

FINAL REPORT

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EAST TEXAS MUSSEL SURVEY

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ABSTRACT

Field surveys of freshwater mussels (family Unionidae) were conducted at 49 sites in 22 waterbodies (4 rivers, 7 reservoirs, and 11 streams) within the Red, Trinity, Neches, and Sabine drainage basins using standard qualitative and quantitative methods. Depth, dominant substrates, GPS coordinates, and water chemistry were recorded at each site. Abundant and diverse mussel beds were located in the Sulphur, Angelina, and Neches rivers. These sites can be used for future monitoring. Several waterbodies were surveyed for the first time (i.e. Cooper Reservoir, Wright Patman Reservoir, Houston County Reservoir, Striker Reservoir, and lower Sabine River tributaries). Extreme rainfall and flooding in 2007 prevented successful sampling of several sites. Mussel populations in a number of waterbodies (i.e. Sulphur River, Cooper Reservoir, Houston County Reservoir, B.A. Steinhagen Reservoir, Toledo Bend Reservoir) were severely damaged during previous droughts or drawdowns. Several sites with abundant and diverse unionid assemblages were suggested for monitoring, conservation, and recovery plans. This survey will provide data necessary for successful management and conservation of unionids in East Texas rivers and reservoirs.

OBJECTIVES

The objective of this project was to conduct freshwater mussel surveys at selected sites in East Texas.

Freshwater mussels are considered one of the most endangered groups of animals in North America. Field surveys conducted in selected areas and locations in East Texas will contribute to determining the current distribution and status of rare, endemic mussels and abundant, diverse assemblages remaining in the region. The results of the study will provide managers, researchers, and decision makers with critically important information on the status of remaining mussels and data necessary for successful management and conservation of unionids in East Texas.

BACKGROUND

Texas Comprehensive Wildlife Conservation Strategy for 2005-2010 (Bender et al., 2005) highlights the importance of monitoring aquatic non-game species, especially those of immediate concern. Freshwater mussels (Unionidae), being the most imperiled group of animals in North America (Richter et al., 1997; Williams et al., 1993), are undoubtedly among the species of immediate concern. Due to their sensitivity to water and habitat quality, long life span, slow growth, and low reproductive rates, over 70% of the unionid species in North America are threatened, endangered, or of special concern (Williams et al., 1993). Among the 52 species known in Texas, there are at least 26 species that require special attention, including six endemic and one federally listed endangered species (Howells et al., 1996; 1997). At the same time, unionids as powerful filter feeders, water clarifiers, and organic-nutrient sinks are widely recognized as important components of aquatic ecosystems and indicator species for water quality. Texas Parks and Wildlife Department (TPWD) statewide unionid surveys between 1992-1998 and State Wildlife Grant (SWG) surveys in 2005-2007 have helped update the status of mussel populations in Texas. Unfortunately, there remain areas in East Texas (where the most diverse unionid fauna, including rare and endemic species occur), that have never been surveyed or that have not been surveyed recently or sufficiently. In addition, the status of individual mussel populations can change rapidly, thereby requiring constant reexamination.

In 2006-2007, SWG funding was obtained to support mussel surveys in East Texas. The survey data were synthesized to develop a broad view of the status of freshwater mussel populations throughout East Texas. This synthesis is important to the development of plans for the general conservation of freshwater mussels in the state. This report presents results from the 2006-2007 survey and assesses the status of mussel populations relative to earlier published surveys.

PROCEDURES

Waterbodies sampled

A review of published TPWD mussel surveys identified sites statewide where significant unionid assemblages had been found in the past or where rare endemic species had been documented. A list of these sites, initially designated for survey in the current project, is given in Table 1.

More detailed sampling efforts were initially planned for Attoyac Bayou and Village Creek; however, due to high water and swift currents, these sites were only sampled in June 2007. This effort was suspended as conditions were deemed unsafe and very few mussels were collected.

Water was at record lows in East Texas from August through October 2006 (before the grant's start date). Prior to funding, opportunities arose to survey a number of sites. Using funding from the Texas Water Development Board (TWDB contract #0604830631), stations on the lower Sabine River, its tributaries, as well as some tributaries of Toledo Bend Reservoir were sampled (Table 2). A few other sites were also surveyed using Stephen F. Austin State University (SFASU) and personal vehicles and time with the assistance of SFASU students and Vadim Karatayev.

Table 1. Initial sites designated for mussel surveys in East Texas.

Survey Sites	County	Drainage	Date sampled
Western tributaries of Toledo Bend Reservoir	Shelby, Sabine	Sabine	09/16-17/2006* and 04/21/2007
Toledo Bend Reservoir	Shelby, Sabine	Sabine	12/09/2006 and 09/17/2006*
Sabine River and its tributaries below Toledo Bend Reservoir	Newton	Sabine	09/16-17/2006* and 04/21/2007
Striker Reservoir	Cherokee, Rusk	Angelina/Neches	06/05/2007
Houston County Reservoir	Houston	Trinity	08/28/07
Wright Patman Reservoir	Bowie, Cass	Red	12/27/2006
Sulphur River	Bowie	Red	05/14-15/2007
Attoyac Bayou	Rusk, Panola, Nacogdoches, Shelby	Neches	06/05/2007
Village Creek	Hardin	Neches	06/03/2007

* Sampled during field work under TWDB contract (see above)

A few sites were added to the survey in 2007 to replace sites where the survey was unsuccessful (Table 2). For instance, a unique opportunity developed to sample the distribution and abundance of mussels in B.A. Steinhagen Reservoir when it was drained down to the river channel.

Table 2. Additional sites surveyed in East Texas.

Survey Site	County	Drainage	Date sampled
Angelina River at US 59	Angelina, Nacogdoches	Neches	08/19/2006
Sabine River at US 59	Panola, Harrison	Sabine	08/19/2006
Angelina River at SR 7	Cherokee, Nacogdoches	Neches	09/07/2006
Neches River at SR 7	Houston, Cherokee	Neches	09/07/2006
Cooper Reservoir	Hopkins	Red	05/15/2007
B.A. Steinhagen Reservoir	Tyler, Jasper	Neches	04/6, 20,21/2007
Starr Ditch Canal on Caddo Lake	Harrison	Red	11/18/2007

Sampling methods

Various habitats were sampled at each collection site. Collection methods and sampling effort varied among sites depending, in part, upon mussel densities and field conditions at the time of sampling. Standard qualitative and quantitative methods were used. Qualitative and semi-qualitative methods included random time search collections by wading and snorkeling. Densities in mussel beds were estimated by taking samples with randomly placed 0.25 m² quadrats. Mussel length was recorded with a caliper to the nearest 0.1 mm at each site for all collected live mussels and shells. Depth and dominant substrates were recorded for each major

habitat surveyed (where mussels were found). Water temperature ($^{\circ}\text{C}$), dissolved oxygen (DO, mg/l and % saturation), pH, total dissolved solids (TDS, g/l), specific conductivity (SpC, $\mu\text{S}/\text{cm}$), and turbidity (NTU units) were recorded for each site with a Hydrolab Quanta, whenever possible. A global positioning system receiver Magellan Explorist 300 was used to record coordinates.

Results are presented as numbers (N) of live and dead mussels, and their densities. Terminology relating to condition of shells followed Howells (1996a, 1996b) (Appendix I).

Mussels were identified to species when possible; however, some subfossil or weathered specimens could not be identified to that level. Common and scientific names generally follow Howells et al. (1996), Parmalee and Bogan (1998), Strayer and Jirka (1997), and were checked against the Integrated Taxonomic Information System on-line database, <http://www.itis.usda.gov>.

RESULTS AND ANALYSES

Results are presented by major river basin. When historical data are available, site-specific records are followed by a comparison of current and past data and an assessment of the overall status of mussels at that site.

Red River Drainage

Sulphur River

Site 1. Sulphur River at Shumake property

The Sulphur River was sampled on the Shumake property (start point 33.36141°N , 94.79845°W , end point 33.36549°N , 94.80084°W), Red River County, Texas, on June 14, 2007. Substrates within the main river channel were mostly comprised of hard clay while sand and mud was more common closer to shore (which is where the mussels were found). The time search totaled 4 mh (man hour) (4 people, 1 hr). Eleven species (5 live, 6 dead) were found at this site (Table 3).

Site 2. Sulphur River at NW 39

The Sulphur River was sampled under the bridge at NW 39 (33.39150°N , 95.06118°W) (CR 1412 after the bridge), Delta/Hopkins Counties, Texas, June 15, 2007. Substrate was comprised of sand and gravel. Depths ranging from 0.5-1.5 m were time searched for 0.7 mh (2 people, 20 min).

Ten species (7 live, 3 dead) were found at this site (Table 3). This site is a very good candidate for future monitoring of the population as the mussel bed is diverse, easy to find (right below the bridge), and located at a shallow depth.

Combined, 11 species (8 live), were found in the Sulphur River in 2007 (Table 3). The most abundant were threeridges (found at relative densities app. 7 mussels/mh), and bluefers (1.5

mussels/mh).

Table 3. List of species collected from the Sulphur River.

