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Final Report

Freshwater mussel survey (Family: Unionidae) of the lower Sabine River between U.S. Hwy 190 and Orange, Texas.

Submitted by:

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March 2014

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Texas Parks and Wildlife Department Contract No. 424770

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Executive Summary

The overall goal of this project was to determine the current status and distribution of freshwater mussels in the lower Sabine River from U.S. Hwy 190 to Orange, Texas and to begin characterizing mussel mesohabitat associations. In total, we surveyed 82 sites and collected 6,396 live individuals of 22 species. Mussel abundance and species richness increased with distance from U.S. Hwy 190, peaking just upstream from State Hwy 12. Downstream from State Hwy 12 mussel abundance and diversity declined such that mussels were almost entirely absent. We also observed two species considered state-threatened: *Fusconaia askewi* (Texas pigtoe) and *Lampsilis satura* (sandbank pocketbook); each represented less than 5% of all live individuals collected. Mussel assemblage structure varied based on linear distance from U.S. Hwy 190. Mussel abundance and richness differed significantly among mesohabitat types; bank, backwater and woody debris were the most productive mesohabitat types. Assemblage structure also varied among these habitat types; lotic species were dominant in bank habitats, whereas lentic species were dominant in backwater and woody debris habitats.

Introduction

Freshwater mussels (Bivalvia: Unionidae) play an important role in freshwater ecosystems, as they contribute to nutrient cycling, increase the heterogeneity of the habitat and represent a food source for certain fish, mammals and birds (Haag and Williams 2013). North America contains the highest diversity of unionid mussels, with approximately 300 recognized species (Williams et al. 1993). Many of these species are in decline or have become extinct due to habitat loss or the elimination of host fish (Neck 1982, Williams et al. 1993, Haag and Williams 2013). In Texas 52 species of freshwater mussel have been impacted, with many streams and rivers unable to support historic populations (Howells et al. 1996). Such statistics have prompted private, state and federal agencies to monitor and implement programs to conserve the remaining mussel populations. As a result of these efforts, 15 mussel species have been listed as state-threatened. Of those species, 11 are being considered for protection under the Endangered Species Act (ESA) (Texas Parks and Wildlife Department [TPWD] 2009).

Despite these recent listings, the conservation status of mussels in many streams and rivers is unknown or is only now becoming apparent. This is the case for the lower Sabine River, where there have been no formal studies of the distribution of unionids. The few reports that do exist are based on opportunistic sampling from a small number of locations (Strecker 1931; Vidrine 1993; Howells 2005; Karatayev and Burlakova 2007, 2008) or have been restricted to stream segments immediately downstream from Toledo Bend Reservoir (Randklev et al. 2009, 2011). The results of these surveys indicate that mussels do occur in the lower Sabine River and that stream segments located considerable distances downstream from Toledo Bend Reservoir appear to contain a diverse and abundant mussel fauna. Despite these observations, the status and distribution of mussels for much of the lower Sabine is still largely unknown, particularly for stream segments between U.S. Hwy 190 and Orange, Texas. In addition to a lack of survey information for most of the lower Sabine, mussel-habitat associations for this river are unknown. Preliminary habitat assessments have been performed (Karatayev and Burlakova 2008; Randklev et al. 2011), but results from those studies have been largely inconclusive.

The objective of this study was to establish baseline data for the distribution and abundance of unionids from U.S. Hwy 190 to Orange, TX and to begin characterizing mussel mesohabitat associations. The information gathered from both tasks may be useful for developing instream flow recommendations relevant to freshwater mussels in the lower Sabine and to inform future habitat restoration projects.

Study Area

The Sabine River begins near Greenville, Texas, east of Dallas, and flows southeast to Sabine Lake and through Sabine Pass into the Gulf of Mexico. The lower Sabine is located in the East Central Texas and Gulf Coastal Plain ecoregions and has a humid subtropical climate. The annual rainfall within the basin is among the highest in the state, often exceeding 1,000 mm per year (Huser 2000). The land use types along the lower Sabine consist primarily of commercial pine plantations and grazing land, with few points of access (Phillips 2008). The Sabine River is impounded by three major dams, two on the river (Lake Tawakoni and Toledo Bend Reservoir) and one on Lake Fork Creek, a major tributary (Huser 2000). Toledo Bend Reservoir, completed in 1969, is the largest and lowermost impoundment, covering a surface area of 185,000 acres and with a storage capacity of 4,477,000 acre-feet (Sabine River Authority of Texas 2010). The purpose of Toledo Bend Reservoir is hydropower generation, along with water supply and recreation, but it is not designed or operated for flood control (Phillips 2008). Discharge in the lower Sabine is influenced by discharge from Toledo Bend Reservoir and, to a lesser extent, from local tributaries. Discharge maxima often correspond to reservoir releases, which can lead to fluctuations in water depth ranging from 1.0 to 3.0 m (Patrick 2003).

Site Selection

Survey sites on the Sabine River were selected using a stratified random sampling design. Initially, the entire length of the Sabine River, from U.S. Highway 190 to Orange, Texas, was divided into 10 km reaches; seven mesohabitats were then randomly selected per reach (Table 1; Figures 1-3). The following mesohabitats were surveyed: 1) banks (BH), 2) front-of-point bars (FPB), 3) behind-point bars (BPB), 4) pools (P), 5) backwaters (BW), 6) mid-channels (MC) and 7) woody debris (WD) (Figure 4). Bank habitats were defined by locating the point in the channel where the slope of the bank leveled out, indicating the beginning of midchannel habitat. Front-of-point bars and behind-point bars were located on the up- or downstream portion, respectively, of sand and gravel bars. Pool habitats were generally characterized by minimal current velocities and relatively deep water; eddies and corner pools were the principal types of pools sampled during this study. Backwater habitats were areas with minimal velocities and variable water depths and were often located near obstructions or in secondary channels. Midchannel habitats were located in the middle of the river channel. Woody debris habitat was defined by locating areas along the river banks where logs or trees with a diameter greater than 10 cm and a length greater than 1 m were the dominant cover type.

Methods

<u>Mussel Surveys</u>

Qualitative surveys using the timed-search method were performed at each site. We confined the search boundaries to the specific habitat type, ensuring that the search area was 50 m in length and did not exceed 15 m in width. Each site was surveyed tactilely and visually for a minimum of 1 person-hour (p-h). Additional 1 p-h searches were added until no new species were recorded. Effort was made to examine all available hydraulic habitats present at each site, i.e. all available depths and current velocities found within each search area. The resulting data were then used to calculate species richness, catch-per-unit-effort (CPUE) and total mussel abundance per site and mesohabitat type.

Results

A total of 6,396 live individuals of 22 species were collected from the study area. Live mussels were observed at 60 of the 82 sites (Table 2). The number of observed species ranged from 0 to 17 per site ($\bar{x} \pm$ SE; 4.59 ± 0.53) and was generally higher in stream segments located upstream of State Hwy 12 in Reach 7 (Figure 5; Table 1). *Lampsilis teres* (yellow sandshell) was the most ubiquitous species, occurring at 53 (65%) of the 82 sites (Figure 6). *Quadrula mortoni* (western pimpleback), *Lampsilis hydiana* (Louisiana fatmucket), *Villosa lienosa* (little spectaclecase) and *Plectomerus dombeyanus* (bankclimber) were other commonly occurring species occupying between 30% and 40% of the sites (Figure 6). Two species considered state-threatened were found in the study area. *F. askewi* (Texas pigtoe) and *L. satura* (sandbank pocketbook) are endemic to the Sabine, Neches-Angelina and Trinity Rivers. In the Sabine River, *F. askewi* is more common upstream from Toledo Bend Reservoir, whereas *L. satura* appears to be more abundant and widely distributed in the lower Sabine River. In this study, *F. askewi* and *L. satura* occurred at 12 and 14 sites, respectively, or less than 20% of the sites surveyed (Figure 6).

Overall, CPUE ranged from 0.00 to 264.20 mussels/p-h (21.68 ± 4.922) and showed a pattern similar to species richness, peaking in stream segments upstream of State Hwy 12 (Figure 5). Total abundance ranged from 0 to 1,321 live individuals (77.58 ± 19.85) per site (Table 2), 16 sites yielded more than 100 individuals, and 4 of those 16 sites yielded more than 400 live mussels. *L. teres* (23% of all live individuals; n = 1,482), *P. dombeyanus* (14% of all live individuals; n =901), *Q. mortoni* (12% of all live individuals; n = 777) and *Quadrula apiculata* (10% of all live individuals; n = 647) were the most abundant species; no other species comprised more than 10% of the live individuals collected (Figure 6). *F. askewi* (n = 73) and *L. satura* (n = 36) represented 5% of all live individuals collected (Figure 6).

<u>Mussel Community Structure</u>

Patterns in mussel assemblage structure among the 11 study reaches were analyzed with nonmetric multidimensional scaling (NMS); abundance data were converted to proportional abundances by species by study reach, and distance was measured using the Morisita-Horn Index. NMS is a distance-based procedure that ordinates study units based on rank dissimilarities. Stream reaches that show proximity in the ordination plots are assumed to have similar species composition and relative proportions of each species, whereas sites that are spaced farther apart have dissimilar species composition and relative proportions of each species. NMS biplots were used to show community dissimilarity in ordination space (McCune and Grace, 2002). The degree to which the biplot accurately represents actual dissimilarities is measured by comparing the rank order of ordination distances and dissimilarities, and the resulting value is termed stress (*S*). Typically, stress values < 0.2 indicate a good measure of fit between ordination distances and observed dissimilarities (Quinn and Keough, 2002). NMS was performed using the VEGAN package in R version 3.02 (R Foundation for Statistical Computing, Vienna, Austria).

NMS ordination separated reaches based on linear distance from U.S. Hwy 190 (stress = 0.06; Figure 7). Reaches 1 – 6 were located along axis 1 near the right-hand side of the biplot, whereas Reaches 9 and 11 occurred along the left-hand side of the same axis. Reaches 7, 8, and 10 were intermediate along axis 1. The ordination of sites based on distance from U.S. Hwy 190 reflected differences in the distributional pattern of mussel species in this portion of the Sabine. For example, *L. hydiana*, *Q. mortoni* and *V. lienosa* were proportionately more abundant in Reaches 1 – 6, whereas *Q. apiculata* and *Glebula rotundata* were the dominant species for Reaches 9 and 11. For reaches between these two groups, *P. dombeyanus*, *Potamilus purpuratus* and *Quadrula nobilis* were proportionally the most abundant (Table 3). Other species, such as *L. teres*, were also abundant but tended to be more cosmopolitan, occurring across all reaches. For the two state-threatened species, *F. askewi* was proportionately more abundant in Reaches 7 and 8, whereas *L. satura* was more abundant only in Reach 7 (Table 3).

<u>Mesohabitat</u>

Mesohabitat usage by mussels was examined across all habitat types using an ANOVA to test differences in mussel abundance (CPUE) and species richness. Tukey's HSD multiple range test was used to perform multiple comparison tests among means. Mussel species richness and abundance were transformed using Box-Cox transformations to satisfy the assumptions of normality and homogeneity of variance. Sites in Reaches 10 and 11 were not included in this analysis because abundance in those reaches appears to be constrained by factors such as tidal inflows (see Phillips 2008), which are unrelated to mesohabitat availability. All analyses were conducted using R software (version 3.02; R Foundation for Statistical Computing, Vienna, Austria), and we considered p-values ≤ 0.10 to be significant.

Patterns in mussel assemblage structure among the 11 study reaches were explored with NMS; abundance data were converted to proportional abundances by species by study reach, and distance was measured using the Morisita-Horn Index. A permutation multivariate ANOVA (PERMANOVA) was used to test for differences in mussel assemblage structure across all habitat types. A permutation analysis of multivariate dispersion (PERMDISP) was used to evaluate whether significant differences in assemblage structure identified by PERMANOVA were a function of actual differences in dissimilarity among habitat types or simply differences in variability within each habitat type. The NMS, PERMANOVA and PERMDISP were performed with the VEGAN package in R version 3.02 (R Foundation for Statistical Computing, Vienna, Austria).

Mesohabitat suitability criteria were examined for all mussels using the Strauss Linear Food Selection Index (Strauss 1979). It is important to note that mussels do not actively seek optimal habitat patches because their dispersal is contingent on the movement of their host fish and flow patterns following transformation (i.e., dropping off their host fish) (Dariao et al 2010; Schwalb et al. 2011). Thus, mussels persist in habitats that range from suitable to optimal, with the latter being areas where significant populations should occur. The values of this index are based on the difference in the proportion of species use for a particular habitat category vs. the proportion of availability for that category. The sampling variance of the linear index allows a statistical comparison between the calculated value and the null-hypothesis value of zero (Strauss, 1979). P-values less than or equal to 0.10 were considered significant. Suitability values were assigned to each index value using significance tests as follows: 1 = significant positive values, 0.5 = non-significant positive values, 0.2 = non-significant values and 0 = significant negative values (Persinger et al. 2011).

In addition to suitability criteria, we used Indicator Species Analysis (Dufrêne Legendre 1997) to test the affinities of different mussel species to different habitat types. Indicator species analysis assigns an indicator value (IV) to each taxon by calculating the product of the relative frequency (percent occurrence of a taxon among sample units in each group) and relative average abundance (percent of the total abundance of a taxon within each group) of each species to a group. The probability of achieving an equal or larger IV value among groups (p) was estimated based on 999 random permutations of the original data (Dufrêne Legendre 1997). Indicator species analysis was performed with the INDICSPECIES package in R version 3.02 (R Foundation for Statistical Computing, Vienna, Austria), and we considered p-values ≤ 0.10 to be significant.

