the sample	611 (5)	242 (5)	126 (3)	235 (5)	246 (5)	466 (5)	498 (5)	508 (5)
IBI total score	44	46	32	46	44	54	42	50
Integrity class	Fair	Fair to Good	Poor	Fair to Good	Fair	Good to Excellent	Fair	Good

[a]seine samples.

[b]all collection methods.

Reasons for the less than excellent rating were: the absence of sucker species, which are intolerant of habitat and chemical degradation (Karr ***et al***. 1986); a less than optimal number of darter species, which are sensitive to degradation as a result of their specificity for reproduction and feeding in benthic habitats (Page 1983); a low number of intolerant species; a high proportion of tolerant species; and an imbalanced trophic structure. Karr ***et al***. (1986) suggested that a balanced trophic structure in a fish community comprises less than 20% omnivores, more than 80% insectivores, and more than 5% piscivores.

Old Sour Lake Road

Twelve species (Tables 4, 5, 6) were collected at this station, ranking it among the most diverse fourth order streams (Harrell ***et al***. 1967; Whiteside and McNatt 1972; Karr ***et al***. 1986). Seidensticker (1982) only collected four species (Table 8) at this location. One intolerant species (pugnose minnow) was found in this study, whereas Seidensticker (1982) collected none. Species diversity (Table 7) was higher than at Highway 105, despite treated wastewater discharges upstream of this station. Increased flow into the system and the resulting increase in habitat probably accounted for that situation. The diversity index value (Table 7) was in the range considered indicative of moderately polluted water ($\overline{H}$ of 1 to 3; Wilhm and Dorris 1968).

Condition factors (Table 9) for white crappie (***Pomoxis annularis***) at this station were lower than values reported by Carlander (1969, 1977), possibly due to an inadequate prey base or natural variability. Values from Carlander ranged from 1.06 to 1.52 for fish of a similar size to those in the study that gave a value to 1.04.

The index of similarity (Table 10) indicated that this station was most similar to the Highway 105 station. Similarity values were approximately the same for the other four stations. This station received a rating of fair to good (Table 11; Appendix A) on the IBI scale (Karr ***et al***. 1986). Major reasons for the less than excellent rating were the lack of more than one darter species, the absence of sucker species, the high proportion of tolerant species, and the low proportion of piscivores.

Above Black Creek

Twenty one species (Tables 4, 5, 6) were collected at this site by all methods, which ranks above comparable values for fifth order streams (Harrell ***et al***. 1967; Whiteside and McNatt 1972; Karr ***et al***. 1986). Seidensticker (1982) collected 16 species (Table 8) at a nearby site. Two species considered pollution intolerant were found at the station in this study (pugnose minnow and longear sunfish), compared to three (spotted sucker, blacktail redhorse, and longear sunfish) in the study by Seidensticker (1982). Species diversity (Table 7) was highest of the study, when all collection methods were combined; whereas, it was the second highest when only seine samples were considered. The diversity value (Table 7) for seine samples was in a range considered indicative of moderate pollution ($\overline{H}$ of 1 to 3; Wilhm and Dorris 1968), whereas for all collection methods combined, the diversity value was in the range indicative of unpolluted water ($\overline{H}$ >3; Wilhm and Dorris 1968).

K-factors are presented along with values from Carlander (1969, 1977) in Table 9. Condition factors for largemouth bass (***Micropterus salmoides***) at this station were within the range of 1.19 to 1.83 that are reported by Carlander (1969, 1977) for fish of a similar size. However, the values were lower than the 1.86 that Seidensticker (1982) reported for the lower Neches River system, of which Pine Island Bayou is a part. The bluegill sunfish (***Lepomis macrochirus***) condition factor was within the range of 1.27 to 1.94 that Carlander (1977) reported. Values for white crappie, blue catfish (***Ictalurus furcatus***), gizzard shad (***Dorosoma cepedianum***), and warmouth (***Lepomis gulosus***) were less than those found in Carlander (1969, 1977); whereas, condition factors for river carpsucker (***Carpiodes carpio***), longear sunfish, and flathead catfish (***Pylodictus olivaris***) were higher. The range of condition factors suggests no particular trend, since members of each trophic level were both above and below values from Carlander (1969, 1977).

The index of similarity (Table 10) indicated that this station was most like the station just downstream at Village Slough. Habitat, stream width, and stream depth (Table 1) were quite similar at Black Creek and Village Slough.

This station was rated poor (Table 11; Appendix A) when the IBI was calculated for seine collections only, but received a fair to good rating when data from all collection methods were combined. Major reasons for the latter rating being less than excellent were the absence of darter species, the collection of only one sucker species, a less than optimal

number of intolerant species, a high proportion of tolerant species, a less than optimal proportion of insectivorous fishes, and a high proportion of diseased fishes.

Below Village Slough

Twenty one species (Tables 4, 5, 6) were collected at this site, which is greater than comparable values for sixth order streams (Harrell ***et al***. 1967; Karr ***et al***. 1986). Seidensticker (1982) collected 11 species (Table 8) near Village Slough. Three species considered pollution intolerant were found in this study (spotted sucker, longear sunfish, and mimic shiner), compared to one (longear sunfish) in the study by Seidensticker (1982). The species diversity index (Table 7) at this station was second highest when data from all collection methods were combined, whereas it was the third highest when only seine samples were considered. The diversity index value (Table 7) for seine samples alone was in the range considered indicative of moderate pollution ($\overline{H}$ of 1 to 3; Wilhm and Dorris 1968); whereas, for all collection methods combined, the diversity value was higher, but still in the same range.