Species Latin name	Common name	N live	N live/ mh*	N shells	N shells/ mh	N valves	N valves/ mh
Site 1. Sulphur River at Shumake property							
<i>Potamilus purpuratus</i>	bleufer	6	1.5	5	1.25	0	0
<i>Lampsilis hydiana</i>	louisiana fatmucket	3	0.75	6	1.5	0	0
<i>Quadrula quadrula</i>	mapleleaf	0	0	3	0.75	0	0
<i>Quadrula verrucosa</i>	pistolgrip	0	0	1	0.25	0	0
<i>Plectomerus dombeyanus</i>	bankclimber	1	0.25	8	2	0	0
<i>Amblema plicata</i>	threeridge	1	0.25	10	2.5	0	0
<i>Obliquaria reflexa</i>	threehorn wartyback	0	0	2	0.5	0	0
<i>Lampsilis teres</i>	yellow sandshell	1	0.25	4	1	0	0
<i>Potamilus ohiensis</i>	pink papershell	0	0	3	0.75	0	0
<i>Fusconaia flava</i>	wabash pigtoe	0	0	2	0.5	1	0.25
<i>Megalonias nervosa</i>	washboard	0	0	10	2.5	0	0
Total mussels found		12		54		1	
Total species found		5		11		1	
Site 2. Sulphur River at NW 39							
<i>Amblema plicata</i>	threeridge	30	45.5	11	16.7	0	0
<i>Potamilus purpuratus</i>	bleufer	1	1.5	0	0.0	0	0
<i>Plectomerus dombeyanus</i>	bankclimber	2	3.0	4	6.1	0	0
<i>Megalonias nervosa</i>	washboard	3	4.5	3	4.5	0	0
<i>Quadrula verrucosa</i>	pistolgrip	0	0.0	2	3.0	0	0
<i>Lampsilis hydiana</i>	louisiana fatmucket	1	1.5	0	0.0	0	0
<i>Quadrula quadrula</i>	mapleleaf	1	1.5	0	0.0	0	0
<i>Obliquaria reflexa</i>	threehorn wartyback	1	1.5	1	1.5	0	0
<i>Fusconaia flava</i>	wabash pigtoe	0	0.0	1	1.5	0	0
<i>Potamilus ohiensis</i>	pink papershell	0	0.0	1	1.5	0	0
Total mussels found		39		23		0	

Species Latin name	Common name	N live	N live/ mh*	N shells	N shells/ mh	N valves	N valves/ mh
Total species found		7		7		0	
Total Sulphur River (Sites 1 and 2)							
<i>Potamilus purpuratus</i>	bleufer	7	1.5	5	1.1	0	0.0
	louisiana						
<i>Lampsilis hydiana</i>	fatmucket	4	0.9	6	1.3	0	0.0
<i>Quadrula quadrula</i>	mapleleaf	1	0.2	3	0.6	0	0.0
<i>Quadrula verrucosa</i>	pistolgrip	0	0.0	3	0.6	0	0.0
<i>Plectomerus</i>							
<i>dombeyanus</i>	bankclimber	3	0.6	12	2.6	0	0.0
<i>Amblema plicata</i>	threeridge	31	6.7	21	4.5	0	0.0
	threehorn						
<i>Obliquaria reflexa</i>	wartyback	1	0.2	3	0.6	0	0.0
	yellow						
<i>Lampsilis teres</i>	sandshell	1	0.3	4	1	0	0
	pink						
<i>Potamilus ohiensis</i>	papershell	0	0	4	0.9	0	0
<i>Fusconaia flava</i>							
	wabash						
	pigtoe	0	0.0	2	0.4	1	0.2
<i>Megalonais nervosa</i>	washboard	3	0.6	13	2.8	0	0.0
Total mussels found		51		76		1	
Total species found		8		11		1	

* mh here and elsewhere: man per hour

Mr. Cheatwood collection of Sulphur River unionid species

During sampling from the Sulphur River at NW 39, we had a chance to examine Mr. Gary Cheatwood's (3705 FM 1487, Bogata, TX 75417) collection of mussel shells gathered from nearby locations on the Sulphur River. Mr. Cheatwood claimed his collection contained all species of unionids that he has ever seen in the river and its tributaries. Twelve species were identified in his collection (Table 4). Only one species (flat floater) was not previously reported from earlier collections by TPWD (nor was it collected in our study). Unfortunately it is hard to precisely determine where this specimen was found.

Table 4. List of species from the Cheatwood collection from the Sulphur River.

##	Latin name	Common name	Quantity
1.	<i>Anodonta suborbiculata</i>	flat floater	1
2.	<i>Potamilus purpuratus</i>	bleufer	1
3.	<i>Unio merus declivis</i>	tapered pondhorn	1
4.	<i>Potamilus ohiensis</i>	pink papershell	1
5.	<i>Lampsilis teres</i>	yellow sandshell	5
6.	<i>Quadrula verrucosa</i>	pistolgrip	2

7. <i>Megalonais nervosa</i>	washboard	3
8. <i>Lampsilis satura</i>	sandbank pocketbook	1
9. <i>Quadrula quadrula</i>	mapleleaf	3
10. <i>Obliquaria reflexa</i>	threehorn wartyback	1
11. <i>Amblema plicata</i>	threeridge	1
12. <i>Pyganodon grandis</i>	giant floater	1

Comparison with previous data: Sulphur River

The Sulphur River at Shumake property was sampled by Marsha May (TPWD) on June 15-16, 2005. In total, 17 species (9 found alive) were found during this sampling (Sulphur River at Shumake property and one species from Roden Creek combined) (Table 5).

Very scarce data on unionid species richness were available from the Sulphur River prior to 2005 TPWD sampling. In total, seven species were reported from the Sulphur River and White Oak Creek in 1993-2001 (Table 6), among them, only one species (tapered pondhorn) was found alive. Based on shell records, the most common were fragile papershell, yellow sandshell, and tapered pondhorn.

Table 5. List of species collected by Marsha May (TPWD) from the Sulphur River at the Shumake property in June 15-16, 2005.

Species Latin name	Common name	N live	N shells
<i>Potamilus purpuratus</i>	bleufer	6	14
<i>Amblema plicata</i>	threeridge	9	2.5
<i>Plectomerus dombeyanus</i>	bankclimber	4	3.5
<i>Lampsilis teres</i>	yellow sandshell	7	1.5
<i>Megalonaias nervosa</i>	washboard	0	1
<i>Quadrula quadrula</i>	mapleleaf	0	2
<i>Quadrula mortoni</i>	western pimpleback	1	2
<i>Potamilus ohiensis</i>	pink papershell	1	2.5
<i>Obliquaria reflexa</i>	threehorn wartyback	2	1
<i>Fusconaia askewi</i>	texas pigtoe	0	2
<i>Quadrula verrucosa</i>	pistolgrip	4	4
<i>Pyganodon grandis</i>	giant floater	0	0.5
<i>Lampsilis satura</i>	sandbank pocketbook	1	1.5
<i>Uniomereus declivis</i>	tapered pondhorn	0	4.5
<i>Pleurobema riddellii</i>	louisiana pigtoe	0	0.5
<i>Leptodea fragilis</i>	fragile papershell	1	1.5
<i>Toxolasma texasiensis</i>	texas lilliput (found in Roden Creek)	0	1

Species Latin name	Common name	<i>N</i> live	<i>N</i> shells
Total mussels found		35	44.5
Total species found		8	17

Our sampling was done at higher water levels and quite strong currents which might have affected the results. However, a severe drought extending from 2005-2006 (Figure 1) likely had a very serious impact on the mussel population.

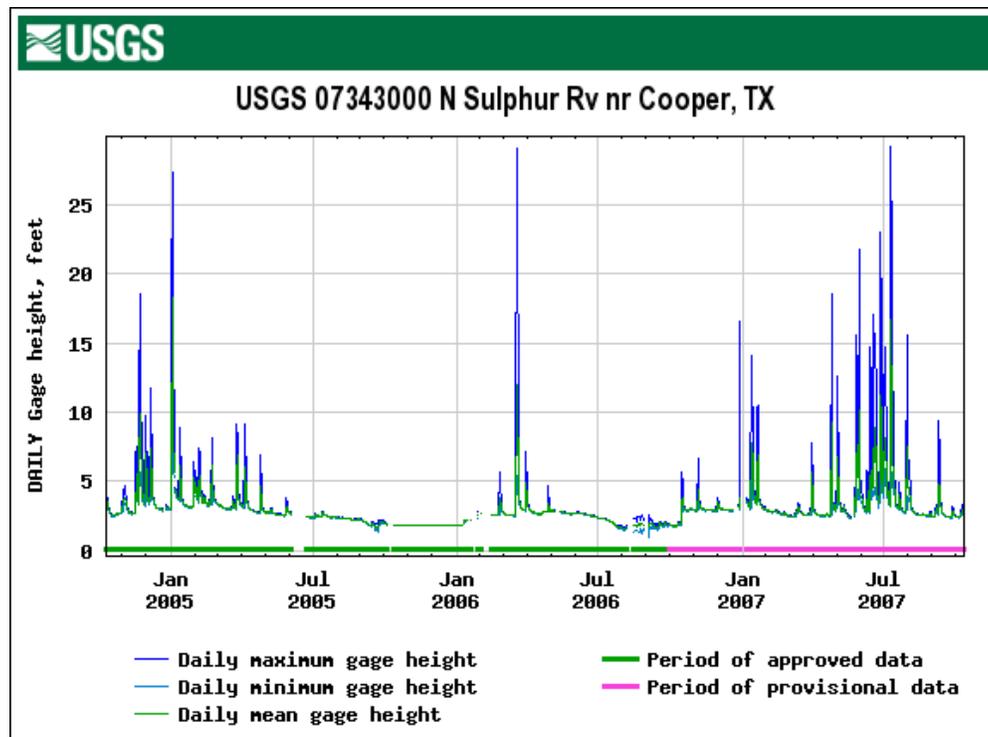


Figure 1. Average gage heights for the Sulphur River (USGS Surface-Water Daily Data for Texas).

The former dominant complex of site 1 found in 2005 (i.e., threeridge, bluefer, and yellow sandshell) was still present at the site in 2007; however, we found three times fewer live mussels compared to the 2005 sampling. Since the sampling effort in 2005 was not reported, and the numbers do not reflect the entire population of the species listed (as many specimens from each species were not counted (M. May, pers. comm.)), the results cannot be compared directly. Seven species (four found live in 2005) that we did not find during our sampling were: sandbank pocketbook, louisiana pigtoe, fragile papershell, giant floater, tapered pondhorn, and western pimpleback.

Table 6. List of species collected by TPWD from the Sulphur River prior to our study (Howells, 1995; 2002). n.r. – not reported.