Mean overall mussel abundance differed significantly among mesohabitat types (F = 13.16, df = 6,58, $p < 0.001$). Mean CPUE across mesohabitat types ranged from 0.28 to 64.02 mussels/p-h and was significantly higher in bank ($\bar{x} \pm$ SE; 47.36 ± 22.78), backwater (64.02 ± 23.59) and woody debris (42.46 ± 12.62) habitats (Figure 8; Table 4); abundance in behind-point bar, front-of-point bar, and pool habitats ranged from 0.27 to 14.93 mussels/p-h (Table 5). For the two state-threatened species observed during this study, the mean CPUE for *F. askewi* was highest in bank habitats (1.15 ± 0.89), whereas *L. satura* was most abundant in front-of-point bar habitats

(0.54 ± 0.33) and, to a lesser extent, in bank (0.21 ± 0.11), behind-point bar (0.36 ± 0.25) and woody debris habitats (0.19 ± 0.10; Figure 9). Mean overall species richness also differed significantly (F = 16.54, df = 6,58, $p < 0.001$) and ranged from 0.44 to 10.22 across all habitat types (Table 5). Similar to CPUE, richness was significantly higher in bank (9.00 ± 1.68), backwater (10.22 ± 1.48) and woody debris habitats (9.00 ± 1.27;) (Figure 8; Table 4); mean species richness in behind-point bar, front-of-point bar, pool and midchannel habitats ranged from 0 to 2 (Table 4).

Suitability curves constructed for all species of each mesohabitat type indicate that mussels are primarily using bank, backwater and woody debris habitats (Figure 10). The suitability values for these habitats were greater than 0.5, indicating optimal habitat conditions. In contrast, the suitability values for behind-point bar, front-of-point bar and midchannel areas were 0, indicating that these habitat types are underutilized by mussels. For pool habitats, the suitability was 0.2, indicating that this habitat is usable but not optimal for mussels. The suitability curves for *F. askewi* show that this species prefers bank habitats (Figure 11). For *L. satura*, our results are less clear, as there were no habitats with suitability values greater than 0.5. Most likely, the reason for this result is that less than 40 individuals of this species were collected during this study. Nevertheless, our results indicate that *L. satura* utilizes bank, behind-point bar and front-of-point bar habitats over all other habitat types (Figure 11).

The assemblage structure obtained from the NMS was described by a two-dimensional solution (stress = 0.02), and 5 of the 7 habitat types were characterized as having distinctive assemblages. The results of a PERMANOVA support this finding, as the mussel assemblages differed among the habitat types (PERMANOVA: F = 1.78, df = 6,47, $p < 0.001$; Figure 12; Table 6) but without accompanying differences in dispersion (i.e., the between group variation was greater than the within group variation) (PERMDISP: F = 0.40, df = 6,47, p = 0.89), indicating group differences in location in ordination space (Figure 12; Table 6). An indicator species analysis revealed affinities of several mussel species for certain habitat types that were higher than expected by chance. Among the 22 species examined, we identified 10 indicator species for three of the seven habitat types. For example, *F. askewi*, *Q. mortoni*, and *Quadrula verrucosa* had significantly high IVs for bank habitats. *Pyganodon grandis*, *Q. apiculata*, *G. rotundata*, *L. hydiana* and *Toxolasma texasense* were significant indicators of backwater habitats, and *L. teres* and *V. lienosa* had high affinities for woody debris habitats (Table 7). No species showed significant IVs for front-of-point bar, behind-point bar, midchannel or pool habitats. For several of these habitat types, however several species had IVs that were nearly significant (Table 7).

Discussion

The lower Sabine River between U.S. Hwy 190 and State Hwy 12 contains a diverse and abundant mussel fauna that includes two species listed as state threatened by Texas Parks and Wildlife. Mussel abundance and species richness increased with distance from U.S. Hwy 190, peaking in Reach 7, located just upstream from State Hwy 12. Downstream from State Hwy 12, mussel abundance and diversity declined such that mussels were almost entirely absent from habitat types that were extremely productive between U.S. Hwy 190 and State Hwy 12. The mussel fauna between U.S. Hwy 190 and State Hwy 12 is dominated by *L. teres*, *P. dombeyanus*, *Q. apiculata* and *Q. mortoni*, a result comparable to the observations made by Randklev et al. (2011) upstream from U.S. Hwy 190. In that study, however, abundance and richness were much lower, such that only 309 live mussels, representing 16 species, were documented; in this study, we found 6,396 live mussels, representing 22 species.

Species that were not previously recorded by Randklev et al. (2011) but were observed during this study are: *Arcidens confragosus*, *Megalonaias nervosa*, *Obliquaria reflexa*, *P. dombeyanus*, *Toxolasma parvum*, *T. texasense* and *Uniomerus declivis*. Except for the latter 3 species, these mussels are ornate with respect to shell sculpturing and typically occur in areas where the substrate is not frequently mobilized (Hornbach et al. 2010). We did not find shell material or live individuals for *A. suborbiculata*, which was documented by Randklev et al. (2011) upstream from U.S. Hwy 190. This species is characteristic of lentic habitats (Howells et al. 1996) and, in the lower Sabine, has only been found in pools located off the main river channel (Randklev et al. 2011). We did survey lentic habitats (e.g., backwaters and pools), but they were either part of or directly connected to the main channel at the time of sampling. Therefore, this species may occur in our study area but only in off-channel pools and backwater areas in the floodplain. We also did not find several species (*Pleurobema riddellii* [Louisiana pigtoe], *Potamilus amphichaenus* [Texas heelsplitter], *Truncilla truncata* [deertoe], *Truncilla donaciformis* [fawnsfoot]) known to occur in the upper Sabine, above Toledo Bend Reservoir.

We found that mesohabitat type influenced the distribution of mussels. Species richness and abundance were markedly higher in bank, backwater and woody debris habitats, whereas mussel populations were less dense and diverse in behind- and front-of point bar, midchannel and, to a lesser extent, pool habitats. Although we did not measure the physical habitat within these mesohabitats, the water velocity appeared to be much lower in bank, backwater and woody debris habitats than in front-of-point bar and midchannel habitats. The substrate composition also appeared to differ across habitat types, with bank and woody debris habitats often showing a mixture of compact sand and silt, whereas backwater habitats were usually composed of unconsolidated silt and clay. In contrast, front-of-point bar and midchannel habitats were largely composed of loose unconsolidated sand. Dominant substrate types in behind-point bar and pool habitats resembled those of the bank and woody debris habitats. However, they were more variable, ranging from sand and silt, with varying levels of compactness.

Assemblage structure also differed markedly across habitat types. Bank habitats were dominated primarily by lotic species, whereas community structure in woody debris and backwater habitats comprised of lentic species and habitat generalists. Similar differences in mussel assemblage structure among lentic and lotic habitat types have been observed in other large lowland rivers (Haag 2012), but these observations have been primarily descriptive and have rarely been explicitly tested. It is doubtful that mussels are choosing these habitat types per se. Rather, it is probable that they are responding to attributes of these habitat types that positively influence survivorship and reproduction. During high flows, bank and backwater habitats are often associated with low current velocities and near-bed shear stress and, as a result, the stream bottom remains stable. Under the same discharge, front-of-point bars and mid-channel habitats tend to experience higher velocities and shear stresses, which often result in bed mobility. Mussels have limited mobility and often do not reach maturity until 2–4 years of age, therefore they require a stable environment (Haag 2012). As a result, mussel aggregations often only occur in areas where substrates remain relatively stable during periods of high flow (Di Maio and Corkum 1995; Morales et al. 2006). Future mussel studies in the basin, particularly those focused on determining instream flow needs for mussels, should examine if and to what extent physical changes occur under different flow regimes.

Host fish availability and infection strategies may also explain the mesohabitat preferences of mussels observed in this study. Freshwater mussels rely on certain fish species for part of their reproductive cycle, and the absence of such fish during critical periods of this cycle could result in the absence of mussels even if all other habitat characteristics were ideal (Haag and Warren, 1998). It is well known that fish are able to move to safety during periods of high river discharge to areas that provide protection from scouring flows. Fishes encysted with mussel larvae (i.e., glochidia) during that time could conceivably seed those locations with mussels. If a particular refugium was visited by a large number of fishes bearing glochidia, that population of mussels would be more likely to become established. These questions were outside the scope of this project; however, future studies, particularly those evaluating habitat availability for mussels, should consider examining utilization of these habitat types by fish during periods of high and low flow.

Combining data from Randklev et al. (2011; see Figure 5) with the results of the present study, diversity and abundance in the lower Sabine River are negatively affected by hydropower generation. Impoundments are detrimental to mussels because they alter flow, temperature and sediment regimes, fragment and eliminate habitat and disrupt patterns of energy flow (Vaughn and Taylor 1999). To date, *L. teres*, *P. grandis* and *Utterbackia imbecillis* have been the only mussel species observed immediately downstream from Toledo Bend Reservoir. These species employ an opportunistic life history strategy that involves short life spans, rapid growth rates, early maturity and high fecundity. These adaptations are ideal for rapid colonization and persistence in disturbed environments (Haag 2012). For stream segments immediately downstream from Toledo Bend Reservoir, the river channel is incised, and discharge is highly pulsed and can be hypolimnetic. As a result, daily fluctuations in river discharge, water depth and temperature can be extreme (Phillips 2008). Between State Hwy 63 and U.S. Hwy 190, mussel community composition changes such that quadrulid species become the most abundant. Species such as *Q. mortoni*, *Q. verrucosa* and *Q. nobilis* are thought to employ either a periodic or equilibrium life history strategy, both of which are characterized, in comparison with the opportunistic strategy, by moderate to low growth rates, fecundity, and relatively long life spans; the periodic strategy is intermediate between the opportunistic and equilibrium strategies, with the former analogous to r- and the latter to K-selection (Haag 2012). Discharge in this portion of the lower Sabine River is still significantly influenced by impoundment releases, although they are relatively more moderate than those immediately downstream from Toledo Bend Dam (Phillips 2008), and the channel form becomes less incised (Phillips 2008). From U.S. Hwy 190 to State Hwy 12, community composition changes again such that the dominant species are those that employ an equilibrium strategy; opportunistic and periodic species are present but do not dominate the assemblage structure. The signature of dam releases is still present in this portion of the Sabine, but sinuosity increases, as does connectivity to the floodplain (i.e., overbank flow), both of which may lessen the impact of those releases (Phillips 2008). Downstream from State Hwy 12, opportunist species once again become dominant, but it is probable that tidal inflows, not dam releases, are responsible for changes in assemblage structure in this reach.

Table 1. Locality information for mussel survey sites on the Sabine River.

Map Number	Reach	River km	Site Number	Datum	Zone	Coordinates x	Coordinates Y	Date of collection	Live mussels
1	1	92.32	45	UTM (NAD83)	15R	441158	3401450	5/9/13	Y
1	1	92.32	11	UTM (NAD83)	15R	441158	3401450	5/9/13	Y
2	1	93.08	56	UTM (NAD83)	15R	440712	3400967	5/9/13	N
3	1	94.58	10	UTM (NAD83)	15R	441772	3399932	5/9/13	Y
4	1	96.99	67	UTM (NAD83)	15R	440904	3398600	5/8/13	N
5	1	97.51	79	UTM (NAD83)	15R	441059	3398118	5/8/13	Y
6	1	99.16	23	UTM (NAD83)	15R	440397	3396667	5/9/13	Y
7	1	101.09	34	UTM (NAD83)	15R	440056	3395271	5/9/13	Y
8	2	102.14	44	UTM (NAD83)	15R	439695	3394385	5/8/13	Y
9	2	102.45	33	UTM (NAD83)	15R	439546	3394128	5/5/13	Y
10	2	105.76	55	UTM (NAD83)	15R	437274	3393310	5/8/13	Y
11	2	106.24	9	UTM (NAD83)	15R	437050	3392858	5/5/13	Y
12	2	107.90	66	UTM (NAD83)	15R	435914	3392037	5/8/13	N
13	2	109.26	78	UTM (NAD83)	15R	435362	3391044	5/8/13	Y
14	2	110.24	22	UTM (NAD83)	15R	434880	3390255	5/5/13	Y
15	3	112.83	32	UTM (NAD83)	15R	434367	3388396	5/8/13	Y
16	3	114.30	43	UTM (NAD83)	15R	434243	3387280	5/4/13	Y
17	3	115.26	54	UTM (NAD83)	15R	434173	3386471	5/7/13	Y
18	3	117.91	21	UTM (NAD83)	15R	434580	3384660	5/7/13	Y
19	3	119.46	65	UTM (NAD83)	15R	433799	3383849	5/7/13	N
20	3	121.79	8	UTM (NAD83)	15R	433027	3384585	5/7/13	Y
21	3	122.00	77	UTM (NAD83)	15R	432793	3384597	5/7/13	Y
22	4	123.05	64	UTM (NAD83)	15R	431955	3384270	5/6/13	N
23	4	123.92	42	UTM (NAD83)	15R	431612	3383714	5/3/13	Y
24	4	125.35	53	UTM (NAD83)	15R	430911	3383361	5/6/13	Y
25	4	125.88	7	UTM (NAD83)	15R	430511	3383022	5/3/13	Y
26	4	126.52	31	UTM (NAD83)	15R	430197	3382565	5/6/13	N
27	4	127.39	76	UTM (NAD83)	15R	430169	3381861	5/6/13	Y
28	4	131.37	20	UTM (NAD83)	15R	429414	3378949	5/4/13	Y
29	5	134.72	6	UTM (NAD83)	15R	430515	3377127	5/17/13	Y
30	5	137.41	52	UTM (NAD83)	15R	431900	3376500	5/18/13	Y
31	5	139.25	75	UTM (NAD83)	15R	432211	3375102	5/18/13	Y
32	5	140.37	30	UTM (NAD83)	15R	431437	3374505	5/18/13	Y
33	5	140.81	63	UTM (NAD83)	15R	431786	3374471	5/18/13	Y
34	5	142.75	19	UTM (NAD83)	15R	431336	3373493	5/18/13	Y
35	5	144.47	41	UTM (NAD83)	15R	431520	3372686	5/19/13	Y
36	6	144.96	51	UTM (NAD83)	15R	431120	3372580	5/20/13	Y
37	6	145.72	62	UTM (NAD83)	15R	431556	3372034	5/19/13	N
38	6	148.36	5	UTM (NAD83)	15R	432543	3370121	5/19/13	Y
39	6	149.15	40	UTM (NAD83)	15R	432649	3369729	5/19/13	Y
40	6	151.47	29	UTM (NAD83)	15R	432077	3368379	5/19/13	Y

