Distribution and Relative Abundance of Freshwater Mussels in the Saint Croix National Scenic Riverway

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Abstract

Mussel distribution and relative abundance along the 250 mile Saint Croix National Scenic Riverway were determined by sampling 84 regularly distributed sites. Sampling took place in the summer of 1987 and utilized SCUBA techniques. Each sample site encompassed 60 square meters of river bottom. Thirty-five midden pile sites were sampled as well. Thirty-eight species were found on the entire Riverway (2 species represented by dead material only). Thirty-five species were found alive and 2 species were represented by dead shells only in the Saint Croix River. Sixteen species, all alive, were found in the Namekagon River . Range extensions were documented for Cumberlandia monodonta, Simpsonaias ambigua, Quadrula fragosa, Truncilla truncata, Epioblasma triquetra, Truncilla donaciformis, Tritogonia verrucosa, Quadrula metanevra, Lampsilis higginsi, Elliptio crassidens, and Ellipsaria lineolata. Eight river stretches or sites were preliminarily identified as having significant mussel diversity or concentrations of rare species which merit special conservation attention. A clustered distribution pattern of mussels was apparent throughout the riverway. Two species associations were apparent and included primarily common species or primarily uncommon species. Areas containing the highest species diversity also had the rarer species, but these areas were not necessarily areas of high mussel densities. Most (96.4%) mussels were collected at depths between 0.5 to 3.5m., this data being influenced by river levels. Over half(64.2%) of all the mussels collected occurred in sand, gravel and rock bottom substrate of varying combinations.

Introduction

The purpose of this study was to determine freshwater mussel(Naiadacea) diversity and abundance in the Saint Croix National Scenic Riverway including the Saint Croix and Namekagon rivers. Objectives also included locating important mussel habitats including high diversity areas and rare species sites. This report covers the first year of the study (1987) and specifically addresses the following objectives:

1) Determine mussel species diversity, population densities, distribution, relative abundance and habitats

2) Determine locations of significant mussel concentrations, rare species sites and midden piles

3) Recommend priorities for mussel conservation and research in subsequent years on the Riverway.

In previous studies on the Saint Croix River Fuller (1978) reported 28 species near Hudson, Wisconsin, Mathiak (1977) identified 19 species, and Dawley (1947) found 25 species. Stern (1983) and Baker (1928) found 14, and 15 species respectively in the Saint Croix River. Only Mathiak (1977) had surveyed the Namekagon River finding 8 species.

Study Area

The Saint Croix National Scenic Riverway forms a 400+ km North-South transect extending from the Lake Superior Basin to the Mississippi River draining a 22,200 square meter basin about equally divided between the States of Minnesota and Wisconsin. The Saint Croix River begins as a cold water stream where at extremely high water it provides a tenuous connection to Lake Superior through the Bois Brule River. As the Saint Croix and its tributaries combine in their southward flow concomitant physical changes occur in velocity, depth, width, temperature, siltation, and related attributes. Three major continental biomes(boreal forest, northern hardwood forest, and central grasslands) each with its attendant riparian wetland communities, through which the rivers flow, contribute further to changes in stream characteristics. Virtually all of the aquatic and riparian biological communities have their origins in, or are shaped by the flowing waters of the Saint Croix and Namekagon Rivers, and their tributaries or their fluvial antecedents of the Wisconsin Glaciation. The present rivers are dynamic ecological systems constantly shifting with seasonal, and annual in-stream variation in both physical and biotic traits. (Andersen, Memorandum to Regional Chief Scientist, NPS, 1987).

The average annual precipitation within the Saint Croix River Basin is 74 cm (71 cm - 79 cm), (Wisconsin Department of Natural Resources, 1972). The average gradient for the Saint Croix River

(275 km in length) is 38 cm/km. The average discharge at Saint Croix Falls, which incudes 80% of the drainage area is 119 cubic meters per second (U.S. Geological Survey., 1982). Bottom substrate is composed primarily of sand, gravel, rubble, muck, and silt, with limited areas of boulder, and detritus(Fago,1986). Major land uses in the Saint Croix River Basin are woodland (57%) and cropland (22%), (Wisconsin Department of Natural Resources, 1980). Population (for Wisconsin) within the Basin in 1978 was estimated at 112,703, which has increased 32% since 1950. (Fago, 1986).