Date	Waterbody name	County	Location	Latin name	Common name	N live	N shells	N valves	Condi- tion	% from total
6/22-23/ 1993	South Sulphur River	Hunt	SH 50	<i>Lampsilis teres</i>	yellow sandshell	0	3	n.r.	n.r.	54.5
				<i>Leptodea fragilis</i>	fragile papershell	0	fragments	n.r.	n.r.	Present
				<i>Potamilus purpuratus</i>	bleufer	0	1	n.r.	n.r.	18.2
				<i>Unio merus declivis</i>	tapered pondhorn	0	1.5	n.r.	n.r.	27.3
				<i>Lampsilis teres</i>	yellow sandshell	0	9.5	n.r.	n.r.	22.6
6/22-23/ 1993	South Sulphur River	Hopkins	SH 154	<i>Leptodea fragilis</i>	fragile papershell	0	23.5	n.r.	n.r.	56
					southern	0	6	n.r.	n.r.	14.3
				<i>Quadrula apiculata</i>	mapleleaf					
				<i>Potamilus purpuratus</i>	bleufer	0	2	n.r.	n.r.	4.8
				<i>Unio merus declivis</i>	tapered pondhorn	0	1	n.r.	n.r.	2.4
6/22-23/ 1993	Middle Sulphur River	Hunt	SH 11, NW of Commerce	<i>Unio merus declivis</i>	tapered pondhorn	13	12	n.r.	n.r.	100
6/22-23/ 1993	Sulphur River	Franklin	SH 37, upstream of the confluence of the North and South Sulphur River branches	<i>Lampsilis teres</i>	yellow sandshell	n.r.	1	n.r.	RD	n.r.
6/22-23/ 1993	White Oak Creek	Franklin	SH 37, upstream of the confluence of the North and South Sulphur River branches	<i>Potamilus purpuratus</i>	bleufer	n.r.	n.r.	6 fragments	VRD	n.r.
5/26/ 2001	North Sulphur River	Hunt	north of Ladonia	<i>Amblema plicata</i>	threeridge	0	0	4	SF	44.4
5/26/ 2001	North Sulphur River	Hunt	north of Ladonia	<i>Unio merus tetralasmus</i>	pondhorn	0	0	5	SF	55.6

Cooper Reservoir

Cooper Reservoir (surface area 78.1 km², impounded in 1991) is situated in northeast Texas, on the Middle and South Forks of the Sulphur River, northwest of Sulphur Springs (Hopkins County).

Site 1. Cooper Reservoir at CR 4795

Cooper Reservoir was sampled at a TPWD boat ramp located at CR 4795 (33.31194°N - 33.31379°N; 95.61089°W - 95.61174°W), Hopkins County, Texas, on June 15, 2007. Substrates were comprised of sand and clay. Depths ranging from 0.2-1.5 m were searched for a total of 2.1 mh (3 people, 40 min). Both sides from the boat ramp were searched. The left shore was searched as far as the incoming creek (app. 450 m). GPS coordinates were taken at the boat ramp (start) and at the end of the west shore search.

The reservoir was very low. Water was down 1 to 1.5 m from normal. The only shells found came from the shore. Thorough sampling by snorkeling did not reveal any live mussels. Five unionid species were found, the dominant being mapleleaf (Table 7).

Site 2. Cooper Reservoir at Doctors Creek Park

Cooper Reservoir was sampled at the pier in Doctors Creek Park (33.34049°N, 95.65103°W), Hopkins County, Texas, on June 15, 2007. Substrates included hard clay (no mussels were found on that substrate), clay and sand. Depths ranging from 0.1-0.5 m were searched for a total of 1 mh (3 people, 20 min). Five species of unionids were found (Table 7) with similar overall dominance by mapleleaf; however, pink papershells were more abundant at this site compared to Site 1.

Table 7. List of species collected from Cooper Reservoir.

Species Latin name	Common name	N live	N live/ mh	N shells	N shells/ mh	N valves	N valves/ mh
Cooper Reservoir Site 1							
<i>Quadrula quadrula</i>	mapleleaf giant	0	0	87	41.4	0	0.0
<i>Pyganodon grandis</i>	floater	0	0	4	1.9	0	0.0
<i>Potamilus purpuratus</i>	bleufer	0	0	1	0.5	0	0.0
<i>Lampsilis hydiana</i>	louisiana fatmucket	0	0	1	0.5	0	0.0
<i>Potamilus ohiensis</i>	pink papershell	0	0	3	1.4	3	1.4
Total mussels found		0		96		3	
Total species found		0		5		1	
Cooper Reservoir Site 2							
<i>Quadrula quadrula</i>	mapleleaf	0	0.0	59	59.6	11	11.1
<i>Pyganodon grandis</i>	giant floater	0	0.0	4	4.0	3	3.0
<i>Potamilus purpuratus</i>	bleufer	0	0.0	1	1.0	0	0.0

Species Latin name	Common name	N live	N live/ mh	N shells	N shells/ mh	N valves	N valves/ mh
<i>Lampsilis teres</i>	yellow sandshell	0	0.0	2	2.0	2	2.0
<i>Potamilus ohiensis</i>	pink papershell	0	0.0	15	15.2	10	10.1
Total mussels found		0		81		26	
Total species found		0		5		4	
Total Cooper Reservoir (Sites 1 and 2)							
<i>Quadrula quadrula</i>	mapleleaf	0	0	146	47.2	11	3.6
	giant floater	0	0	8	2.6	3	1.0
<i>Pyganodon grandis</i>	bleufer	0	0	2	0.6	0	0.0
	louisiana fatmucket	0	0	3	1.0	2	0.6
<i>Lampsilis hydiana</i>	pink papershell	0	0	18	5.8	13	4.2
<i>Potamilus ohiensis</i>							
Total mussels found		0		177		29	
Total species found		0		5		4	

Apparently, the community in the reservoir is less diverse than in the Sulphur River. The dominant species was mapleleaf which comprised over 80% of the community. Thin-shelled species (pink papershell and giant floater) were next by occurrence, while only a few bluefers and Louisiana fatmuckets were found. This community has been heavily damaged by the spring 2007 drawdown. No live mussels were found at either site.

We were unable to find any previous data from Cooper Reservoir for comparison purposes. Of the two sites sampled in 2007, the Doctors Creek Park site will be the best for future monitoring efforts.

Caddo Lake, Starr Ditch

Two small collections were made in the Starr Ditch on Caddo Lake (32°42'43"N, 94°06'26"W) on April 15, 2006, and on October 18, 2007. The ditch was deepened before the first sampling (April 2006) and shells were collected along the shores of the canal. Six species were collected during the first sampling effort and four during the second (Table 8). The most common species were yellow sandshells and louisiana fatmuckets.

Previous records from Caddo Lake include live washboards in the beginning of the 20th century (Shira, 1913), as well as a record of old washboard shells collected by musselers in 1993 (Howells, 1995). In the 1992 mussel survey of Big Cypress Bayou and Caddo Lake (U.S. Army Engineer Waterways Experiment Station Review available at <http://clidata.org/Reports/DaingerfieldReach/Geomorphic/part1.pdf>), eight species were found:

Pyganodon grandis, *Anodonta suborbiculata*, *Utterbackia imbecillis*, *Lampsilis teres*, *Lampsilis straminea* (this report of *L. straminea* in Texas were misidentified *L. hydiana* or *L. bracteata*. R. Howells, pers. comm.), *Ligumia subrostrata*, *Plectomerus dombeyanus*, and *Toxolasma texasiensis*. The most common species in the lake was bankclimber (found at all six sites), and yellow sandshell (found at 67% of the sites). Authors noted that unionid fauna of Caddo Lake was dominated by thin-shelled species such as giant floater (33%) and flat floater. Other species were found only in one of six sites sampled (17%).

We cannot directly compare the results of our collections, which were made in only a small part of the lake (Starr Ditch), with the 1992 data from the whole lake; however, one of the dominant species in 1992 (yellow sandshell) was also the most common species in 2006. The lack of bankclimbers on our sampling site could be due to the prevalence of soft substrates in the ditch.

Table 8. List of species collected from Caddo Lake in 2006 and 2007.

Date	Species	Common name	N live	N shells	N valves
April 15, 2006	<i>Pyganodon grandis</i>	giant floater	0	1	0
	<i>Anodonta suborbiculata</i>	flat floater	0	1	0
	<i>Lampsilis teres</i>	yellow sandshell	0	12	4
	<i>Toxolasma texasiensis</i>	texas lilliput	0	2	0
	<i>Ligumia subrostrata</i>	pond mussel	0	2	0
	<i>Lampsilis hydiana</i>	louisiana fatmucket	0	3	0
October 18, 2007	<i>Toxolasma texasiensis</i>	texas lilliput	0	1	1
	<i>Ligumia subrostrata</i>	pond mussel	0	0	1
	<i>Lampsilis teres</i>	yellow sandshell	0	0	1
	<i>Lampsilis hydiana</i>	louisiana fatmucket	0	0	4

Wright Patman Reservoir

Wright Patman Reservoir (surface area 82.2 km², impounded on the Sulphur River in 1956) is located southwest of Texarkana in Bowie, Cass, Morris, Titus, and Red River counties. The drainage area upstream of the dam is 8,917 km². The surrounding low-rolling to flat terrain is surfaced by shallow to deep clay and sandy loams that support mixed hardwoods and pines and grasses (Dowell, 1964).

Four sites were sampled on Wright Patman Reservoir by shoreline search and wading on December 27, 2006 during low water conditions. These sites included: the south corner of the dam near the spillway in Atlanta State Park; Knights Bluff Camping Area; White Oak Ridge boat ramp; and the boat ramp located on SR 8. About 100 m of shoreline was searched at each of the four sites for a total search time of 0.5 mh per site. No live mussels were found, but only shells of four species. These species included: mapleleaf (10 shells, 4 valves); flat floater (1 shell, 1 valve), giant floater (1 shell), and fragile papershell (1 shell). The dewatering of the reservoir in the beginning of 2006 could have depauperated the unionid community. We were not able to find previous data from Wright Patman Reservoir to compare.