Table 1. Continued

Map Number	Reach	River km	Site Number	Datum	Zone	Coordinates x	y	Date of collection	Live mussels
41	6	153.12	18	UTM (NAD83)	15R	432959	3367784	5/20/13	Y
42	6	154.53	74	UTM (NAD83)	15R	432601	3366763	5/19/13	Y
43	7	156.32	28	UTM (NAD83)	15R	431382	3366605	5/20/13	Y
44	7	157.61	39	UTM (NAD83)	15R	430937	3366064	5/20/13	Y
45	7	158.52	50	UTM (NAD83)	15R	430620	3366883	5/20/13	Y
46	7	162.14	73	UTM (NAD83)	15R	429568	3365048	5/21/13	Y
47	7	162.57	4	UTM (NAD83)	15R	429353	3364658	9/28/12	Y
48	7	163.60	17	UTM (NAD83)	15R	429050	3363727	5/21/13	Y
49	7	165.49	61	UTM (NAD83)	15R	427827	3362928	5/21/13	N
50	8	165.77	49	UTM (NAD83)	15R	427676	3362682	9/27/12	Y
51	8	167.06	3	UTM (NAD83)	15R	427118	3361841	9/26/12	Y
52	8	168.56	16	UTM (NAD83)	15R	427477	3360445	9/26/12	Y
53	8	171.38	60	UTM (NAD83)	15R	427526	3359258	9/26/12	Y
54	8	172.05	27	UTM (NAD83)	15R	427812	3358874	5/21/13	Y
55	8	173.19	38	UTM (NAD83)	15R	427194	3358483	9/26/12	Y
56	8	173.74	72	UTM (NAD83)	15R	427065	3358264	9/27/12	Y
57	9	177.39	2	UTM (NAD83)	15R	426582	3356764	9/25/12	Y
58	9	179.09	48	UTM (NAD83)	15R	426332	3355972	9/26/12	Y
59	9	180.56	15	UTM (NAD83)	15R	427346	3355756	9/25/12	Y
60	9	181.44	26	UTM (NAD83)	15R	427299	3355062	5/22/13	N
61	9	182.05	59	UTM (NAD83)	15R	427719	3354680	9/25/12	N
62	9	182.29	71	UTM (NAD83)	15R	427869	3354631	5/22/12	Y
63	9	183.03	37	UTM (NAD83)	15R	428002	3354232	9/25/12	N
64	9	183.85	1	UTM (NAD83)	15R	428202	3353773	9/25/12	Y
65	10	186.58	57	UTM (NAD83)	15R	428917	3352701	11/3/12	N
66	10	187.18	35	UTM (NAD83)	15R	429372	3352429	5/22/13	N
67	10	188.51	12	UTM (NAD83)	15R	429795	3352060	9/26/12	Y
68	10	190.44	24	UTM (NAD83)	15R	431020	3351664	9/26/12	Y
69	10	191.30	46	UTM (NAD83)	15R	431264	3351719	9/26/12	N
70	10	193.52	68	UTM (NAD83)	15R	432134	3351318	11/2/12	N
71	10	195.44	80	UTM (NAD83)	15R	432239	3350108	11/1/12	N
72	11	197.65	25	UTM (NAD83)	15R	431555	3348358	11/1/12	Y
73	11	198.25	36	UTM (NAD83)	15R	431150	3347955	5/22/13	N
74	11	199.09	58	UTM (NAD83)	15R	430953	3347372	11/1/12	N
75	11	199.86	81	UTM (NAD83)	15R	431001	3346717	10/31/12	Y
75	11	199.86	82	UTM (NAD83)	15R	431001	3346717	9/26/12	Y
76	11	201.21	47	UTM (NAD83)	15R	431095	3345712	10/31/12	N
77	11	203.63	13	UTM (NAD83)	15R	430859	3343888	10/31/12	N
78	11	205.71	69	UTM (NAD83)	15R	430736	3342366	10/31/12	N
79	11	208.17	14	UTM (NAD83)	15R	430944	3341276	11/2/12	Y
80	11	210.25	70	UTM (NAD83)	15R	431375	3340031	11/2/12	N

Table 2. Mussel data for sites qualitatively sampled on the Sabine River. Numbers in columns are the total number of live individuals collected during timed-searches. Habitat type acronyms denote the following: BH – deep bank habitat; BPB – immediately downstream of point bar; FPB – immediately upstream of point bar; BW – backwater; MC– mid-channel; P – pool; and WD – woody debris.

Map No.		1	1	2	3	4	5	6	7	8	9	10	11	12	13
		Site No./Habitat type													
Species	Common name	11 BH	45 BPB	56 P	10 BH	67 MC	79 BW	23 WD	34 FPB	44 BPB	33 FPB	55 P	9 BH	66 MC	78 BW
Subfamily Ambleminae															
Amblema plicata	Threeridge	-	-	-	-	-	4	-	-	-	-	-	-	-	1
Fusconaia askewi	Texas pigtoe	1	-	-	-	-	-	1	-	-	-	-	1	-	-
Megalonaias nervosa	Washboard	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plectomerus dombeyanus	Bankclimber	-	-	-	-	-	2	-	-	-	-	-	-	-	10
Quadrula apiculata	Southern mapleleaf	11	-	-	-	-	-	-	-	-	-	-	-	-	7
Quadrula mortoni	Western pimpleback	54	1	-	3	-	4	5	8	2	1	-	27	-	22
Quadrula nobilis	Gulf mapleleaf	5	-	-	-	-	1	1	1	-	-	-	-	-	6
Quadrula verrucosa	Pistolgrip	1	-	-	-	-	-	-	-	-	-	-	1	-	-
Uniomerus declivis	Tapered pondhorn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subfamily: Anodontinae															
Arcidens confragosus	Rock-pocketbook	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyganodon grandis	Giant floater	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Utterbackia imbecillis	Paper pondshell	-	-	-	-	-	3	-	-	-	-	-	-	-	-
Subfamily: Lampsilinae															
Glebula rotundata	Round pearlshell	-	-	-	-	-	1	-	-	-	-	-	-	-	2
Lampsilis hydiana	Louisiana fatmucket	25	-	-	2	-	17	5	2	-	1	1	6	-	59
Lampsilis satura	Sandbank pocketbook	-	-	-	-	-	-	-	1	-	-	-	1	-	-
Lampsilis teres	Yellow sandshell	20	1	-	-	-	8	2	1	-	-	-	3	-	80
Leptodea fragilis	Fragile papershell	3	-	-	-	-	-	-	-	-	-	-	-	-	1
Obliquaria reflexa	Threehorn wartyback	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potamilus purpuratus	Bleufer	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Toxolasma parvum	Lilliput	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Toxolasma texasense	Texas lilliput	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Villosa lienosa	Little spectaclecase	54	-	-	1	-	4	-	1	-	-	-	7	-	66
Total individuals		175	2	0	6	0	45	14	14	2	2	1	46	0	262
Time (p-h)		3	2	1	2	1	5	2	3	2	2	2	3	1	3
CPUE		58.33	1.00	0.00	3.00	0.00	9.00	7.00	4.67	1.00	1.00	0.50	15.33	0.00	87.33
Species richness		10	2	0	3	0	10	5	6	1	2	1	7	0	13
Length (m)		50	50	50	50	50	50	50	50	50	50	50	50	50	50
Width (m)		5	15	15	4	15	15	15	15	15	15	15	3.5	15	15

Table 2. Continued

Map No.		14	15	16	17	18	19	20	21	22	23	24	25	26	27
Species	Common name	Site No./Habitat type													
		22 WD	32 FPB	43 BPB	54 P	21 WD	65 MC	8 BH	77 BW	64 MC	42 BPB	53 P	7 BH	31 FPB	76 BW
Subfamily Ambleminae															
Amblema plicata	Threeridge	-	-	1	-	-	-	-	4	-	-	-	-	-	-
Fusconaia askewi	Texas pigtoe	2	-	-	-	-	-	-	1	-	-	-	-	-	-
Megalonaias nervosa	Washboard	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plectomerus dombeyanus	Bankclimber	3	-	-	-	-	-	-	19	-	-	-	2	-	10
Quadrula apiculata	Southern mapleleaf	16	-	-	-	-	-	-	14	-	-	-	-	-	276
Quadrula mortoni	Western pimpleback	204	2	1	-	3	-	48	42	-	-	5	14	-	1
Quadrula nobilis	Gulf mapleleaf	52	-	-	-	-	-	1	15	-	-	-	-	-	23
Quadrula verrucosa	Pistolgrip	9	-	-	-	-	-	-	2	-	-	-	1	-	1
Uniomerus declivis	Tapered pondhorn	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Subfamily: Anodontinae															
Arcidens confragosus	Rock-pocketbook	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Pyganodon grandis	Giant floater	-	-	1	-	-	-	-	7	-	-	-	-	-	8
Utterbackia imbecillis	Paper pondshell	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Subfamily: Lampsilinae															
Glebula rotundata	Round pearlshell	-	-	-	-	-	-	-	2	-	-	-	-	-	87
Lampsilis hydiana	Louisiana fatmucket	21	-	3	2	1	-	4	103	-	-	-	4	-	26
Lampsilis satura	Sandbank pocketbook	3	-	-	-	-	-	-	-	-	-	-	1	-	-
Lampsilis teres	Yellow sandshell	26	1	10	7	5	-	4	82	-	1	2	6	-	22
Leptodea fragilis	Fragile papershell	3	-	-	-	-	-	-	3	-	-	-	-	-	-
Obliquaria reflexa	Threehorn wartyback	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Potamilus purpuratus	Bleufer	-	-	-	-	-	-	-	5	-	-	-	-	-	-
Toxolasma parvum	Lilliput	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Toxolasma texasense	Texas lilliput	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Villosa lienosa	Little spectaclecase	34	-	7	5	9	-	7	108	-	-	-	7	-	1
Total individuals		373	3	23	14	18	0	64	409	0	1	8	35	0	461
Time (p-h)		4	2	4	3	3	1	3	4	1	2	2	3	1	2
CPUE		93.25	1.50	5.75	4.67	6.00	0.00	21.33	102.3	0.00	0.50	4.00	11.67	0.00	230.5
Species richness		11	2	6	3	4	0	5	16	0	1	3	7	0	12
Length (m)		50	50	50	50	50	50	50	50	50	50	50	50	50	50
Width (m)		8	15	10	15	5	15	4	15	15	8	15	4.5	15	15

Table 2. Continued

Map No.		28	29	30	31	32	33	34	35	36	37	38	39	40	41
Species	Common name	Site No./Habitat type													
		20	6	52	75	30	63	19	41	51	62	5	40	29	18
		WD	BH	P	BW	FPB	MC	WD	BPB	P	MC	BH	BPB	FPB	WD
Subfamily Ambleminae															
Amblema plicata	Threeridge	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fusconaia askewi	Texas pigtoe	3	2	-	-	-	-	-	-	-	-	-	-	-	2
Megalonaias nervosa	Washboard	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plectomerus dombeyanus	Bankclimber	20	5	-	1	-	-	1	-	-	-	-	-	-	16
Quadrula apiculata	Southern mapleleaf	14	4	-	2	-	-	-	-	-	-	-	-	-	-
Quadrula mortoni	Western pimpleback	25	104	-	-	-	-	-	-	2	-	1	-	-	7
Quadrula nobilis	Gulf mapleleaf	31	7	-	-	-	-	-	-	-	-	-	-	-	1
Quadrula verrucosa	Pistolgrip	6	1	-	-	-	-	1	-	-	-	-	-	-	-
Uniomerus declivis	Tapered pondhorn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subfamily: Anodontinae															
Arcidens confragosus	Rock-pocketbook	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyganodon grandis	Giant floater	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Utterbackia imbecillis	Paper pondshell	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subfamily: Lampsilinae															
Glebula rotundata	Round pearlshell	-	1	-	4	-	-	-	-	-	-	-	-	-	-
Lampsilis hydiana	Louisiana fatmucket	27	21	-	10	-	-	-	-	3	-	-	-	-	4
Lampsilis satura	Sandbank pocketbook	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lampsilis teres	Yellow sandshell	78	53	4	30	20	1	39	3	11	-	5	8	8	62
Leptodea fragilis	Fragile papershell	-	3	-	-	-	-	4	1	-	-	-	-	1	1
Obliquaria reflexa	Threehorn wartyback	1	2	-	-	-	-	-	-	-	-	-	-	-	1
Potamilus purpuratus	Bleufer	2	-	-	1	-	-	-	-	-	-	-	-	-	-
Toxolasma parvum	Lilliput	1	-	-	-	-	-	-	-	-	-	-	-	-	3
Toxolasma texasense	Texas lilliput	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Villosa lienosa	Little spectaclecase	45	21	-	10	-	-	8	-	4	-	1	-	-	13
Total individuals		253	224	4	58	20	1	54	4	20	0	7	8	9	110
Time (p-h)		3	3	2	2	2	2	4	2	2	1	2	2	3	4
CPUE		84.33	74.67	2.00	29.00	10.00	0.50	13.50	2.00	10.00	0.00	3.50	4.00	3.00	27.50
Species richness		12	12	1	7	1	1	6	2	4	0	3	1	2	10
Length (m)		50	50	50	50	50	50	50	50	50	50	50	50	50	50
Width (m)		5	5	15	15	15	15	15	8	15	15	3	3	15	15