K-factors from this study are presented along with values from Carlander (1969, 1977) in Table 9. Condition of largemouth bass at this station was identical to that at Black Creek and within the range reported by Carlander (1969, 1977) for fish of a similar size. As with Black Creek, K-factors for bass were lower than the 1.86 value that Seidensticker reported for the Neches River system. The bluegill sunfish condition factor was slightly higher than at Black Creek, but within the reported range. Gizzard shad and warmouth condition factors were low; whereas, the values for longear sunfish, smallmouth buffalo (***Ictiobus bubalus***), and redear sunfish (***Lepomis microlophus***) were all higher than that reported by Carlander (1969, 1977).

Index of similarity (Table 10) indicated this station was closest in species composition to Little Pine Island Bayou below the Pinewood Wastewater Treatment Plant when only seine samples were considered.

This station was rated fair (Table 11; Appendix A) when the IBI was calculated for seine collections only, but received a good to excellent rating when data from all collection methods were combined. Major reasons resulting in the latter rating being less than excellent were a less than optimal number of darter species, a low proportion of piscivores, and a low number of sucker species.

Little Pine Island at Highway 326

Nine species (Tables 4, 5, 6) were collected at this station. This ranks the station among the most diverse third order streams (Harrell ***et al***. 1967; Whiteside and McNatt 1972; Karr ***et al***. 1986). Seidensticker (1982) collected 13 species at this site. No intolerant species were collected, though habitat (Table 1) and water quality (Table 2) at this site would not appear to be limiting to any of the intolerant species found elsewhere. Seidensticker collected one intolerant species (longear sunfish) at this location. The species diversity value (Table 7) was the third lowest in this study and in the range considered indicative of moderate pollution ($\overline{H}$ of 1 to 3; Wilhm and Dorris 1968). The index of similarity (Table 10) indicated this station was most like the area below Village Slough when seine samples alone were considered.

This station was rated fair (Table 11; Appendix A) based on the IBI. Major reasons for the less than excellent rating were a lower than optimal number of darter species, no sucker species, no intolerant species, a high proportion of tolerants, and a lack of piscivores.

Little Pine Island Bayou below the Pinewood WWTP

Thirteen species (Tables 4,5,6) were collected at this station. This ranks above average when compared to other third order streams (Harrell ***et al***. 1967; Whiteside and McNatt 1972; Karr ***et al***. 1986). Seidensticker (1982) did not sample this site. Four pollution intolerant species (pugnose minnow, longear sunfish, tadpole madtom, and dusky darter) were collected at this station. The species diversity index value (Table 7) at this station was the lowest in the study, mainly because of disproportionally large numbers of ribbon shiner (***Notropis fumeus***). Species richness was higher at this site than at the upstream station at Highway 326, despite an intervening wastewater discharge. As in the situation at Old Sour Lake Road, the increase in species number probably resulted from additional flow.

K-factors are presented along with expected values from Carlander (1969, 1977) in Table 9. Condition of largemouth bass at this station was within the reported range of 1.19 to 1.83 Carlander (1969, 1977) reported for fish of a similar size. However, it was less than the 1.86 that Seidensticker (1982)

reported for the lower Neches River system. The one longear sunfish collected had a condition factor that was slightly low, whereas redear sunfish condition was within an acceptable range.

Index of similarity (Table 10) was highest between this station and Village Slough when seine samples alone were considered.

This station was rated good (Table 11; Appendix A) based on the IBI. Major reasons for a less than excellent rating were a less than optimal number of darter species, the absence of sucker species, and a low proportion of piscivores.

Conclusion

The potential for a diverse fish community exists in Pine Island and Little Pine Island bayous, particularly at the downstream stations. Despite an apparent problem with organic loading and oxygen depleted bottom waters, the two reaches farthest downstream (Black Creek and Village Slough) supported numbers of sportfish and had high species richness. However, fish fauna at upstream sites appeared to be limited during this survey. Low flows, high temperatures, and organic loading, all of which can contribute to depressed dissolved oxygen levels, may have been responsible for limiting the fish community upstream. Increases in water volume downstream brought about a corresponding increase in species number, possibly because of increased habitat. Other factors not addressed by this survey could also explain trends in the fish community.

In the absence of limiting factors, potential for recovery is good, given the sources of recruitment in the lower bayou.

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APPENDIX A. Total Index of Biotic Integrity (IBI) scores, the designated integrity class, and the attributes of those classes as modified from Karr et al. (1986).

Total IBI score (sum of the 12 metric ratings)	Integrity class	Attributes
58-60	Excellent	Comparable to the best situations without human disturbance; all regional expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of age (size) classes; balanced trophic structure.
48-52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some signs of stress.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores and green sunfish or other tolerant species); older age classes of top predators may be rare.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.
12-22	Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.
No fish		Repeated sampling finds no fish.