Trinity River Drainage

Houston County Reservoir

Houston County Reservoir on Little Elkhart Creek (surface area 6.1 km², impounded in 1966) is located 10 miles northwest of Crockett, off Farm Road 229 in Houston County. The only site with public access sampled on the lake was at the public boat ramp (31.40974°N, 95.60443°W). Sampling was done on August 28, 2007. Due to the relatively high water level of the reservoir, only two species were collected during 1 mh (2 people, 30 min) of searching. These species included: giant floater (2 live, 2 dead) and pigtoe (*Fusconaia* sp.) (1 shell, 1 valve, very long dead). This reservoir was very low in 2005-2006 (USGS Surface-Water Data for Texas). Water level fluctuations in reservoirs often induce high mortality and decreased abundance of freshwater mussels (Howells, 2000b; Burlakova and Karatayev, 2007). That might explain why only a few mussels were found during our sampling. To our knowledge, this was the first sampling effort on this reservoir.

Neches River Drainage

Angelina River

Site 1. Angelina River at SR 7

The Angelina River was sampled on September 7, 2006 at the SR 7 bridge crossing (31°29.216N, 94°49.416W) at very low water levels (depth 0.2 – 0.5 m). A mussel bed was found within a very close distance (app. 10-15 m upstream) of the bridge on sand substrate during the time search, which totaled 2.7 mh (4 people, 40 min.) (Figure 2). Quadrats were used to estimate mussel density at the bed. A search further upstream of the bridge (app. 100 m) revealed no live mussels.

In total, 15 unionid species were found (Table 9). Bankclimbers and western pimplebacks were the most common species. Their densities were 15.2 m⁻² (± 11.5) and 4.8 m⁻² (± 4), respectively. Other species found in the quadrats were pistolgrips (2.4 ± 2.7 m⁻²), and yellow sandshells (0.8 m⁻²). Average density in the quadrats was 24 ± 15 m⁻².

Unfortunately, there was a problem with species identification at this site. During sampling, a number of live washboards were identified as bankclimbers, due to heavy shell erosion. Later in the lab after careful examination of shells (tooth, beak cavities, etc.) and comparison with the specimens in our collection, several bankclimbers were re-identified as washboards. Therefore, many of the mussels that we recorded as bankclimbers (71 total) on the site could be washboards. If that's the case, this mussel bed could contain one of the most significant populations of washboards in the Angelina River as well as in East Texas, and should receive special protection. The ongoing widening of SR 7, that will require construction of a new bridge, could potentially threaten the mussel bed.

This site could serve as a very good location for continued monitoring given the abundant and diverse mussel bed and easy access.



Figure 2. Sampling Angelina River at SR 7 in September 2007.

Table 9. List of species collected from the Angelina River.

Species Latin name	Common name	N live	N live/ mh	N shells	N shells /mh
Site 1. Angelina River at SR 7					
<i>Plectomerus dombeyanus</i>	bankclimber	71	26.6	3	1.1
<i>Pyganodon grandis</i>	giant floater	5	1.9	0	0.0
<i>Leptodea fragilis</i>	fragile papershell	1	0.4	0	0.0
<i>Lampsilis satura</i>	sandbank pocketbook	2	0.7	0	0.0
<i>Fusconaia</i> sp. (<i>lananensis</i> ?)	pigtoe sp.	1	0.4	0	0.0
<i>Fusconaia askewi</i>	texas pigtoe	10	3.7	0	0.0
<i>Quadrula verrucosa</i>	pistolgrip	13	4.9	1	0.4
<i>Arcidens confragosus</i>	rock pocketbook	1	0.4	0	0.0
<i>Potamilus purpuratus</i>	bluefer	3	1.1	1	0.4
<i>Truncilla truncata</i>	deertoe	5	1.9	2	0.7
<i>Lampsilis teres</i>	yellow sandshell	2	0.7	0	0.0
<i>Obliquaria reflexa</i>	threehorn wartyback	3	1.1	0	0.0
<i>Quadrula mortoni</i>	western pimpleback	31	11.6	0	0.0
<i>Megaloniaias nervosa</i>	washboard	13	4.9	1	0.4
<i>Lampsilis hydiana</i>	louisiana fatmucket			density 0.8 m ^{-2*}	
Total mussels found		161		8	
Total species found		14		5	
Site 2. Angelina River at US 59					
<i>Plectomerus dombeyanus</i>	bankclimber	29	19.3	5	3.3
<i>Quadrula verrucosa</i>	pistolgrip	4	2.7	0	0.0
<i>Quadrula apiculata</i>	southern mapleleaf	4	2.7	1	0.7
<i>Amblema plicata</i>	threeridge	16	10.7	1	0.7
<i>Quadrula mortoni</i>	western pimpleback	22	14.7	0	0.0
<i>Obliquaria reflexa</i>	threehorn wartyback	5	3.3	0	0.0
<i>Arcidens confragosus</i>	rock pocketbook	1	0.7	0	0.0
<i>Leptodea fragilis</i>	fragile papershell	0	0.0	12	8.0
<i>Pleurobema riddellii</i>	louisiana pigtoe	2	0.8	0	0.0
<i>Fusconaia lananensis</i>	triangle pigtoe	2	1.3	1	0.7
<i>Uniomereus declivis</i>	tapered pondhorn	1	0.7	0	0.0
<i>Potamilus purpuratus</i>	bluefer	1	0.7	1	0.7
<i>Truncilla truncata</i>	deertoe	6	4.0	6	4.0
<i>Megaloniaias nervosa</i>	washboard	1	0.7	0	0.0
Total mussels found		94		27	
Total species found		13		7	

* Found in quadrat sampling.

Angelina River, Sites 1 and 2					
<i>Plectomerus</i>					
<i>dombeyanus</i>	bankclimber	100	24.0	8	1.9
<i>Pyganodon grandis</i>	giant floater	5	1.2	0	0.0
<i>Leptodea fragilis</i>	fragile papershell	1	0.2	12	2.9
<i>Lampsilis satura</i>	sandbank pocketbook	2	0.5	0	0.0
<i>Fusconaia lananensis</i>	triangle pigtoe	3	0.7	1	0.2
<i>Fusconaia sp.</i> (<i>lananensis</i> ?)	triangle pigtoe?	1	0.2	0	0.0
<i>Fusconaia askewi</i>	texas pigtoe	10	2.4	0	0.0
<i>Quadrula verrucosa</i>	pistolgrip	17	4.1	1	0.2
<i>Arcidens confragosus</i>	rock pocketbook	2	0.5	0	0.0
<i>Potamilus purpuratus</i>	bluefer	4	1.0	2	0.5
<i>Truncilla truncata</i>	deertoe	11	2.6	8	1.9
<i>Lampsilis teres</i>	yellow sandshell	2	0.5	0	0.0
<i>Obliquaria reflexa</i>	threehorn wartyback	8	1.9	0	0.0
<i>Quadrula mortoni</i>	western pimpleback	53	12.7	0	0.0
<i>Amblema plicata</i>	threeridge	16	3.8	1	0.2
<i>Quadrula apiculata</i>	southern mapleleaf	4	1.0	1	0.2
<i>Uniomerus declivis</i>	tapered pondhorn	1	0.2	0	0.0
<i>Pleuroblema riddellii</i>	louisiana pigtoe	2	0.5	0	0.0
<i>Megaloniaias nervosa</i>	washboard	14	3.4	1	0.2
Total mussels found		256		34	
Total species found		18		8	

Site 2. Angelina River at US 59

This site was sampled on August 19, 2006 under the bridge of US 59 (from 31.457087°N, 94.726190°W to 31.457231°N, 94.726742°W) at very low water levels (depth 0.2 – 0.5 m) (Figure 3). Mussels were found under the bridge and on the west side of the bridge on sand, silty sand, sand and gravel, and sand and clay substrates. Time search was 1.5 mh (2 people, 45 min); an additional search for 1 mh (2 people, 30 min) for rare species was made after the first search was finished. An area of 4 m² was searched to estimate mussel density at the bed (app. 5-8 m on the left downstream from the bridge).

Thirteen species were found alive in this site (Table 9). In addition, very recently dead shells of fragile papershell were found during the sampling. Shells of this thin-shelled species were found on dry banks of the river, higher than other molluscs (that were found in the river bed), and probably died in the same year due to the drought. Mussel density was 3.3 mussels m⁻² at the mussel bed. The most common were bankclimbers, western pimplebacks, and threeridges. Several species of concern and rare species (e.g., louisiana and triangle pigtoes, sandbank and rock-pocketbook, western pimpleback) are still present at both sites sampled in the Angelina River.



Figure 3. Angelina River at US 59 during low water in August 2007 (upper) and mussels collected at the site (bottom).

Comparison with previous data: Angelina River

Parks and Bachtel (1940) listed 25 species as common or fairly common in the Angelina River (*Amblema plicata*, *Fusconaia askewi*, *F. flava*, *Glebula rotundata*, *Lampsilis hydiana*, *L. satura*, *L. teres*, *Leptodea fragilis*, *Megalonaias nervosa*, *Obliquaria reflexa*, *Plectomerus dombeyanus*, *Potamilus purpuratus*, *Pyganodon grandis*, *Quadrula apiculata*, *Q. nodulata*, *Q. pustulosa*, *Q. quadrula*, *Toxolasma texasiensis*, *Tritogonia verrucosa*, *Truncilla donaciformis*, *T. macrodon*, *T. truncata*, *Uniomerus declivis*, *U. tetralasmus*, and *Villosa lienosa*).

Only one species (*Quadrula mortoni*) was recorded from the Angelina River in 1993 (Sam Rayburn Reservoir Dam downstream to Bevilport) (Howells, 1995); two in 1997 (downstream of SH 103), *Anodonta suborbiculata* and *Pyganodon grandis* (Howells, 1998). Nine species of unionids were collected in November 1994 at the same location (at US 59): *Amblema plicata*, *Glebula rotundata*, *Lampsilis hydiana*, *Megalonaias nervosa*, *Obliquaria reflexa*, *Quadrula apiculata*, *Quadrula mortoni*, *Tritogonia verrucosa*, and *Uniomerus declivis* (Feaster, 1996). During our previous collection on May 15, 2003, we found four species at the same site, but further downstream from the US 59 bridge (*Amblema plicata*, *Quadrula mortoni* (4 live), *Plectomerus dombeyanus*, and *Quadrula verrucosa*). The water level during this 2003 sampling effort was about 1 m higher than in 2006.