Table 2. Continued

Map No.		42	43	44	45	46	47	48	49	50	51	52	53	54	55
Species	Common name	Site No./Habitat type													
		74	28	39	50	73	4	17	61	49	3	16	60	27	38
		BW	FPB	BPB	P	BW	BH	WD	MC	P	BH	WD	MC	FPB	BPB
Subfamily Ambleminae															
Amblema plicata	Threeridge	-	-	-	3	4	16	-	-	-	2	9	-	-	-
Fusconaia askewi	Texas pigtoe	-	-	-	-	-	50	-	-	-	4	3	-	-	-
Megalonaias nervosa	Washboard	-	-	-	-	-	19	-	-	-	1	-	-	-	-
Plectomerus dombeyanus	Bankclimber	8	-	-	165	34	354	37	-	-	45	77	-	-	-
Quadrula apiculata	Southern mapleleaf	2	-	-	68	7	86	4	-	-	11	16	-	-	-
Quadrula mortoni	Western pimpleback	-	2	-	10	1	149	8	-	-	2	12	2	2	1
Quadrula nobilis	Gulf mapleleaf	-	-	-	15	-	256	2	-	-	12	26	1	-	-
Quadrula verrucosa	Pistolgrip	-	-	-	-	-	204	9	-	-	1	3	-	-	1
Uniomerus declivis	Tapered pondhorn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subfamily: Anodontinae															
Arcidens confragosus	Rock-pocketbook	-	-	-	3	-	10	1	-	-	-	2	-	1	-
Pyganodon grandis	Giant floater	4	-	-	5	1	-	-	-	-	-	-	-	-	-
Utterbackia imbecillis	Paper pondshell	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subfamily: Lampsilinae															
Glebula rotundata	Round pearlshell	5	-	-	82	-	3	1	-	-	2	18	-	-	-
Lampsilis hydiana	Louisiana fatmucket	2	-	-	13	15	21	27	-	2	4	36	-	-	1
Lampsilis satura	Sandbank pocketbook	-	5	4	1	-	6	-	-	-	1	1	-	4	5
Lampsilis teres	Yellow sandshell	62	52	23	121	70	93	115	-	24	52	93	1	13	5
Leptodea fragilis	Fragile papershell	-	2	3	6	1	1	3	-	1	1	1	-	9	1
Obliquaria reflexa	Threehorn wartyback	-	-	-	1	-	24	-	-	-	-	-	-	-	-
Potamilus purpuratus	Bleufer	-	-	-	1	1	4	5	-	1	1	2	-	-	-
Toxolasma parvum	Lilliput	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Toxolasma texasense	Texas lilliput	3	-	-	-	11	-	-	-	-	-	-	-	-	-
Villosa lienosa	Little spectaclecase	-	-	-	-	9	25	125	-	18	6	19	-	-	-
Total individuals		86	61	30	494	154	1321	337	0	47	145	318	4	29	14
Time (p-h)		3	2	2	5	5	5	5	1	5	5	4	2	2	4
CPUE		28.67	30.50	15.00	98.80	30.80	264.2	67.40	0.00	9.40	29.00	79.50	2.00	14.50	3.50
Species richness		7	4	3	14	11	17	12	0	6	15	15	3	5	6
Length (m)		50	50	50	50	50	50	50	50	50	50	50	50	50	50
Width (m)		15	15	5	15	15	15	15	15	15	15	15	15	15	13

Table 2. Continued

Map No.		56	57	58	59	60	61	62	63	64	65	66	67	68	69
Species	Common name	Site No./Habitat type													
		72	2	48	15	26	59	71	37	1	57	35	12	24	46
		BW	BH	P	WD	FPB	MC	BW	BPB	BH	P	FPB	BH	WD	BPB
Subfamily Ambleminae															
Amblema plicata	Threeridge	-	2	-	1	-	-	1	-	-	-	-	-	-	-
Fusconaia askewi	Texas pigtoe	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Megalonaias nervosa	Washboard	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plectomerus dombeyanus	Bankclimber	2	1	-	-	-	-	25	-	40	-	-	-	2	-
Quadrula apiculata	Southern mapleleaf	-	-	-	1	-	-	30	-	7	-	-	-	1	-
Quadrula mortoni	Western pimpleback	-	1	-	-	-	-	-	-	1	-	-	-	-	-
Quadrula nobilis	Gulf mapleleaf	1	-	-	2	-	-	1	-	5	-	-	-	-	-
Quadrula verrucosa	Pistolgrip	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Uniomerus declivis	Tapered pondhorn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subfamily: Anodontinae															
Arcidens confragosus	Rock-pocketbook	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyganodon grandis	Giant floater	3	-	-	-	-	-	5	-	1	-	-	-	-	-
Utterbackia imbecillis	Paper pondshell	-	-	-	-	-	-	15	-	-	-	-	-	-	-
Subfamily: Lampsilinae															
Glebula rotundata	Round pearlshell	4	-	7	-	-	-	47	-	6	-	-	-	-	-
Lampsilis hydiana	Louisiana fatmucket	-	-	-	1	-	-	2	-	2	-	-	-	-	-
Lampsilis satura	Sandbank pocketbook	-	-	-	2	-	-	-	-	1	-	-	-	-	-
Lampsilis teres	Yellow sandshell	-	5	8	4	-	-	42	-	91	-	-	1	1	-
Leptodea fragilis	Fragile papershell	1	2	-	-	-	-	-	-	4	-	-	-	-	-
Obliquaria reflexa	Threehorn wartyback	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potamilus purpuratus	Bleufer	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Toxolasma parvum	Lilliput	-	-	-	-	-	-	5	-	-	-	-	-	-	-
Toxolasma texasense	Texas lilliput	-	-	-	-	-	-	47	-	1	-	-	-	-	-
Villosa lienosa	Little spectaclecase	-	2	-	-	-	-	-	-	13	-	-	-	-	-
Total individuals		11	13	15	11	0	0	220	0	178	0	0	1	5	0
Time (p-h)		3	3	3	3	1	1	4	1	5	1	1	3	3	2
CPUE		3.67	4.33	5.00	3.67	0.00	0.00	55.00	0.00	35.60	0.00	0.00	0.33	1.67	0.00
Species richness		5	6	2	6	0	0	11	0	14	0	0	1	4	0
Length (m)		23	50	50	50	50	50	50	50	43	50	50	50	50	50
Width (m)		15	5	15	15	15	15	15	15	16	15	15	15	15	15

Table 2. Continued

Map No.		70	71	72	73	74	75	75	76	77	78	79	80
Species	Common name	Site No./Habitat type											
		68 MC	80 BW	25 WD	36 FPB	58 P	81 BW	82 BW	47 BPB	13 BH	69 MC	14 BH	70 MC
Subfamily Ambleminae													
Amblema plicata	Threeridge	-	-	1	-	-	-	-	-	-	-	-	-
Fusconaia askewi	Texas pigtoe	-	-	-	-	-	-	-	-	-	-	-	-
Megalonaias nervosa	Washboard	-	-	-	-	-	-	-	-	-	-	-	-
Plectomerus dombeyanus	Bankclimber	-	-	18	-	-	2	2	-	-	-	-	-
Quadrula apiculata	Southern mapleleaf	-	-	2	-	-	20	48	-	-	-	-	-
Quadrula mortoni	Western pimpleback	-	-	-	-	-	-	-	-	-	-	-	-
Quadrula nobilis	Gulf mapleleaf	-	-	-	-	-	-	-	-	-	-	-	-
Quadrula verrucosa	Pistolgrip	-	-	-	-	-	-	-	-	-	-	-	-
Uniomerus declivis	Tapered pondhorn	-	-	-	-	-	-	-	-	-	-	-	-
Subfamily: Anodontinae													
Arcidens confragosus	Rock-pocketbook	-	-	-	-	-	-	-	-	-	-	-	-
Pyganodon grandis	Giant floater	-	-	-	-	-	4	3	-	-	-	-	-
Utterbackia imbecillis	Paper pondshell	-	-	1	-	-	1	-	-	-	-	-	-
Subfamily: Lampsilinae													
Glebula rotundata	Round pearlshell	-	-	1	-	-	20	16	-	-	-	10	-
Lampsilis hydiana	Louisiana fatmucket	-	-	-	-	-	-	-	-	-	-	-	-
Lampsilis satura	Sandbank pocketbook	-	-	-	-	-	-	-	-	-	-	-	-
Lampsilis teres	Yellow sandshell	-	-	1	-	-	2	-	-	-	-	-	-
Leptodea fragilis	Fragile papershell	-	-	-	-	-	-	-	-	-	-	-	-
Obliquaria reflexa	Threehorn wartyback	-	-	-	-	-	-	-	-	-	-	-	-
Potamilus purpuratus	Bleufer	-	-	-	-	-	-	-	-	-	-	-	-
Toxolasma parvum	Lilliput	-	-	-	-	-	-	-	-	-	-	-	-
Toxolasma texasense	Texas lilliput	-	-	-	-	-	-	-	-	-	-	-	-
Villosa lienosa	Little spectaclecase	-	-	-	-	-	-	-	-	-	-	-	-
Total individuals		0	0	24	0	0	49	69	0	0	0	10	0
Time (p-h)		1	1	4	1	1	3	2	2	1	1	2	1
CPUE		0.00	0.00	6.00	0.00	0.00	16.33	34.50	0.00	0.00	0.00	5.00	0.00
Species richness		0	0	6	0	0	6	4	0	0	0	1	0
Length (m)		50	50	50	50	50	50	50	50	50	50	50	50
Width (m)		15	15	15	15	15	15	15	15	15	15	15	15

Table 3. Proportion of mussel community by river reach using abundance data from the timed searches.

Species	Common name	Proportion of mussel community Reach										
		1	2	3	4	5	6	7	8	9	10	11
Subfamily Ambleminae												
Amblema plicata	Threeridge	0.016	0.001	0.009	0.000	0.000	0.000	0.010	0.019	0.009	0.000	0.012
Fusconaia askewi	Texas pigtoe	0.008	0.004	0.002	0.004	0.005	0.008	0.021	0.012	0.007	0.000	0.000
Megalonaias nervosa	Washboard	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.002	0.000	0.000	0.000
Plectomerus dombeyanus	Bankclimber	0.008	0.019	0.036	0.042	0.019	0.100	0.246	0.218	0.151	0.333	0.241
Quadrula apiculata	Southern mapleleaf	0.043	0.034	0.026	0.383	0.016	0.008	0.069	0.048	0.087	0.167	0.265
Quadrula mortoni	Western pimpleback	0.293	0.373	0.181	0.059	0.285	0.042	0.071	0.033	0.005	0.000	0.000
Quadrula nobilis	Gulf mapleleaf	0.031	0.085	0.030	0.071	0.019	0.004	0.114	0.070	0.018	0.000	0.000
Quadrula verrucosa	Pistolgrip	0.004	0.015	0.004	0.011	0.005	0.000	0.089	0.009	0.007	0.000	0.000
Uniomerus declivis	Tapered pondhorn	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subfamily: Anodontinae												
Arcidens confragosus	Rock-pocketbook	0.000	0.000	0.000	0.005	0.000	0.000	0.006	0.005	0.000	0.000	0.000
Pyganodon grandis	Giant floater	0.000	0.007	0.015	0.011	0.003	0.017	0.003	0.005	0.014	0.000	0.048
Utterbackia imbecillis	Paper pondshell	0.012	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.034	0.000	0.024
Subfamily: Lampsilinae												
Glebula rotundata	Round pearlshell	0.004	0.003	0.004	0.115	0.014	0.021	0.036	0.042	0.137	0.000	0.373
Lampsilis hydiana	Louisiana fatmucket	0.199	0.128	0.213	0.075	0.085	0.038	0.032	0.076	0.011	0.000	0.000
Lampsilis satura	Sandbank pocketbook	0.004	0.006	0.000	0.001	0.000	0.000	0.007	0.019	0.007	0.000	0.000
Lampsilis teres	Yellow sandshell	0.125	0.159	0.205	0.144	0.411	0.650	0.198	0.331	0.343	0.333	0.036
Leptodea fragilis	Fragile papershell	0.012	0.006	0.006	0.000	0.022	0.008	0.007	0.025	0.014	0.000	0.000
Obliquaria reflexa	Threehorn wartyback	0.000	0.000	0.000	0.004	0.005	0.004	0.010	0.000	0.000	0.000	0.000
Potamilus purpuratus	Bleufer	0.000	0.003	0.009	0.003	0.003	0.000	0.005	0.007	0.000	0.167	0.000
Toxolasma parvum	Lilliput	0.004	0.001	0.002	0.001	0.000	0.013	0.000	0.002	0.011	0.000	0.000
Toxolasma texasense	Texas lilliput	0.004	0.000	0.000	0.000	0.000	0.013	0.005	0.000	0.110	0.000	0.000
Villosa lienosa	Little spectaclecase	0.234	0.156	0.256	0.070	0.107	0.075	0.066	0.076	0.034	0.000	0.000
Total number of mussels		256	686	531	758	365	240	2,397	568	437	6	83
Total		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 4. Pair-wise comparison of CPUE (top) and richness (bottom) across habitat types using Tukey's HSD test. Bold numbers indicate significant values ($\alpha = 0.10$).

Habitat type_CPUE	BPB	BW	FPB	MC	P	WD
Bank habitat (BH)	**0.03**	0.98	**0.04**	**0.00**	0.23	1.00
Behind point bar (BPB)	-	**0.00**	1.00	**0.03**	0.98	**0.02**
Backwater (BW)	-	-	**0.01**	**0.00**	**0.05**	1.00
Front of point bar (FPB)	-	-	-	**0.02**	0.99	**0.03**
Midchannel (MC)	-	-	-	-	**0.00**	**0.00**
Pool (P)	-	-	-	-	-	0.19

Habitat type_Richness	BPB	BW	FPB	MC	P	WD
Bank habitat (BH)	**0.01**	1.00	**0.00**	**0.00**	**0.06**	1.00
Behind point bar (BPB)	-	**0.01**	1.00	**0.01**	1.00	**0.01**
Backwater (BW)	-	-	**0.00**	**0.00**	**0.02**	1.00
Front of point bar (FPB)	-	-	-	**0.01**	0.96	**0.00**
Midchannel (MC)	-	-	-	-	**0.00**	**0.00**
Pool (P)	-	-	-	-	-	**0.06**

Table 5. Mean, standard deviation (SD), and standard error (SE) for CPUE and species richness by habitat type for the Sabine River.

Habitat	N	CPUE			Species Richness		
		Mean	SD	SE	Mean	SD	SE
BH	11	47.36	75.55	22.78	9.00	5.58	1.68
BPB	9	3.64	4.66	1.55	2.44	2.19	0.73
BW	9	64.02	70.76	23.59	10.22	4.46	1.49
FPB	9	7.24	10.02	3.34	2.44	2.14	0.71
MC	9	0.28	0.67	0.22	0.44	0.89	0.30
P	9	14.93	31.64	10.55	3.78	4.09	1.36
WD	9	42.46	37.88	12.63	9.00	3.82	1.27

Table 6. Proportion of mussel community by mesohabitat using abundance data from the timed searches.