The upper portion of the Saint Croix River starts at a dam near Gordon, Wisconsin in Douglas County. It flows in a southerly direction for 164 km to the dam at Saint Croix Falls in Polk County. The upper Saint Croix River lies in Wisconsin for its first 40 km, and then becomes a border river between Minnesota and Wisconsin. Only the historic remnants of the Copper Mine Dam interrupts this narrow, small stream until it is joined with the Namekagon 32 km down-stream. The Saint Croix then becomes wider, deeper, and slower until it reaches the impoundment formed by the dam at Saint Croix Falls.

The Lower Saint Croix River forms a narrow corridor for 84 km from Saint Croix Falls Dam to Prescott, Wisconsin, where the river joins the Mississippi River. The Lower Saint Croix is wider, deeper, and slower than the Upper, its flow being controlled by the hydroelectric dam at its upstream end. Immediately downstream of the dam are the high cliffs of the Saint Croix River Dalles, which formed as meltwater from the retreating glaciers cut a deep vertical walled gorge through the basaltic bedrock. From the Dalles, for approximately 3.2 km, the river, in places, is 21-30 m deep and its flow is the fastest. South of the dalles, the river becomes wider, shallower, and passes between high banks for the next 32 km. About 35 km below the dam, the Apple River flows into the Saint Croix River. The river then becomes deeper and slower. Approximately 43 km downstream the stream widens more forming the 40 km long Lake Saint Croix. Near Hudson, Wisconsin, the Saint Croix River reaches a maximum width of 2,255 m.

The upper portion of the Namekagon River starts at Namekagon Lake Dam in Bayfield County. it is a fast, narrow, shallow, rocky, warm-water stream until it reaches County Trunk M. From County Trunk M, the Namekagon's water is cooled considerably from spring seepage and becomes a trout stream interrupted by four dams on its southwesterly flow. Upstream from each dam are four flowages that have warmer, slower water, with silt and muck bottoms. The dams create the Pacwawong Flowage, the Phipps Flowage, Lake Hayward, and the Trego Flowage. The Namekagon enters the Saint Croix just north of the Danbury, Wisconsin, completing a 158 km south and west journey. The lower portion of the Namekagon River from Trego Dam (Washburn County) south is wider, warmer, and slower passing through areas of high sandy banks, with many sharp bends.

Methods

The survey utilized three sampling strategies:

1) Regular Transects-50 transects, approximately 60 sq. m. in area, located every 8.2 river km.;

2) Relative Abundance Transects- 34 transects, approximately 60 sq. m. in area, one located in each ten km. stretch of river and only where a mussel bed was present;

3) Midden Piles-mussel species and relative abundance data from remains at 34 sites.

In the regular transect and the relative abundance transect an approximately two meter wide transect perpendicular to the river course was followed for 30 m through all habitats. All bottom substrate was probed and sifted to 0.25m depth. The sample width was the distance measured from the extended tips of the diver's fingers to their knees (an estimated two meters). In the regular transects and in the relative abundance transects all live and dead mussel material were removed for immediate analysis . Data collected for each specimen was recorded in the field on WI DNR Mussel Survey Form (Figure 1) and included species, number found alive and number found dead. Voucher collections were made for each species in each 8.2 km. river segment. Live specimens not utilizes as vouchers were returned to river after processing.

S.C.U.B.A. was used as a collecting method when appropriate. Skin diving was used as a collection method in areas with low water levels-i.e. less than 0.5m. Live voucher specimens were placed in 70% ethyl alcohol. All voucher specimens were deposited at the James Ford Bell Museum in Saint Paul, Minnesota. Rare or questionable shell identification was performed by Marian E. Havlik of Malacological Consultants, La Crosse, Wisconsin, William A. Smith, Wisconsin Bureau of Endangered Resources, and Dr. Robert Bright, University of Minnesota.