In total, 12 species (*Anodonta suborbiculata*, *Lampsilis hydiana*, *L. teres*, *Leptodea fragilis*, *Anodonta sp.*, *Obliquaria reflexa*, *Pyganodon grandis*, *Quadrula apiculata*, *Q. mortoni*, *Toxolasma texasensis*, *Utterbackia imbecillis*, and *Villosa lienosa*) were found in Sam Rayburn Reservoir on the Angelina River between 1994-1997 (Feaster, 1996; Howells, 1996b; 1998).

The number of species (18) found at the two sites sampled in 2006 was lower than that reported for the 1930s (Parks and Bachtel, 1940). Species like *Fusconaia flava*, *Quadrula apiculata*, *Q. nodulata*, *Q. pustulosa*, *Truncilla donaciformis*, and *T. macrodon* have not been found in the river for the last 15 years. It is hard to compare the data directly as Parks and Bachtel (1940) provide categories ("common, uncommon, etc.) rather than actual presence and absence. Some species from their list (e.g. *Truncilla macrodon*) are not listed in the watershed (Howells et al., 1996). However, the number of unionid species found in 2006 was much higher than that found in the last two decades. The success of our 2006 survey was due to unusually low water levels that made the sampling very effective. For example, high water levels in the Angelina River in 2007 precluded sampling (Figure 4).

Our collections in 2006 indicated the river still maintains a high variety of species (Table 9), and both sites can be used for future monitoring.



Figure 4. Angelina River during flooding in July 2007 (app. 100 m from the bridge at US 59).

Attoyac Bayou

We sampled Attoyac Bayou on June 5, 2007, in Nacogdoches and Shelby counties. Two sites were surveyed: US 59 (30.39778°N, 94.26463°W) and FM 138 (31.768386°N, 94.426159°W). The time search at US 59 totaled 1.5 mh (3 people, 30 min). Substrate at this site was predominantly comprised of clay and silt. No mussels were found there. At FM 138, with the same time search (1.5 mh), live specimens of three species (threeridge (1), triangle pigtoe (1), and louisiana fatmucket (2)) were found, as well as long dead shells of little spectaclecase (2) and louisiana fatmucket (1). Attempts to sample a third site (SH 7; 31.648730°N, 94.397057°W) were abandoned due to high water and strong current.

Unusually high water and strong currents prevented the detailed sampling that was designed for this waterbody. For example, water level in the nearby Angelina River in 2007 was about 1.5 m higher than in 2006 (Figure 5) (unfortunately there is no similar data available for Attoyac Bayou). Therefore, due to the extremely rainy year, the results of our survey in 2007 do not adequately reflect the diversity of the unionid population in the bayou.

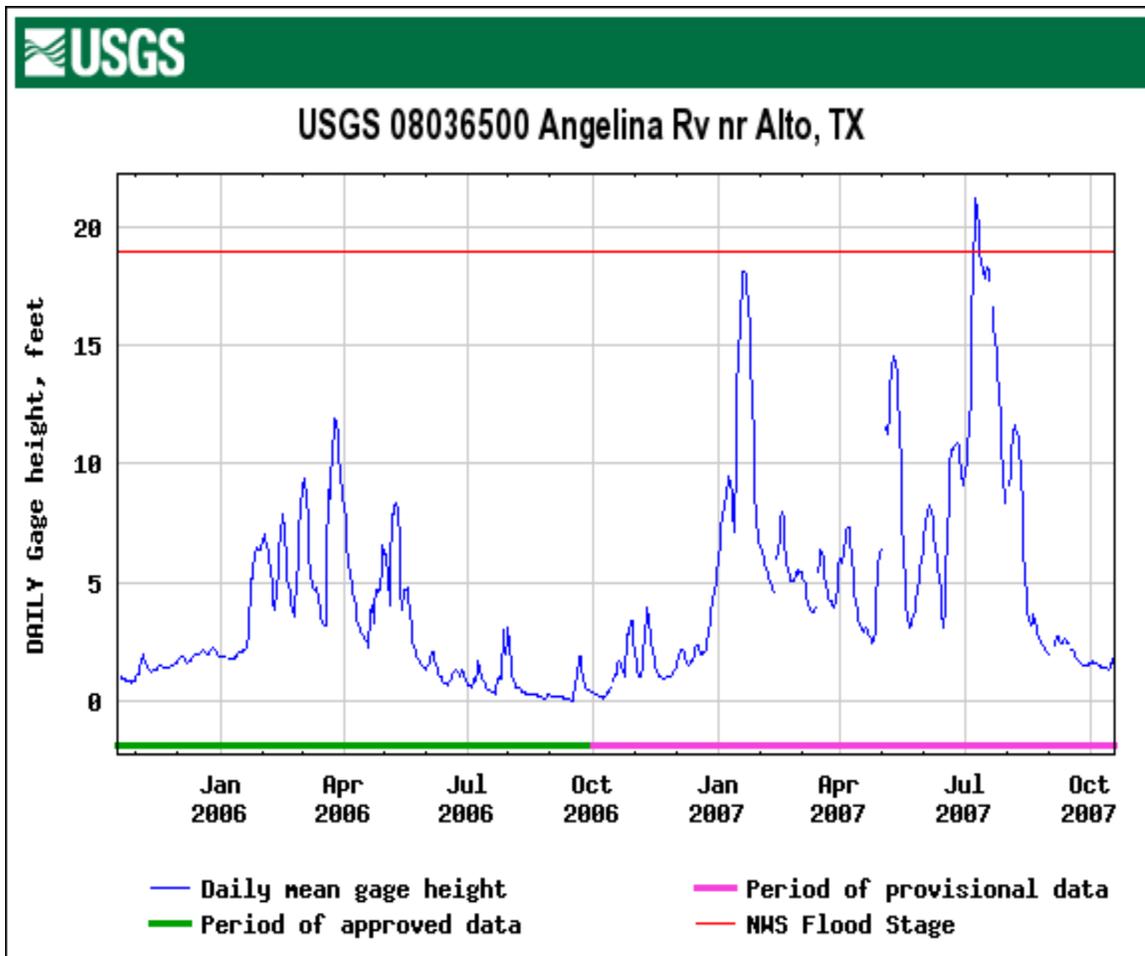


Figure 5. Average gage heights for the Angelina River from 2006 to 2007 (USGS Surface-Water Daily Data for Texas).

Striker Reservoir

Striker Reservoir (surface area 9.7 km², impounded on Striker Creek in 1957 and formerly known as Striker Creek Reservoir), is located 29 km southwest of Henderson, straddling the Rusk and Cherokee county line. The drainage area upstream of the dam is 471 km², and the local terrain is flat to rolling and surfaced by sandy and clay loams that support water-tolerant hardwoods, conifers, and grasses (Dowell, 1964).

The reservoir was sampled on June 5, 2007 at the only public access - swim area/boat ramp (CR 4256) (31.938978°N, 94.974764°W). Waters up to 1.8 m deep with sand and gravel substrates were searched. Three species were collected during the timed search (0.75 mh, 1 man, 45 min). These species included: bluefer (1 live), louisiana fatmucket (3 live), and yellow sandshell (1 shell). To our knowledge, this was the first sampling event for mussels in this reservoir.

Village Creek

We sampled Village Creek (Hardin County) at several sites in June 2007. Live mussels were only found at two of the sites.

Site 1 was sampled on June 3, 2007 at FM 418 (31.64641°N, 94.63700°W). The substrates were sand and clay. Only two species, louisiana pigtoe (3 live) and western pimpleback (1 live), were found during 2.25 mh of time search (3 people, 45 min). The other site was at a Nature Conservancy area (30.39620°N, 94.26629°W), where after 1 mh time search (3 people, 20 min), 1 live triangle pigtoe and 1 shell of texas lilliput were found.

On June 27, 2007 we canoed from FM 418 near Kountze downstream to CR 327, sampling five sites about 500 meters apart along the way. Surveying of these sites often was hindered or not possible due to high water and strong current and did not reveal any live mussels or shells.

Unfortunately, we were not able to sample Village Creek as we planned due to high water conditions. The average water level in 2007 in Village Creek was 3.18 m compared to 1.60 m in 2006, and was 1.7 times higher than average for 2001-2006 (1.90 ± 0.25 m) (Figure 6). As a result, our sampling was not effective. Even when we re-sampled the sites where we found dense and diverse mussels beds in 2005 (e. g. Site 1 at FM 418 crossing), no mussels were found, probably due to highly turbid water and strong current. It is also possible that the mussels were dislodged and flushed away by violent currents during flooding. That stresses the importance of continuing monitoring of the abundant and diverse assemblages in this sanctuary.