Species	Common name	Proportion of mussel community Habitat type						
		BH	BPB	BW	FPB	MC	P	WD
Subfamily Ambleminae								
Amblema plicata	Threeridge	0.009	0.012	0.008	0.000	0.000	0.005	0.007
Fusconaia askewi	Texas pigtoe	0.028	0.000	0.001	0.000	0.000	0.000	0.007
Megalonaias nervosa	Washboard	0.009	0.000	0.000	0.000	0.000	0.000	0.000
Plectomerus dombeyanus	Bankclimber	0.202	0.000	0.065	0.000	0.000	0.274	0.103
Quadrula apiculata	Southern mapleleaf	0.054	0.000	0.198	0.000	0.000	0.113	0.034
Quadrula mortoni	Western pimpleback	0.182	0.060	0.041	0.109	0.400	0.028	0.177
Quadrula nobilis	Gulf mapleleaf	0.129	0.000	0.028	0.007	0.200	0.025	0.077
Quadrula verrucosa	Pistolgrip	0.096	0.012	0.002	0.000	0.000	0.000	0.019
Uniomerus declivis	Tapered pondhorn	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Subfamily: Anodontinae								
Arcidens confragosus	Rock-pocketbook	0.005	0.000	0.002	0.007	0.000	0.005	0.002
Pyganodon grandis	Giant floater	0.000	0.012	0.019	0.000	0.000	0.008	0.001
Utterbackia imbecillis	Paper pondshell	0.000	0.000	0.011	0.000	0.000	0.002	0.000
Subfamily: Lampsilinae								
Glebula rotundata	Round pearlshell	0.005	0.000	0.089	0.000	0.000	0.148	0.013
Lampsilis hydiana	Louisiana fatmucket	0.040	0.048	0.137	0.022	0.000	0.035	0.082
Lampsilis satura	Sandbank pocketbook	0.005	0.107	0.000	0.072	0.000	0.002	0.004
Lampsilis teres	Yellow sandshell	0.150	0.607	0.232	0.688	0.400	0.294	0.285
Leptodea fragilis	Fragile papershell	0.006	0.060	0.004	0.087	0.000	0.012	0.008
Obliquaria reflexa	Threehorn wartyback	0.012	0.000	0.001	0.000	0.000	0.002	0.001
Potamilus purpuratus	Bleufer	0.002	0.000	0.005	0.000	0.000	0.003	0.006
Toxolasma parvum	Lilliput	0.000	0.000	0.004	0.000	0.000	0.002	0.003
Toxolasma texasense	Texas lilliput	0.000	0.000	0.036	0.000	0.000	0.000	0.000
Villosa lienosa	Little spectaclecase	0.065	0.083	0.116	0.007	0.000	0.045	0.170
Total number of mussels		2,214	84	1,706	138	5	603	1,488
Total		1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 7. Indicator values for all mussel species based on relative abundance and frequency of occurrence across all mesohabitat types. *P* is the probability of exceeding the observed indicator value and was calculated using 999 permutations of the original data. Bold numbers indicate significant values (α = 0.10) and only the highest IV values are shown for each species.

Species	Common name	Habitat type							
		BH	BPB	BW	FPB	MC	P	WD	P-value
Subfamily Ambleminae									
Amblema plicata	Threeridge	-	-	0.40	-	-	-	-	0.24
Fusconaia askewi	Texas pigtoe	**0.67**	-	-	-	-	-	-	0.01
Megalonaias nervosa	Washboard	0.42	-	-	-	-	-	-	0.13
Plectomerus dombeyanus	Bankclimber	0.53	-	-	-	-	-	-	0.17
Quadrula apiculata	Southern mapleleaf	-	-	**0.68**	-	-	-	-	0.01
Quadrula mortoni	Western pimpleback	**0.72**	-	-	-	-	-	-	0.01
Quadrula nobilis	Gulf mapleleaf	0.58	-	-	-	-	-	-	0.18
Quadrula verrucosa	Pistolgrip	**0.74**	-	-	-	-	-	-	0.01
Uniomerus declivis	Tapered pondhorn	-	-	0.33	-	-	-	-	0.84
Subfamily: Anodontinae									
Arcidens confragosus	Rock-pocketbook	0.20	-	-	-	-	-	-	1.00
Pyganodon grandis	Giant floater	-	-	**0.79**	-	-	-	-	0.00
Utterbackia imbecillis	Paper pondshell	-	-	0.46	-	-	-	-	0.11
Subfamily: Lampsilinae									
Glebula rotundata	Round pearlshell	-	-	**0.70**	-	-	-	-	0.00
Lampsilis hydiana	Louisiana fatmucket	-	-	**0.66**	-	-	-	-	0.00
Lampsilis satura	Sandbank pocketbook	0.36	-	-	-	-	-	-	0.40
Lampsilis teres	Yellow sandshell	-	-	-	-	-	-	**0.54**	0.05
Leptodea fragilis	Fragile papershell	0.37	-	-	-	-	-	-	0.53
Obliquaria reflexa	Threehorn wartyback	0.39	-	-	-	-	-	-	0.47
Potamilus purpuratus	Bleufer	-	-	0.40	-	-	-	-	0.19
Toxolasma parvum	Lilliput	-	-	0.42	-	-	-	-	0.15
Toxolasma texasense	Texas lilliput	-	-	**0.66**	-	-	-	-	0.00
Villosa lienosa	Little spectaclecase	-	-	-	-	-	-	**0.56**	0.05

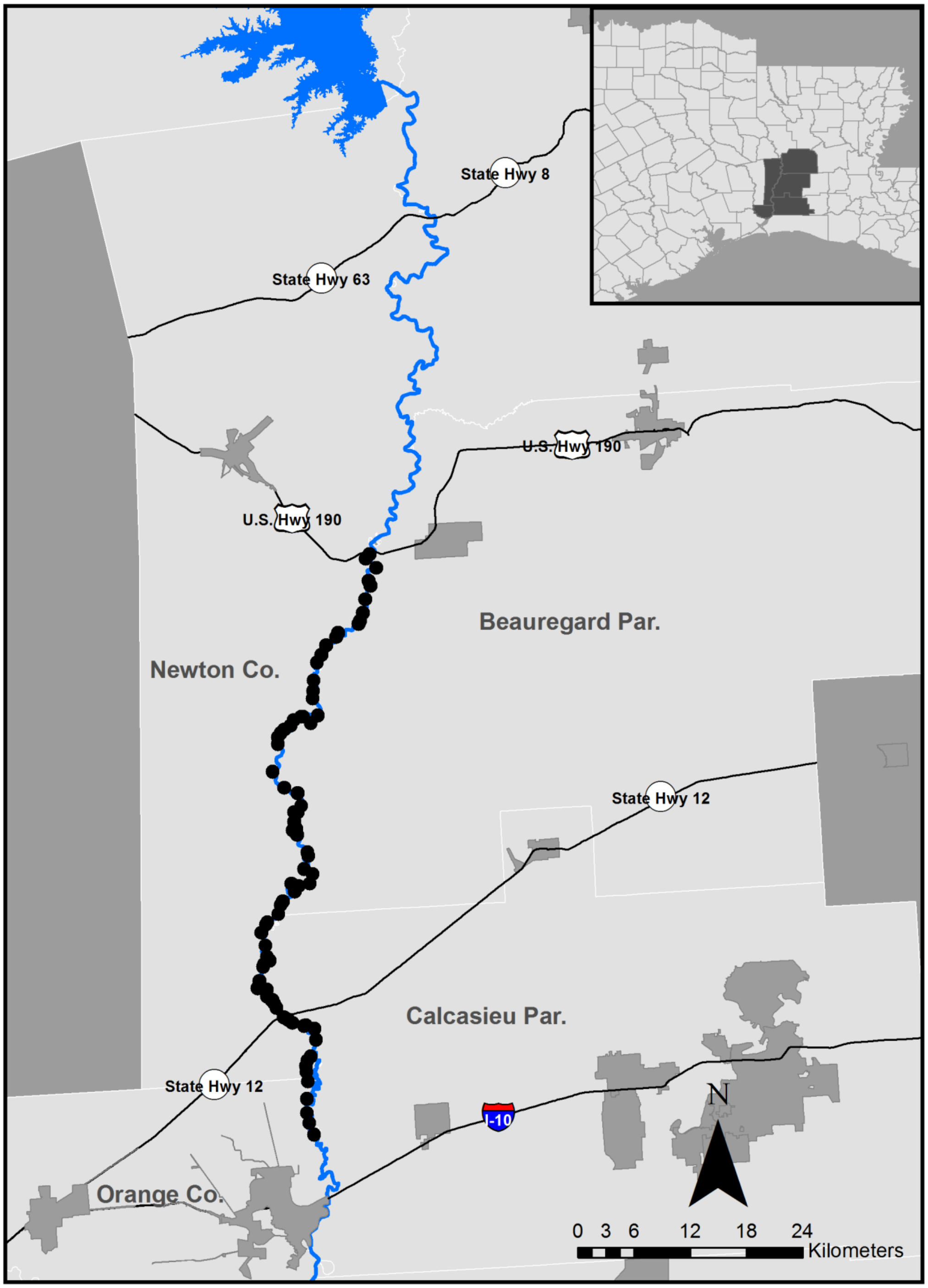

Figure 1. Study area for the lower Sabine River. Black dots indicate sample sites, which are located between U.S. Hwy 190 and Orange, Texas.

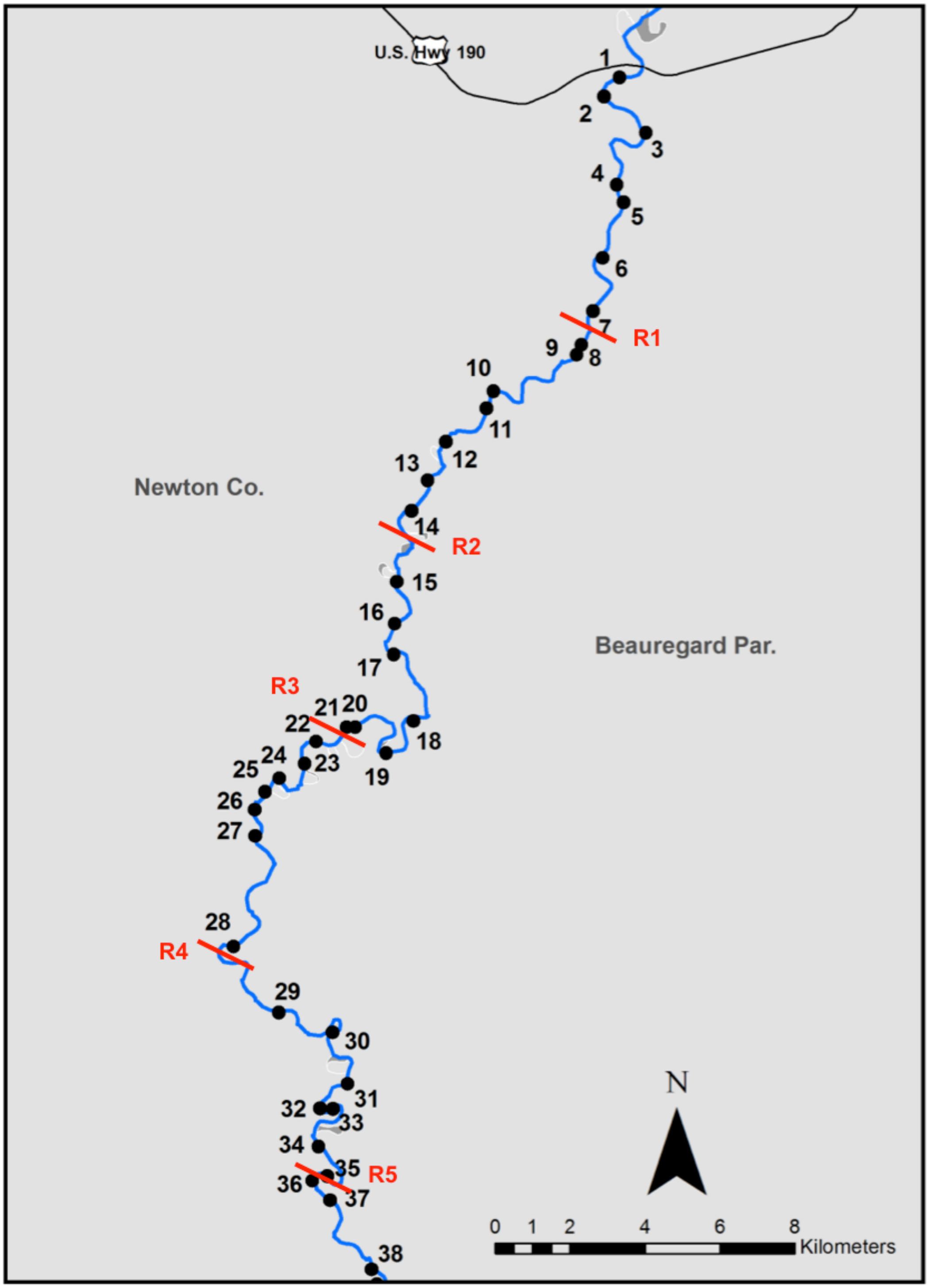

Figure 2. Sites sampled in lower Sabine River. Sites codes and their respective reaches are listed in Table 1.