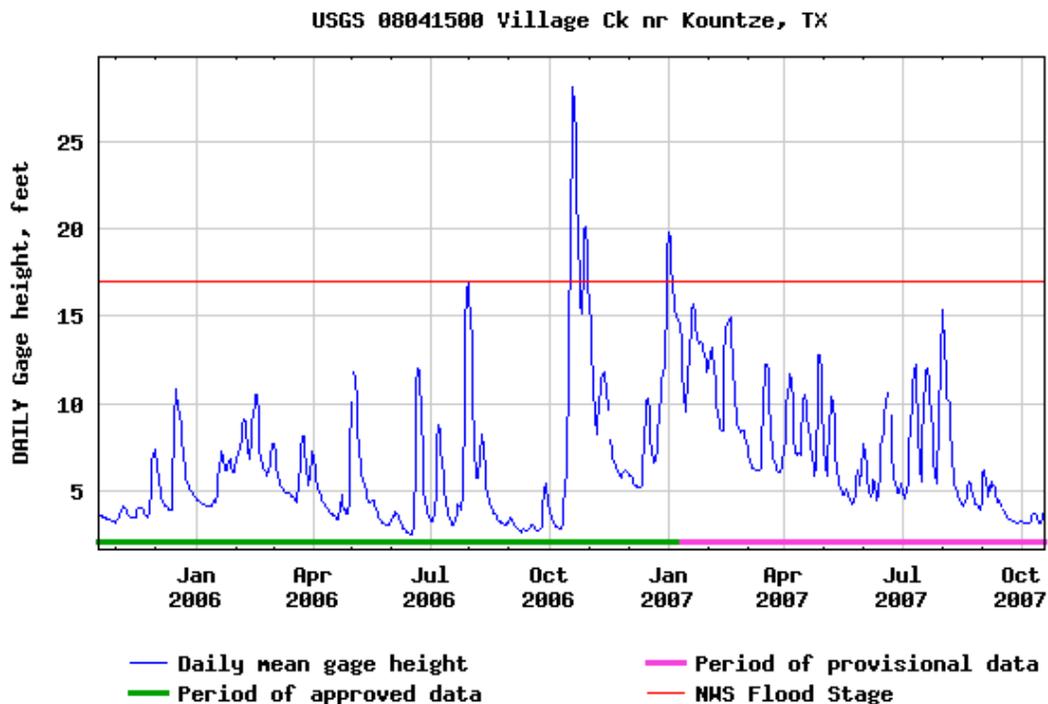


Figure 6. Average gage heights for Village Creek from 2006 to 2007 (USGS Surface-Water Daily Data for Texas).

Neches River

The Neches River was sampled on September 7, 2006, in Trinity and Angelina counties, at SR 7 (31°23.794 N, 094°57.935W) during very low water level (Figure 7). Mussels were found at depths ranging from 0.1 – 1.2 m (no mussels were found in deeper water). Substrates were sand, clay, and silt. Most mussels were found on the softer substrates. Bankclimbers were found among the submerged logs. We used time search (2.5 mh: 5 people, 30 min.) and quadrats (13 total) to estimate mussel density. Five quadrats were sampled in 0.25 m deep water, five in 1 m depths, and three in 0.5 m depths.

One hundred eighty-four live specimens belonging to 14 species of unionids were found (Table 10). The most common were wartyback and yellow sandshell. Several rare species (louisiana pigtoe, washboards, gulf mapleleaf) were also found at this site. Density of unionids varied from 8 to 48 mussel m⁻² and averaged 19.4±10.7 mussel m⁻². This site is a very good candidate for future monitoring of the population as the mussel bed is diverse, abundant, and easy to find.

A few occasional collections were made at this site in August 1994 during a paddlefish (*Polyodon spathula*) spawning habitat study. Live *Quadrula mortoni* (2), *Plectomerus dombeyanus* (1) and *Tritogonia verrucosa* (1) were found in Peterson dredge samples. In addition, shells of *Lampsilis hydiana*, *Lampsilis satura*, *Lampsilis teres*, *Leptodea fragilis*, and *Plectomerus dombeyanus* were collected on sand and gravel bars (Howells, 1996a).

Table 10. List of species collected from the Neches River at SR 7.

Species Latin name	Common name	N live	N live/ mh	N shells	N shells /mh
<i>Lampsilis teres</i>	yellow sandshell	48	19.2	16	6.4
<i>Potamilus purpuratus</i>	bluefer	9	3.6	5	2
<i>Pyganodon grandis</i>	giant floater	1	0.4	0	0
<i>Truncilla truncata</i>	deertoe	0	0	1	0.4
<i>Megaloniaias nervosa</i>	washboard	2	0.8	0	0
<i>Quadrula apiculata</i>	southern mapleleaf	12	4.8	0	0
<i>Obliquaria reflexa</i>	threehorn wartyback	51	20.4	0	0
<i>Amblema plicata</i>	threeridge	9	3.6	0	0
<i>Plectomerus dombeyanus</i>	bankclimber	15	6	1	0.4
<i>Lampsilis hydiana</i>	louisiana fatmucket	21	8.4	4	1.6
<i>Villosa lienosa</i>	little spectaclecase	3	1.2	0	0
<i>Quadrula nobilis</i>	gulf mapleleaf	2	0.8	0	0
<i>Leptodea fragilis</i>	fragile papershell	0	0	2	0.8
<i>Quadrula mortoni</i>	western pimpleback	10	4	0	0
<i>Pleurobema riddellii</i>	louisiana pigtoe	3	1.2	0	0
<i>Unio merus declivis</i>	tapered pondhorn	1	0.4	0	0
Total mussels found		184		29	
Total species found		14		6	



Figure 7. Site location (upper) and mussels found in Neches River at SR 7 (bottom).

B.A. Steinhagen Reservoir

B.A. Steinhagen Reservoir (surface area 43.2 km², maximum depth 11 m) is a shallow multi-purpose reservoir impounded on the Neches and Angelina rivers in 1951. It captures nutrient-rich run-off from East Texas. The reservoir has slowly silted in over the years, becoming infested with exotic vegetation such as water hyacinth, hydrilla, and common salvinia, to such a point that recreation and hydroelectric generation have become greatly hampered during most of the summer and fall. Aquatic herbicide applications and winter drawdowns to control vegetation have been used in the past decade with limited success. In an effort to combat nuisance levels of non-native aquatic vegetation the U. S. Army Corps of Engineers, in coordination with the TPWD, employed an intense summer drawdown in 2006 in an effort to strand and desiccate the vegetation (US Army Corp of Engineers News Release available at www.swf.usace.army.mil/pubdata/pao/releases/fy2006/nr06-027.pdf). As a result of this severe drawdown, the reservoir reached historically low levels from the late summer of 2006 until late May 2007 (Figure 8). There have been numerous occasions where the level has dropped, but usually for only a two to three month period and never through the summer months (Floyd E. Boyett, Natural Resource Specialist/Park Ranger, Town Bluff Project, Woodville, TX, pers. comm.).

We sampled the reservoir at nine sites during one of the lowest water levels (April 20 and 21, 2007). We collected over 700 shells (from very recently dead to long dead) of 18 unionid species, including three species of concern (texas and triangle pigtoes, texas heelsplitter) and four rare species (fawnsfoot, western pimpleback, gulf mapleleaf, and rock-pocketbook) (Table 11).

Comparison with previous data: B. A. Steinhagen Reservoir

We collected 20 unionid species during our 2005-2007 surveys (counting two other species, paper pondshell and flat floater, found during a previous 2005 survey). Compared to TPWD data (Howells, 1995; 1997; 2000; 2002; 2005) we collected all but four species previously reported from this reservoir. These species include: *Uniomerus tetralasmus*, *Toxolasma parvus*, *Ligumia subrostrata*, and *Lampsilis satura*. Although Howells (1997) lists *T. parvus* in the list of species collected in the reservoir in 1996, he and his coauthors do not include the Neches River in the range of this species (Howells et al., 1996). Three other species that we did not find in our survey are very uncommon in the reservoir: only one live *Ligumia subrostrata*, one shell of *Lampsilis satura* and 2 shells of *Uniomerus tetralasmus* were found from 1993-2004 (Howells, 1995; 1997; 2000; 2002; 2005). Both *Uniomerus tetralasmus* and *Ligumia subrostrata* are soft-bottom species that are common in small impoundments and lakes (Howells et al., 1996).

B.A. Steinhagen Reservoir and the Neches River immediately downstream of Town Bluff Dam are known to support the most abundant and diverse unionid assemblage found in Texas (Howells, 2000; 2006). Some 25 species have been documented in the reservoir, with two more species found downstream of the dam. Repeated drawdowns decrease abundance and diversity and may potentially cause a shift in composition of the mussel assemblage.



Figure 8. B.A. Steinhagen Reservoir during drawdown in April 2007 (upper); mussels found in one 0.25 m² quadrat (bottom).

Table 11. List of species collected from B. A. Steinhagen Reservoir during historic record low drawdown on April 20-21, 2007.

Species	Common name	N live	N shells
<i>Amblema plicata</i>	threeridge	0	12
<i>Arcidens confragosus</i>	rock pocketbook	0	3
<i>Lampsilis hydiana</i>	louisiana fatmucket	0	13
<i>Lampsilis teres</i>	yellow sandshell	0	35
<i>Leptodea fragilis</i>	fragile papershell	0	4
<i>Megaloniaias nervosa</i>	washboard	0	24
<i>Obliquaria reflexa</i>	threehorn wartyback	0	141
<i>Plectomerus dombeyanus</i>	bankclimber	0	108
<i>Potamilus amphichaenus</i>	texas heelsplitter	0	6
<i>Potamilus purpuratus</i>	bluefer	0	53
<i>Pyganodon grandis</i>	giant floater	0	2
<i>Quadrula verrucosa</i>	pistolgrip	0	13
<i>Quadrula apiculata</i>	southern mapleleaf	0	23
<i>Quadrula mortoni</i>	western pimpleback	0	166
<i>Quadrula nobilis</i>	gulf mapleleaf	0	94
<i>Toxolasma texasiensis</i>	texas lilliput	0	1
<i>Truncilla donaciformis</i>	fawnsfoot	0	4
<i>Truncilla truncata</i>	deertoe	0	12
Total mussels found		0	714
Total species found		0	18

Sabine River Drainage

Sabine River

The Sabine River was sampled on August 19, 2006 at US 59 (32.32790°N, 94.35292°W) in Panola and Garrison counties. The river was very low and slow flowing. Many sandy areas were checked for mussels along the north shore, but most of them were devoid of mussels. Almost all unionids were found at the south steep forested shore at 0.2 – 1 m depth on sand and clay, and under the bridge on the south side in a mixture of sand and gravel.

Live specimens of nine species and shells of pond and fragile papershell were found during a time search of 2.17 mh (2 people for 1 hour; 1 for 10 min) (Table 12).

Table 12. List of species collected from the Sabine River at US 59 on August 19, 2006.