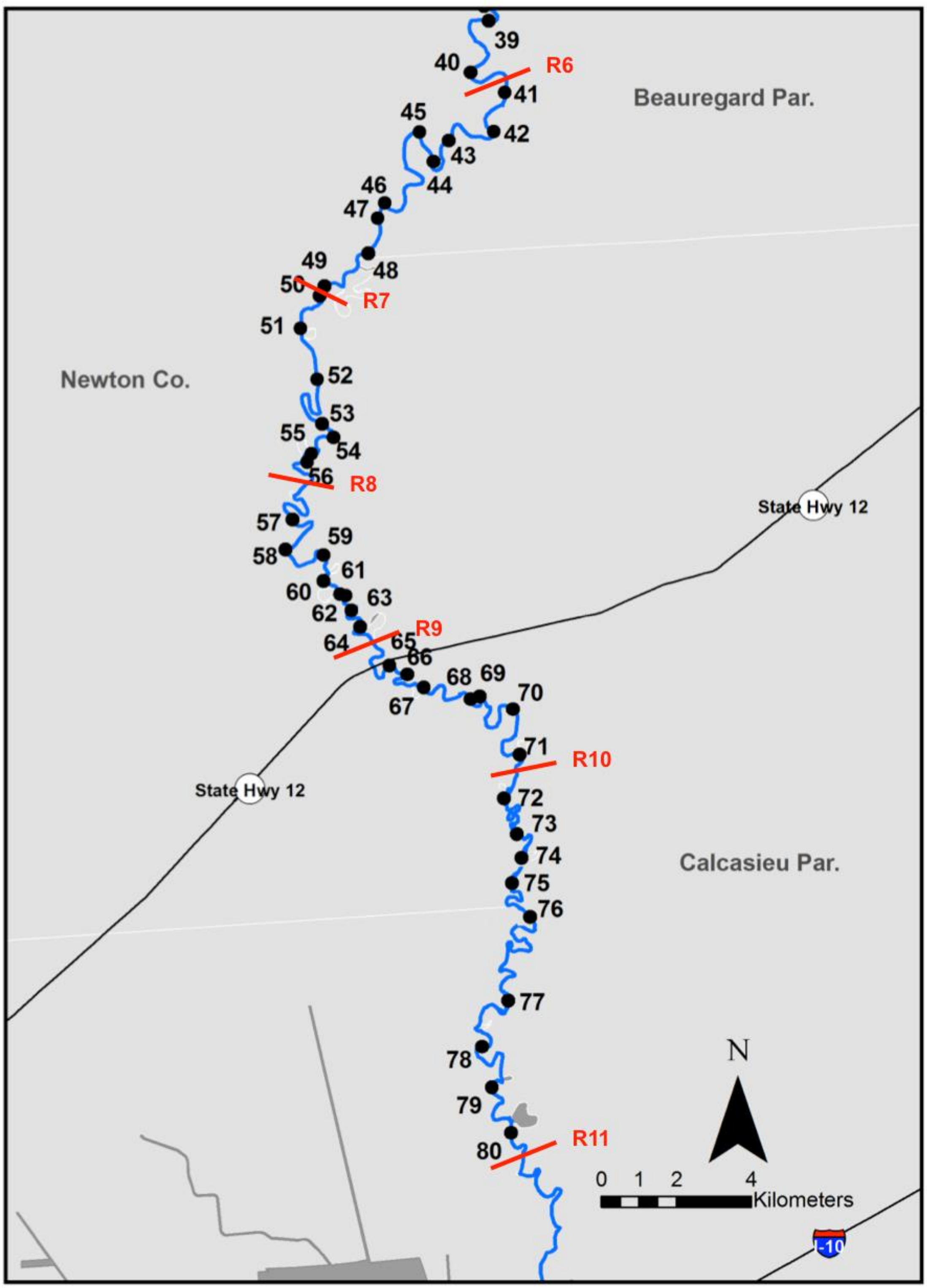

Figure 3. Sites sampled in the lower Sabine River. Sites codes and their respective reaches are listed in Table 1.

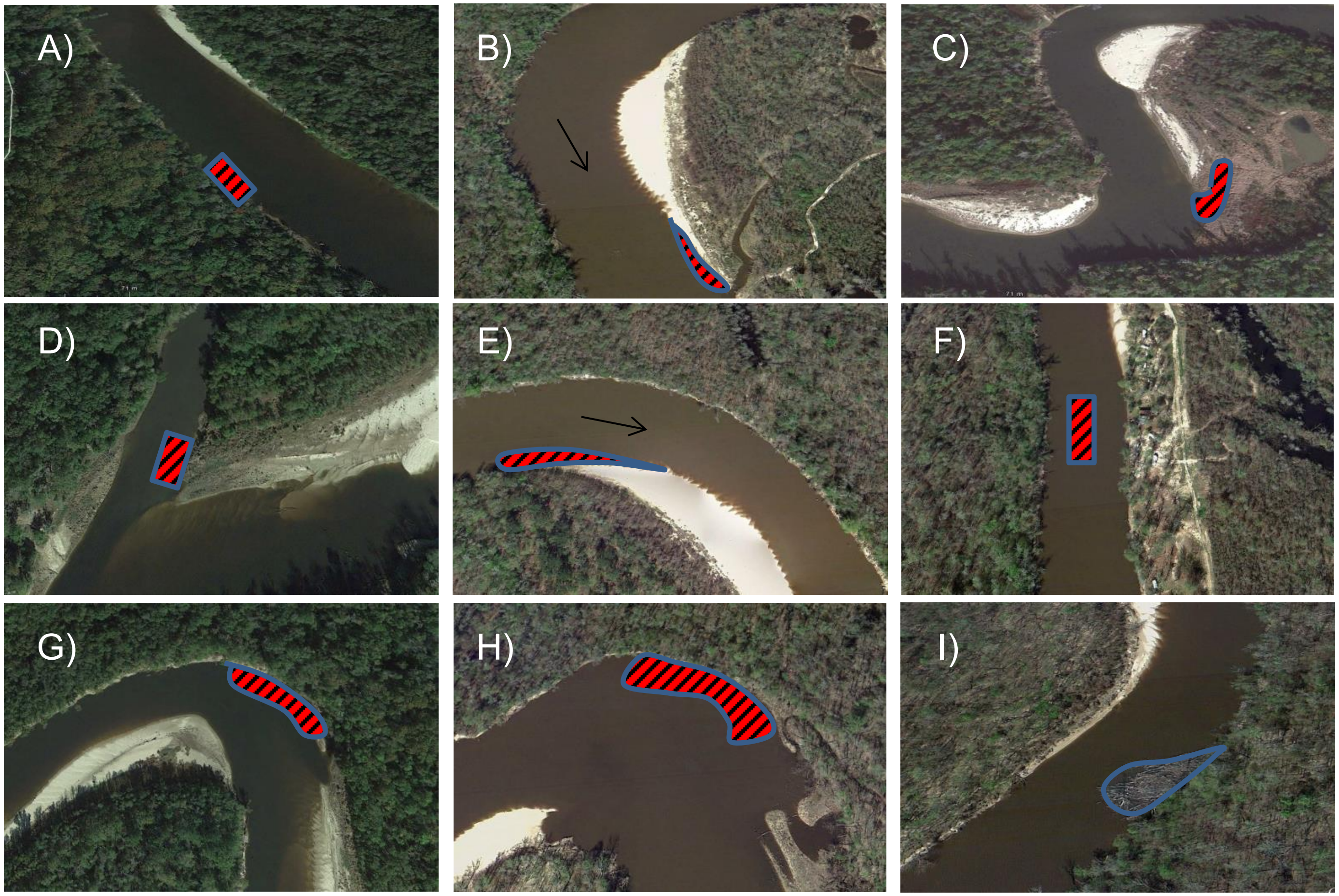

Figure 4. Mesohabitat types sampled on the Sabine River: A) bank habitat (BH); B) behind point bar (BPB); C) backwater: side channel (BW); D) backwater: abandoned channel (BW); E) front of point bar (FPB); F) midchannel (MC); G) corner pool (P); H) main channel pool (P); I) and woody debris (WD). Arrows denote direction of flow.

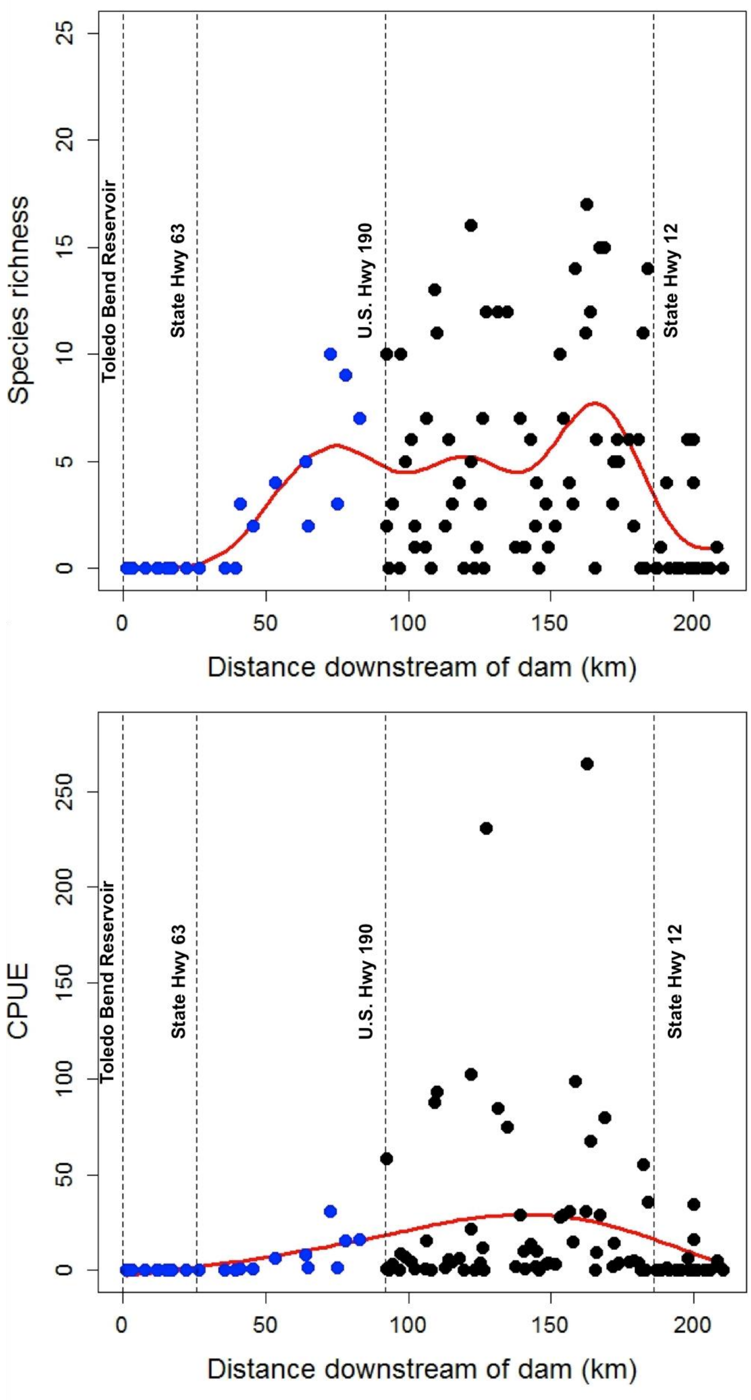

Figure 5. Species richness (top) and CPUE [catch-per-unit effort; mussels/p-h] (bottom) from timed-searches for collection sites on the lower Sabine River. Sites shaded blue are from Randklev et al. (2011) and those shaded black are from the present study. The best-fit line, using GAM, is shown for reference.

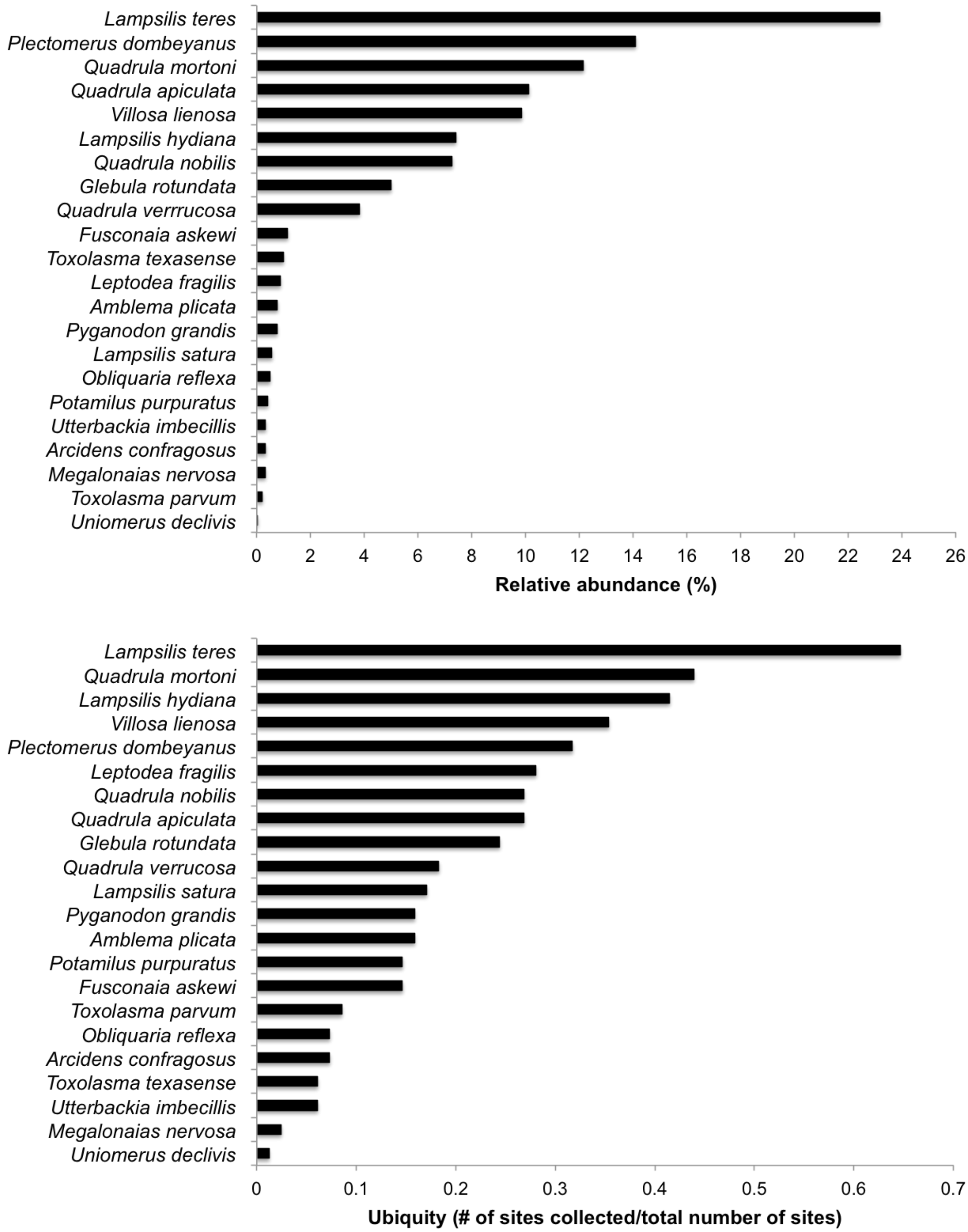

Figure 6. Relative abundance (top) and ubiquity (bottom) of mussel species in the lower Sabine River between U.S. Hwy 190 and Orange, Texas.

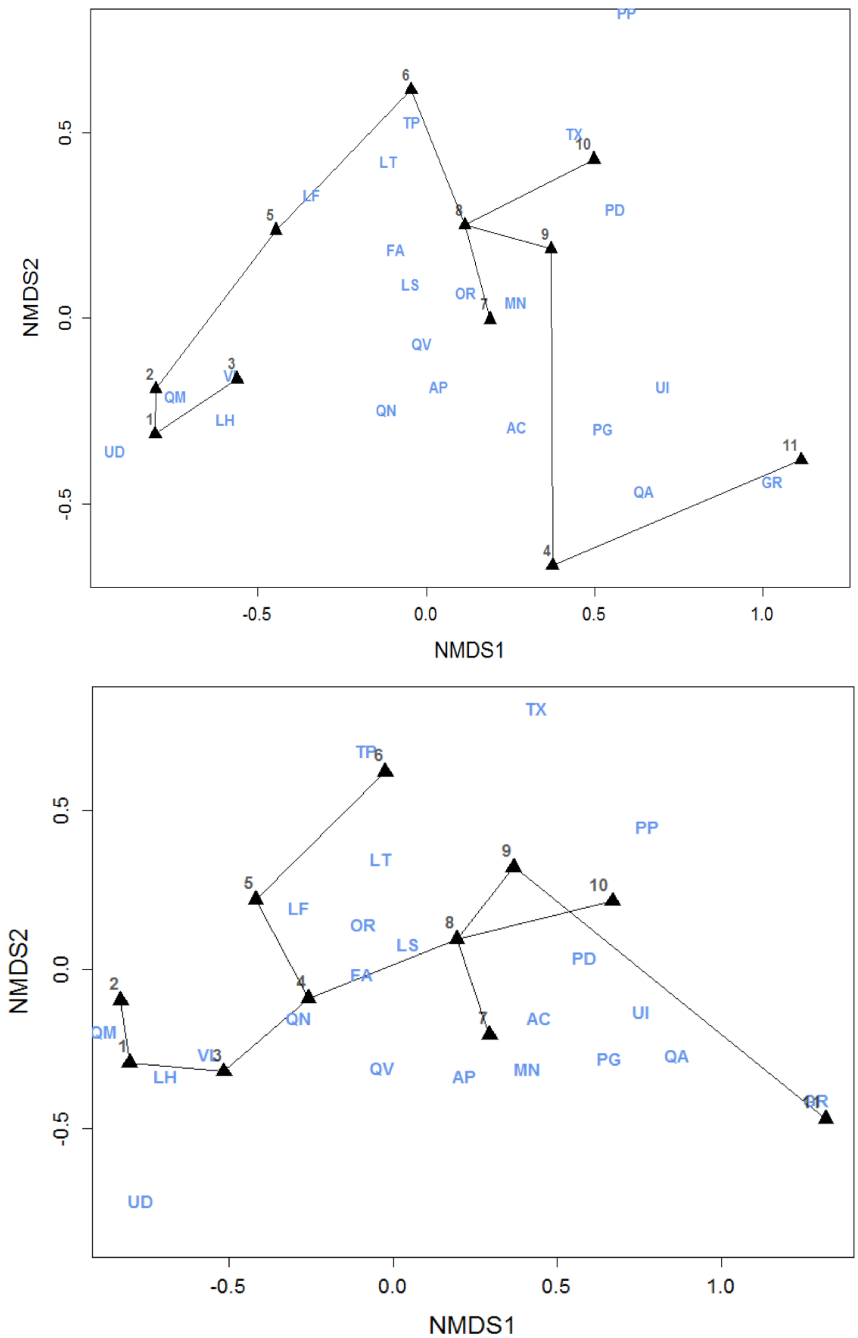

Figure 7. NMS ordination of the lower Sabine River based on species proportional abundances by river reach. The top biplot includes all sites and species while the bottom biplot is also based on all species and sites, with the exception of reach 4 where the backwater site was removed to show that this site is more similar to reaches near U.S. Hwy 190. Sites are connected based on relatedness and length of the line denotes the strength of that relationship.

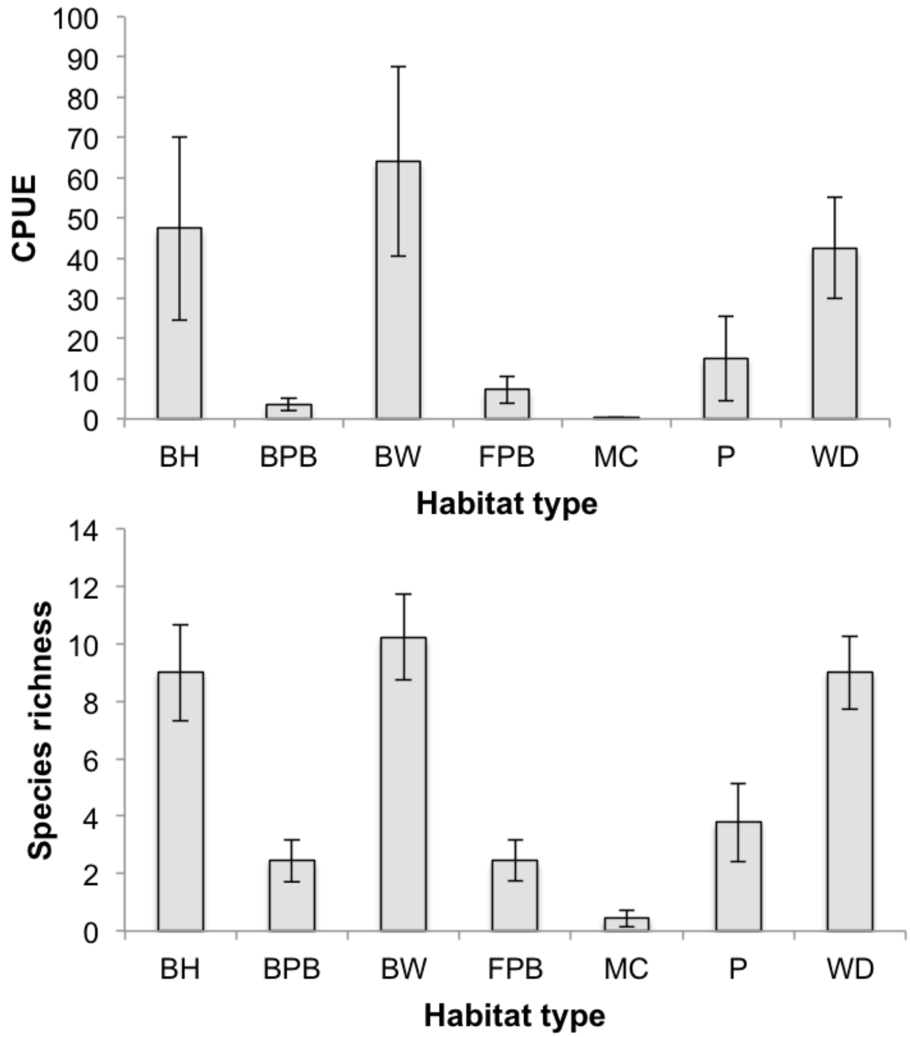

Figure 8. Mean CPUE (top) and species richness (bottom) by mesohabitat type. Error bars = ± 1 SE and acronyms for each habitat type correspond to the following: (BH) bank habitat; (BPB) behind point bar; (BW) backwater; (FPB) front of point bar; (MC) midchannel; (P) pool; and (WD) woody debris.

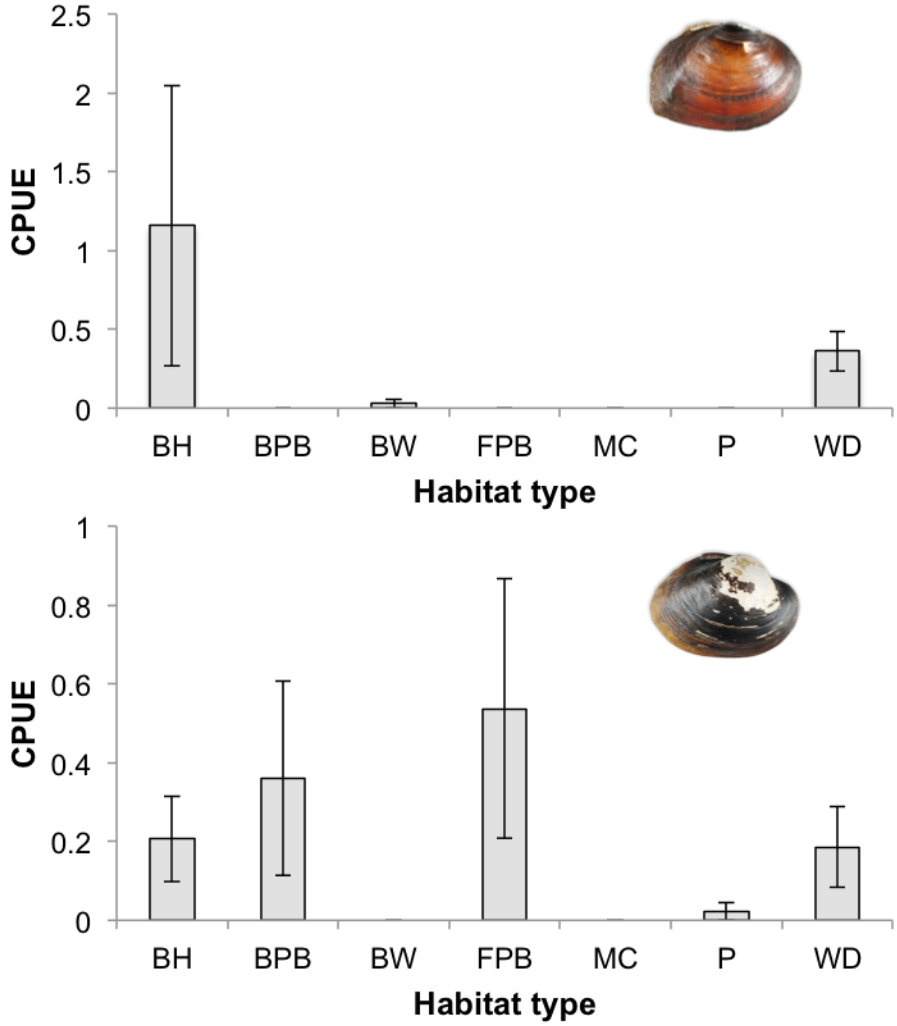

Figure 9. Mean CPUE for *F. askewi* (top) and *L. satura* (bottom) by mesohabitat type. Error bars = ± 1 SE and acronyms for each habitat type correspond to the following: (BH) bank habitat; (BPB) behind point bar; (BW) backwater; (FPB) front of point bar; (MC) midchannel; (P) pool; and (WD) woody debris.

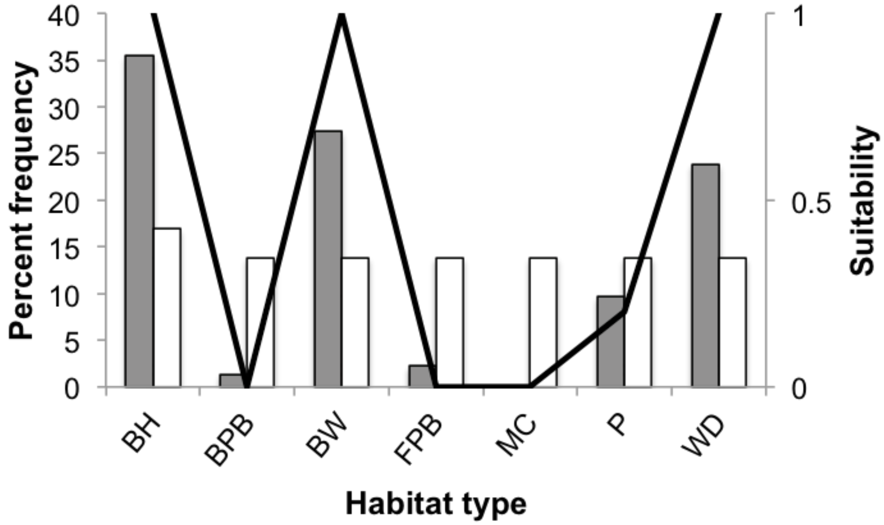

Figure 10. Percent frequency of mussel occurrence (grey bars), habitat availability (white bars), and Strauss linear index values (black line) by mesohabitats. The number of observations used were: N = 6,396. Acronyms for each habitat type correspond to the following: (BH) bank habitat; (BPB) behind point bar; (BW) backwater; (FPB) front of point bar; (MC) midchannel; (P) pool; and (WD) woody debris.