Species Latin name	Common name	N live	N live/ mh	N shells	N shells /mh
<i>Lampsilis teres</i>	Yellow sandshell	15	6.9	7	3.2
<i>Quadrula verrucosa</i>	Pistolgrip	2	0.9	1	0.5
<i>Potamilus purpuratus</i>	Bluefer	1	0.5	1	0.5

Species Latin name	Common name	N live	N live/ mh	N shells	N shells /mh
<i>Potamilus amphichaenus</i>	texas heelsplitter	1	0.5	3	1.4
<i>Quadrula apiculata</i>	southern mapleleaf	2	0.9	0	0.0
<i>Utterbackia imbecillis</i>	pond papershell	0	0.0	1	0.5
<i>Leptodea fragilis</i>	fragile papershell	0	0.0	3	1.4
<i>Quadrula mortoni</i>	western pimpleback	29	13.4	12	5.5
<i>Amblema plicata</i>	threeridge	1	0.5	0	0.0
	sandbank				
<i>Lampsilis satura</i>	pocketbook	4	1.8	0	0.0
<i>Fusconaia askewi</i>	texas pigtoe	1	0.5	0	0.0
Total mussels found		56		28	
Total species found		9		7	

Comparison with previous data: Sabine River at US 59

This site was sampled previously in July 1994 and June 1995 by TPWD (Howells, 1996b) and by us in 2005. Live threeridges (1), texas pigtoes (9), louisiana fatmucket (1), sandbank pocketbook (1), yellow sandshells (7), fragile papershell (1), texas heelsplitter (1), bleuffers (2), western pimplebacks (3), pistolgrips (9), and paper pondshell (1), as well as shells of bankclimbers and deertoos were found on this site during previous surveys in 1994-2005. Therefore, several species of concern (sandbank pocketbook, texas heelsplitter, and texas pigtoe) are still present on the site. In our 2006 sampling we found more yellow sandshells, western pimplebacks, and sandbank pocketbooks, however direct comparison between our and previous collections is not possible as time search was not reported.

Toledo Bend Reservoir

Toledo Bend Reservoir is located in Louisiana and Texas on the Sabine River, which forms a portion of the boundary between the two states. From the dam site the reservoir extends up the river for about 105 km to Logansport, Louisiana, and inundates land in Sabine, Shelby, Panola, and Newton counties. It is the largest man-made body of water in the south and fifth largest in surface area in the United States (748.7 km²) (Sabine River Authority of Texas data available at <http://www.sratx.org/projects/tbp.asp>).

To our knowledge, Toledo Bend Reservoir has not been systematically surveyed for mussels. A few occasional reports are from collections made during drawdowns in 1995 (Howells, 1996b) and 1997 (Howells, 1998). Live specimens of four species (*Toxolasma texasiensis* (1), *Pyganodon grandis* (1), *Utterbackia imbecillis* (1), and *Ligumia subrostrata* (4)) were found there in 1995. In addition, shells of *Anodonta suborbiculata*, *Lampsilis hydiana*, *Lampsilis teres*, and *Unio merus declivis* were collected in 1995 and 1997.

One site was sampled on September 17, 2006 (Six Mile Creek at SH 87, north of the boat ramp,

during a time search of 0.5 mh (2 people, 15 min) at low water conditions), as part of the Texas Instream Flow Program. Shells of three species were found: pond mussel (2 shells, 4 valves); louisiana fatmucket (1 shell); giant floater (1 shell). All shells were long dead.

Three sites were sampled on December 9, 2006. At the first site, Six Mile Creek at SH 87 (31°14.321 N, 93°45.339 W, at public boat launch, SW side of bridge), a time search of 1 mh (2 people, 30 min) at the public boat ramp along the southwest side of the bridge (along with a 100 m search of the shoreline for mussel shells) yielded texas lilliput (1 shell, 2 valves); pond mussel (2 shells, 3 valves), and giant floater (1 shell). Sampling depths ranged from 0.1 to 0.5 m over sand and clay

The second site was at Harborlight Marina, Sunshine Bay, along the southwest side of the FM 3121 bridge (31°24.558 N, 93°46.902 W). The survey included a time search of 0.7 mh (2 people, 20 min) at depths ranging from 0.1 to 0.5 m over clay and hard sand substrates and a shoreline search of about 100 m. Species found included louisiana fatmucket (6 valves) and texas lilliput (5 valves).

The third site was located at SH 21 (SE corner of first bridge, 31°24.557 N, 93°45.606 W). The time search was 0.7 mh (2 people, 20 min) at depths ranging from 0.1 to 0.5 m. Substrate consisted of sand. About 400 m of shoreline was also searched for mussel shells. Species found on the site were yellow sandshell (1 valve), pond mussel (2 valves), and giant floater (1 valve).

A few more sites were approached, but nothing was collected on the shores and by wading. Sampling was discontinued due to the high level of the reservoir at the time (Figure 9).

Attempts to sample the reservoir and its tributaries were made on April 21, 2007, but were abandoned due to high water level.

Usually, significant drawdowns in impoundments induce high unionid mortality, especially on shallow depths (Howells, 2000b; Burlakova and Karatayev, 2007). Given the authors experience, we believe the population will need at least several years to restore; therefore, sampling in the same year after a significant dewatering is usually not efficient. Our collections did not add to the list of species found in the reservoir previously.

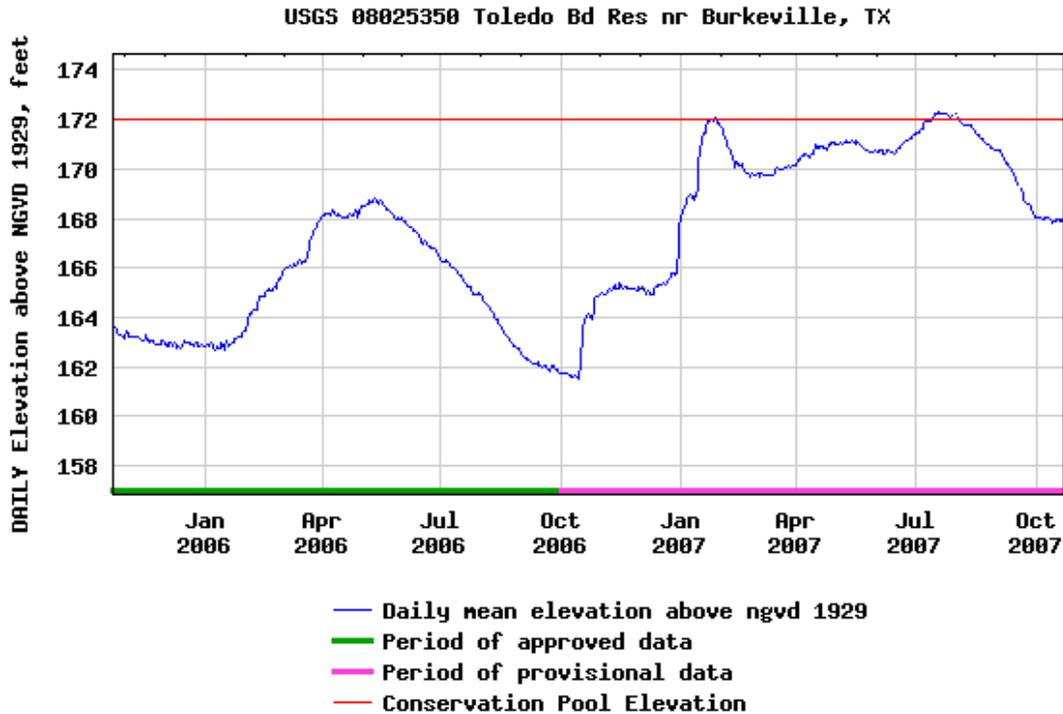


Figure 9. Average elevation data for Toledo Bend from 2005 to 2007 (USGS Surface-Water Daily Data for Texas).

Lower Sabine River tributaries

Sampling of Lower Sabine River tributaries was done during low water condition in September 16-17, 2006 while working on another grant “Distributional survey and habitat utilization of freshwater mussels” for the Texas Instream Flow Program (funded by TWDB). Another attempt to sample the tributaries was made on April 21, 2007, but was unsuccessful due to high water level.

Big Cow Creek

Site 1 on Big Cow Creek was sampled at FM 2460 in Newton County (30°40.119 N, 93°47.912 W) on September 16, 2007. Stream flow was moderate during sampling and the substrates were dominated by sand. Only the invasive bivalve *Corbicula fluminea* was found during a 1 mh time search (3 people, 20 min).

A second site was sampled at FM 363 in the Jesse J. Lee County Park in Newton County (30°43.102 N, 93°46.170 W). A time search of 0.5 mh (2 people, 15 min) in moderate current over a sandy bottom with leaf litter and submerged logs yielded one shell of louisiana fatmucket (60 mm, very long dead). As at site 1, *Corbicula fluminea* were present.

Caney Creek

Caney Creek (Newton County, 30°44.480 N, 93°38.069 W) was sampled on September 16, 2006 at FM 363, close to Bon Weir. A 0.5 mh time search (3 people, 10 min) in moderate current over a sandy bottom with woody debris yielded no live mussels or shells.

A second site, located at US 190 in Caney Creek City Park, Newton County (30°50.882 N, 93°45.777 W), also yielded no live mussels or shells. Depths sampled during a 0.7 mh time search (2 people for 15 min; 1 for 10 min) ranged from 0.2-0.5 m. The aquatic invasive plant *Myriophyllum acuaticum* was present at this site.

Quicksand Creek

Quicksand Creek (Newton County, 30°44.815 N, 93°37.114 W) was sampled on September 16, 2006 at FM 363. A time search of 0.7 mh (2 people, 15 min; 1 for 10 min) was conducted in moderate current over a sandy bottom. No live mussels or shells were found.

A second site was surveyed at SR 87, Newton County (30°52.845 N, 93°42.957 W), on September 17, 2006. The main substrate was also sand, but the shores were more stable than at the previous site. A time search of 1 mh (3 people, 20 min) only yielded one shell of pigtoe (*Fusconaia* sp., 57 mm, very long dead). No live mussels or other shells, including *Corbicula fluminea*, were found.