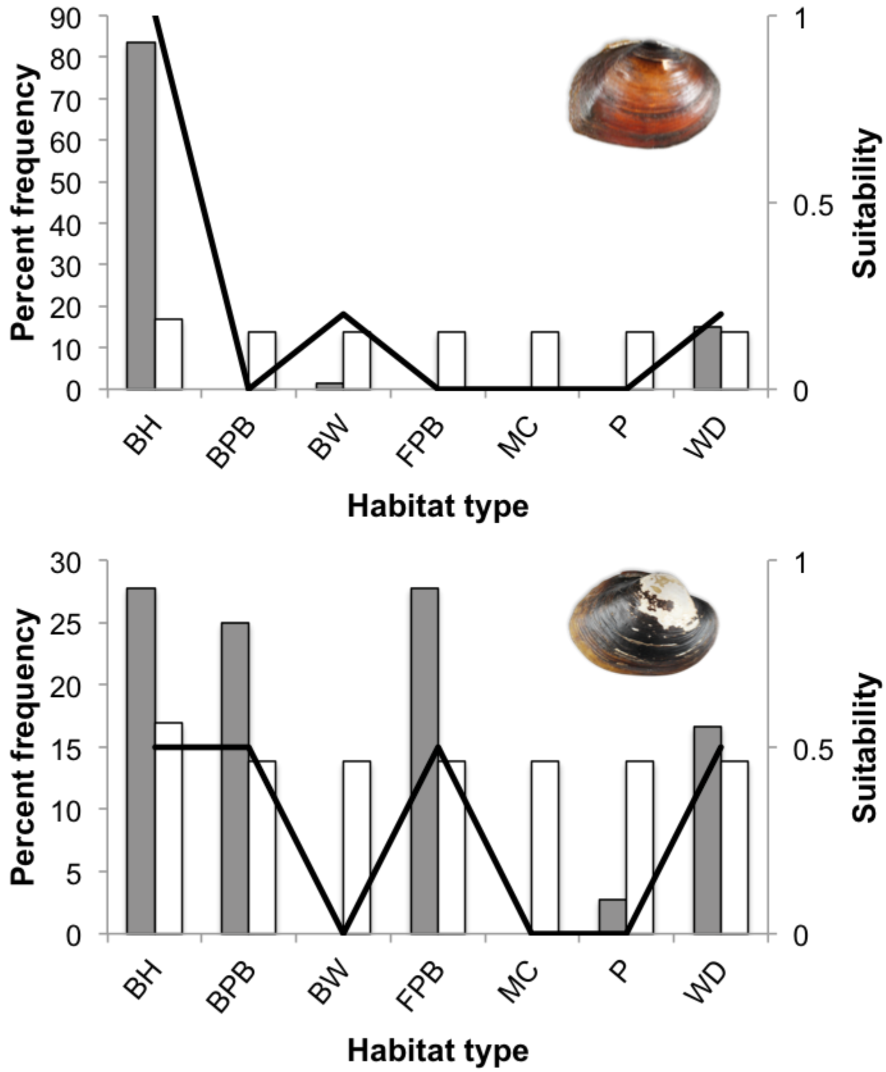

Figure 11. Percent frequency of mussel occurrence (grey bars), habitat availability (white bars), and Strauss linear index values (black line) by mesohabitats. Suitability criteria are shown for *Fusconaia askewi* (top) and *Lampsilis satura* (bottom) and the number of observations used were: N = 73 and N = 36, respectively. Acronyms for each habitat type correspond to the following: (BH) bank habitat; (BPB) behind point bar; (BW) backwater; (FPB) front of point bar; (MC) midchannel; (P) pool; and (WD) woody debris.

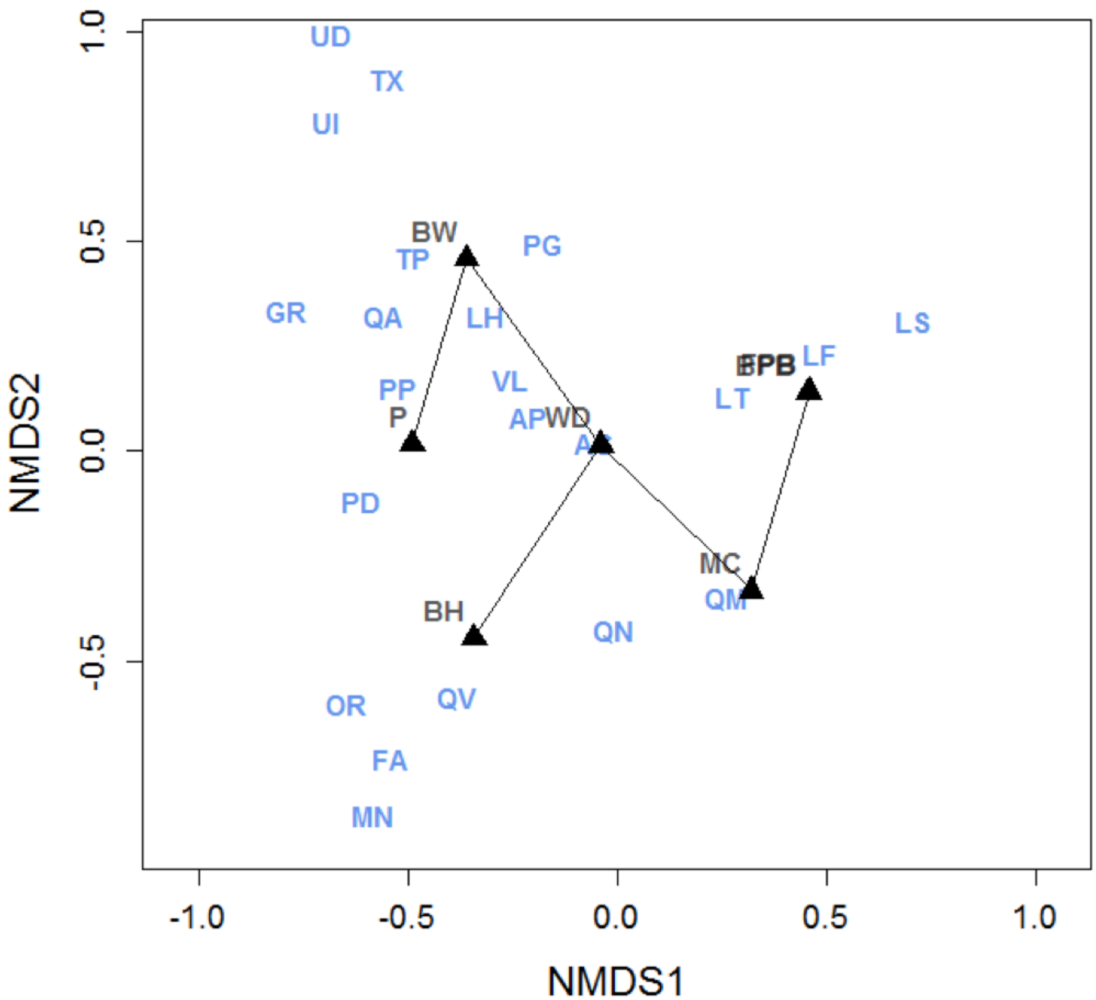

Figure 12. NMS ordination of the lower Sabine River based on species proportional abundances by mesohabitat. Lines connecting habitats indicate relatedness and length of the line denotes the strength of that relationship.

Literature Cited

Daraio, J.A., L.J. Weber, and T.J. Newton. 2010. Hydrodynamic modeling of juvenile mussel dispersal in a large river: the potential effects of bed shear stress and other parameters. Journal of North American Benthological Society 29: 838-851.

Di Maio, J. and L.D. Corkum. 1995. Relationship between the spatial distribution of freshwater mussels (Bivalvia: Unionidae) and the hydrological variability of rivers. Canadian Journal of Zoology 73: 663 – 671.

Dufrêne, M., and P. Legendre. 1997. Species assemblage and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs 67:345-366.

Haag, W.R. 2012. North American freshwater mussels: Natural History, Ecology and Conservation. Cambridge University Press, New York.

Haag, W.R., and M.L. Warren. 1998. Role of ecological factors and reproductive strategies in structuring freshwater mussel communities. Canadian Journal of Fisheries and Aquatic Sciences 55: 297-306.

Haag, W. R., and J. D. Williams. 2013. Biodiversity on the brink: an assessment of conservation strategies for North American freshwater mussels. Hydrobiologia DOI: 10.1007/s10750- 013-1525-7.

Hornbach, D.J., V.J. Kurth, and M.C. Hove. 2010. Variation in freshwater mussel shell sculpture and shape along a river gradient. American Midland Naturalist 164: 22-36.

Howells, R.G. 2005. Distributional surveys of freshwater bivalves in Texas: Progress report for 2004. Texas Parks and Wildlife Department, Management Data Series 233, Austin.

Howells, R.G., R.W. Neck, and H.D. Murray. 1996. Freshwater Mussels of Texas. Texas Parks and Wildlife Press, Austin, Texas.

Huser, V. 2000. Rivers of Texas. Texas A&M University Press, College Station, Texas.

Karatayev, A.Y., and L.E. Burlakova. 2007. East Texas Mussel Survey. State Wildlife Grant submitted to Texas Parks and Wildlife Department, Austin.

Karatayev, A.Y., and L.E. Burlakova. 2008. Distributional Survey and Habitat Utilization of Freshwater Mussels. Interagency final report submitted to the Texas Water Development Board March 2008.

McCune, B., and J.B. Grace. 2002. Analysis of ecological communities. MjM Software Design, Gleneden Beach, Oregon.

Morales Y., Weber J.J., Mynett A.E. & Newton T.J. 2006. Effects of substrate and hydrodynamic conditions on the formation of mussel beds in a large river. Journal of North American Benthological Society, 25, 664–676.

Neck, R.W. 1982. A Review of Interactions Between Humans and Freshwater Mussels in Texas. In Proceedings of the Symposium on Recent Benthological Investigations in Texas and Adjacent States, edited by Jack R. Davis, pp. 169-182. Texas Academy of Science, Austin.

Patrick, R. 2003. Rivers of the United States: Gulf of Mexico, Volume V. John Wiliey & Sons, Inc. Hoboken, New Jersey.

Persinger, J.W., D.J. Orth, and A.W. Averett. 2011. Using habitat guilds to develop habitat suitability criteria for a warmwater stream fish assemblage. River research and applications 27: 956-966.

Phillips, J.D. 2008. Geomorphic controls and transition zones in the lower Sabine River. Hydrological Processes 22: 2424-2437.

Quinn G.P., and M.J. Keough. 2002. Experimental design and data analysis for biologists. Cambridge University Press, New York, New York.

Randklev, C.R., B.J. Lundeen, J.H. Kennedy, and S. Wolverton. 2009. Report on the Reconnaissance Survey of the Lower Sabine River, September 2009. Interagency report submitted to the Sabine River Authority November 2009.

Randklev, C.R., B.J. Lundeen, J.H. Kennedy, and S. Wolverton. 2011. Toledo Bend Relicensing Project: Lower Sabine River Mussel Study. Final interagency report submitted to the Sabine River Authority March 2011.

Schwalb, A.N., K. Cottenie, M.S. Poos, and J.D. Ackerman. 2011. Dispersal limitation of unionid mussels and implications for their conservation. Freshwater Biology 56:1509-1518.

Strauss, R.E. 1979. Reliability estimates for Ivlev's Electivity Index, the Forage Ratio, and a proposed linear index of food selection. Transactions of the American Fisheries Society 108: 344-352.

Strecker, J.K. 1931. The distribution of the naiads or pearly fresh-water mussels of Texas. Baylor University Museum Special Bulletin 2, Waco, Texas.

Texas Parks and Wildlife. 2009. 15 Texas Freshwater Mussels Placed on State Threatened List. Electronic Document. http://www.tpwd.state.tx.us/newsmedia/releases/ ?req=20091105c& nrtype=all&nrspan =2009&nrsearch=, accessed January 13, 2010.

Vaughn, C.C., and C.M. Taylor. 1999. Impoundments and the decline of freshwater mussels; a case study of an extinction gradient. Conservation Biology 13:912-920.

Vidrine, M.F. 1993. The historical distributions of freshwater mussels in Louisiana. Gail Q. Vidrine Collectables, Eunice, Louisiana.

Williams, J.D., M.L. Warren, K.S. Cummings, J.L. Harris, and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18: 6-12.

Appendix A – Responses to TWDB Comments

REQUIRED CHANGES TO TASK 1 REPORT

1. Please reference "TWDB Contract No. 1104831145" on the cover of the report.

   Response: addressed

2. Please check the report for typos such as the following and correct as necessary:
   a. Page 4, 3rd paragraph, 1st sentence, "performed at each" should be "performed at each site."
   b. Page 9, 3rd paragraph, 2nd to last sentence, "relatively moderate" should be "relatively more moderate."

   Response: all addressed

3. As described in paragraph 2 on page 4, one of the seven mesohabitats evaluated in this effort was "woody debris." A previous report (Randklev, Kennedy, and Lundeen 2009) raised some question as to whether woody debris was a habitat of value to mussels or merely a location where they were deposited during high flow events that scoured upstream mussel habitat (but without long term habitat value). Please indicate if the current study sheds any light on this question.

   Randkev, C.R., J.H. Kennedy, and B. Lundeen, 2009, Distributional survey and habitat utilization of freshwater mussels (Family Uninonidae) in the lower Brazos and Sabine River basins, Texas Water Development Board Contracted Report No. 0704830778, 78 p. www.twdb.texas.gov/publications/reports/contracted_reports/doc/0704830778_Mussels/index.asp.

   Response: It is still unclear as to whether woody debris is a habitat of value to mussels or merely a place where they are deposited during high flows or place where fish congregate.

4. On page 4, in the 3rd paragraph, the authors state that "Effort was made to examine all available microhabitats present at each site." The report makes no further reference to the term "microhabitat." Please provide a definition of the term "microhabitat" and include any data or analyses related to microhabitats in the report or an appendix as appropriate.

   Response: this sentence has been modified to remove the term "microhabitat" and instead used hydraulic habitat to refer to all available depths and velocities within the search area. Data was not recorded at a microhabitat level for this study, therefore it is not available.

SUGGESTED CHANGES TO TASK 1 REPORT

5. In the title for Table 2, on page 13, the “front-of-point bar” and “back-of-point bar” habitats are described as being “immediately upstream of point bar” and “immediately downstream of point bar,” respectively. The description of habitat as being upstream or downstream of a point bar seems to be more readily understandable (as compared to “front-of” or “back-of” a point bar). Please consider using the designations “upstream of point bar” and “downstream of point bar” to refer to these mesohabitats throughout the document.

   Response: We see how this may be confusing, but our explanation in the methods of each habitat type and the example image of each habitat type in Figure 4 should make this distinction clear.

6. Just to be clear, suggest changing “changes in assemblage structure” in the last sentence of the 1st paragraph on page 10 to “changes in assemblage structure in this reach.”

   Response: addressed