Yellow Bayou

Yellow Bayou was sampled in Newton County at SR 87 (30°57.626 N, 93°40.908 W) on September 17, 2006. Main substrates were clay and gravel. A time search of 0.75 mh (3 people, 15 min) was conducted. The invasive bivalve *Corbicula fluminea* was present in low densities. No other live or dead mussels were found.

Little Cow Creek

Yellow Bayou was sampled in Newton County at SR 87 (30°59.429 N, 93°39.967 W) on September 17, 2006. Substrate was sand and the flow was moderate to strong. No live mussels or shells were found during 1 mh of time search (3 people, 20 min).

Little Prone Creek

Little Prone Creek was sampled in Sabine County at SR 87 (31°11.968 N, 93°44.090 W) on September 17, 2006. Substrate was sand and flow was low to moderate. No live mussels or shells were found during 0.75 mh of time search (3 people, 15 min).

Texas tributaries of Toledo Bend Reservoir

Six Mile Creek

Six Mile Creek was sampled in the Sabine National Forest (Sabine County) at NF 111 (31°13.841 N, 93°48.536 W) on September 17, 2006. Substrate was sand, silt, leaf litter, wood, and other debris. There was no flow in the creek. A 1 mh time search (3 people, 20 min) yielded giant floater (1 live 112 mm, 1 relatively long dead shell, 1 very long dead valve), and pond

mussel (1 live 65 mm). No live or dead *C. fluminea* were present at this site.

Palo Gancho Bayou

Palo Gancho Bayou was sampled in the Sabine National Forest (Sabine County) at SR 87 (31°23.152 N, 93°50.115 W) on September 17, 2006. Substrate was clay, sand, coarse particulate organic matter, leaf litter, and woody debris; there was no flow. A 0.8 mh time search (2 people, 15 min, 1 per 20 min) yielded giant floater (2 relatively long dead shells) and louisiana fatmucket (1 relatively long dead shell, 1 very long dead valve). *Corbicula fluminea* shells were present at this site.

Nichols Creek

Nichols Creek was surveyed at Sutton Place (Hemphill, TX) (31°22.649 N, 93°49.266 W) on September 17, 2006. The creek was dry. Only one relatively long dead giant floater was found.

SUMMARY AND RECOMMENDATIONS

1. Forty-nine sites in 22 waterbodies (four rivers, seven reservoirs and 11 streams) within four drainage basins (Red, Trinity, Neches, and Sabine) were sampled during this survey.
2. We found 12 species of unionids (8 of them alive) from two sites in the Sulphur River (Red River Basin) in May 2007. The most abundant were threeridges and bluefers. The dominant complex was similar to what was found in previous sampling in 2005 (by Marsha May, TPWD); however, we did not find four species recorded live in 2005 and overall collected fewer live mussels. The results of these two sampling efforts cannot be compared directly since the 2007 sampling was done at a higher water level and in stronger current. The severe droughts in 2005-2006 might also have had negative effect on the mussels.
3. Four reservoirs were surveyed for the first time: Cooper, Wright Patman, Striker, and Houston County. Due to current or preceding severe dewatering, no live mussels were found in Cooper, Wright Patman, and Houston County reservoirs. Five species of unionids were found in Cooper Reservoir with the most common species being mapleleaf *Quadrula quadrula*. Four unionid species were found in Wright Patman Reservoir, two species in Houston County Reservoir, and three (two live) in Striker Reservoir. Severe drawdowns in 2005-2006 probably depauperated unionid populations in the reservoirs.
4. Fourteen live unionid species (18 species total including species found dead) were collected at two sites in the Angelina River (Neches River Basin). Average densities were up to 24 ± 15 mussels m^{-2} . The most common species were bankclimbers ($15.2 \pm 11.5 m^{-2}$) and western pimplebacks ($4.8 \pm 4 m^{-2}$). Several species of concern and rare species (Louisiana and triangle pigtoes, sandbank and rock-pocketbook, and western pimpleback) are still present in the Angelina River. Current unionid diversity in the Angelina River is lower than was recorded 70 years ago (25 common or fairly common species according to Parks and Bachtel, 1940), but was much higher than had been reported in the last two decades.
5. Sixteen unionid species (14 alive) were collected in the Neches River; average density was 19.4 ± 10.7 mussel m^{-2} . The most common were wartybacks and yellow sandshells. Several rare species (Louisiana pigtoe, washboard, Gulf mapleleaf) were found at this site.
6. B.A. Steinhagen Reservoir (Neches River Basin) was surveyed at a historically low water level. Over 700 dead unionids belonging to 18 species were collected, including three species of concern (Texas and triangle pigtoes and Texas heelsplitter) and several rare species (fawnsfoot, western pimpleback, Gulf mapleleaf, and rock-pocketbook). We conducted a detailed study of the distribution of mussels across the reservoir and selected several sites for future monitoring. The series of recent drawdowns harmed this unionid community, which previously was the most abundant and diverse unionid assemblage of any Texas reservoir. Monitoring and rigorous protection is essential to preserve this valuable unionid assemblage in the future.
7. Eleven species (nine of them alive) were collected in the upper Sabine River, including several species of concern (sandbank pocketbook, Texas heelsplitter, and Texas pigtoe). Results of our surveys confirm that the upper Sabine River still maintains a diverse and abundant unionid population. In contrast, only two live yellow sandshells (along with shells

of eight other species) were found in the lower Sabine River downstream of Toledo Bend Reservoir. Only a few dead unionid shells were found in the lower Sabine River tributaries.

8. High water and strong currents in 2007 prevented the detailed sampling that we had planned for Attoyac Bayou and Village Creek (Neches River Basin). This effort was suspended as conditions were deemed unsafe and very few mussels were collected. Continuing monitoring of the abundant and diverse assemblages in the Village Creek mussel sanctuary is very important given the recent drought in 2006 and flooding in 2007.
9. Our survey of Toledo Bend Reservoir and its tributaries revealed only a few dead specimens of five species and was generally ineffective due to the recent 2006 dewatering and subsequent high water level in late 2006-2007. After such a significant drawdown, unionid populations will need at least several years to re-establish.
10. We suggest several sites (Angelina River at SR 7 and US 59; Neches River at SR 7; Sabine River at US 59; Sulphur River at NW 39; and Cooper Reservoir at Doctors Creek Park) with abundant and diverse unionid assemblages for future monitoring (given the recent drought in 2006 and flooding in 2007), and for conservation.

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APPENDIX I.

COMMON AND SCIENTIFIC NAMES

Common and scientific names used in this report include:

Family: Unionidae

Threeridge *Amblema plicata*
Flat floater *Anodonta suborbiculata*
Rock-pocketbook *Arcidens confragosus*
Texas pigtoe *Fusconaia askewi*
Wabash pigtoe *Fusconaia flava*
Triangle pigtoe *Fusconaia lananensis*
Louisiana fatmucket *Lampsilis hydiana*
Sandbank pocketbook *Lampsilis satura*
Yellow sandshell *Lampsilis teres*
Fragile papershell *Leptodea fragilis*
Pond mussel *Ligumia subrostrata*
Washboard *Megalonaias nervosa*
Threehorn wartyback *Obliquaria reflexa*
Bankclimber *Plectomerus dombeyanus*
Louisiana pigtoe *Pleurobema riddellii*
Texas heelsplitter *Potamilus amphichaenus*
Pink papershell *Potamilus ohioensis*
Bleufer *Potamilus purpuratus*
Giant floater *Pyganodon grandis*
Southern mapleleaf *Quadrula apiculata*
Western pimpleback *Quadrula mortoni*
Gulf mapleleaf *Quadrula nobilis*
Wartyback *Quadrula nodulata*
Texas pimpleback *Quadrula petrina*
Pimpleback *Quadrula pustulosa*
Mapleleaf or common mapleleaf *Quadrula quadrula*
Pistolgrip *Quadrula verrucosa* (Serb et al., 2003) – previously placed in *Tritogonia*
Lilliput *Toxolasma parvus*
Texas lilliput *Toxolasma texasiensis*
Fawnsfoot *Truncilla donaciformis*
Texas fawnsfoot *Truncilla macrodon*
Deertoe *Truncilla truncata*
Tapered pondhorn *Unio merus declivis*
Pondhorn *Unio merus tetralasmus*
Paper pondshell *Utterbackia imbecillis*
Little spectaclecase *Villosa lienosa*

Family: Corbiculidae

Asian clam *Corbicula fluminea*

SHELL CONDITION TERMINOLOGY

It is difficult to determine exactly how long a freshwater mussel shell has been dead. Different conditions such as water chemistry, substrate, pH, erosive or corrosive environments, and exposure to sun can affect specimen condition and rate of disintegration. Nonetheless, some qualitative estimate of time-since-death can be useful. The following terms were used (Howells, 1996a, 1996b):

Very-recently dead: Soft tissue remains attached to the shell; shell in good condition, essentially as it would be in a living specimen; internal and external colors are not faded.

Recently dead: No soft tissue remains, but shell otherwise in good condition (looks like a live specimen); internal nacre is glossy without evidence of algal staining, calcium deposition, or external erosive effects; internal and external colors are not faded.

Relatively-recently dead: Shell in good condition, but internal nacre is losing its gloss; some algal staining, calcium deposition, or external erosion evident on the nacre; internal and external colors somewhat faded.

Long dead: Shell shows signs of internal and external erosion, staining, calcium deposition, or some combination of these; most or all of the internal coloration and gloss has faded (especially in species with colored nacre); shell epidermis with major sections absent or aged and flaking.

Very-long dead: Shell shows significant signs of erosion, staining, and calcium deposition; coloration often faded white or nearly so; relatively little intact epidermis; for specimens in erosive environments, internal features (e.g., pseudocardinal teeth) and external features (e.g., pustules) often weathered and smoothed, or otherwise exfoliated; shells often chalky, brittle, and crumbling.

Subfossil: Shells with little or no epidermis; nacre faded white and entire shell often white; sometimes with signs of erosion, staining, or calcium deposition; typically chalky; shells often brittle and crumbling.