Results and Discussion

Thirty-eight species of freshwater mussels live and/or dead were identified during the period of study (Table 1.) Only *Fusconaia ebena*, and *Potamilus laevissima* were not found live. *Elliptio crassidens* was found alive, but not on a designated transect. Species considered Endangered, Threatened or of Special Concern by Wisconsin and or Minnesota Departments of Natural Resources include: *Lampsilis higginsi*, *Cumberlandia monodonta*, *Epioblasma triquetra*, *Quadrula fragosa*, *Simpsonaias ambigua*, and *Elliptio crassidens*, *Ellipsaria lineolata*, *Cyclonaias tuberculata*, *Quadrula metanevra*, and *Tritogonia verrucosa*. *C. monodonta*, *S. ambigua*, *Q. fragosa*, *E. triquetra*, and *E. crassidens* are species considered to be exceptionally rare from Wisconsin waters, but each of these species was found alive during the study period. L. higginsi was the only federally endangered species found.

Northern range extensions were documented for L. higginsi, E. crassidens, Q. fragosa, E. triquetra, Q. metanevra, E. lineolata, Truncilla donaciformis, Truncilla truncata, C. monodonta, T. verrucosa and S. ambigua up to river kilometer 83.5 (Havlik in preparation). Also C. monodonta and S. ambigua were found in Burnett County Wisconsin at river kilometer 141.3 and 185.2 respectively, representing the most drastic range increase.

Midden pile data occasionally reflected mussel diversity in adjacent water. However, Isom et.al. (1971) reported that midden pile searches are ineffective as a single sampling technique. Dead shells do not accumulate in the same proportion to the occurrence of the live specimens in adjacent waters because muskrats appear to be selective for small mussels (both juveniles and small species). However, midden piles may be beneficial in establishing the presence of rare species (Kovalak et.al., 1986). In my opinion the selectivity for small mussels has primarily to do with the physical limitations of a muskrat not being able to open larger shells, and some mussel species may be simply more palatable.

Mussel Abundance and Distribution

Mussel collections by S.C.U.B.A. in the 60 square meter transects were done in 84 locations. All of the mussels used in the distribution and abundance data were collected by this method. In general mussels were not randomly distributed in the riverway area but were clustered in specific areas. This type of distribution was also noted by Thiel (1981) on the Mississippi River. On all the transects, 4,550 live shells and 2,176 dead shells were collected. In 36 midden pile checks 12,810 shells were tabulated. For most species live shell abundance exceeded that of dead shells in both regular transects and relative abundance transects. The only exception was the Asiatic clam (Corbicula fluminea). The primary population of the Asiatic clam was in the proximity of the effluent pipe of the Stillwater, MN power plant.

Live shell and dead shell densities, means, and relative abundances suggests that mussel populations in the Saint Croix and Namekagon Rivers are generally healthy. This was ascertained by the greater proportion of live individuals for most species. For the less common species (species found in 5 or fewer locations) there is not enough data for analysis. These species were: L. higginsi, Q. fragosa, E. triquetra, E. crassidens, C. monodonta, S. ambigua, E. lineolata, Q. quadrula, Anodontoides ferussacianus, F. ebena, Lasmigona complanata, P. laevissima, Toxolasma parvus, and T. donaciformis. These species were the least abundant and had the least frequency of occurrence in the entire riverway.

Actinonaias ligamentina had the highest relative abundance value for live clams in both relative abundance transect and regular transect (see Table 2). Two species, C. monodonta and S. ambigua typically occur in dense aggregations under or around large rocks and relative abundance values are not a good indicator of abundance.

In both relative abundance transects and regular transects live shell density data showed that A. ligamentina also had the highest density. C. fluminea, for 2 locations shows a high density, but only for dead shells. F. flava, E. dilatata, Amblema plicata, and Lampsilis radiata also show high densities.

Clustering of species was apparent with less common species being associated with each other and more common species being associated with each other. For instance, a common species such as A. ligamentina, is associated with E. dilatata, F. flava, L. radiata, and Lampsilis ventricosa, while a less common species such as T. truncata is associated with O. metanevra and T. verrucosa.

The clusters with the largest species diversity are the areas that contain the least common species in the riverway. These areas did not usually have high mussel densities. This was determined by reviewing field data sheets in relation to the cluster analysis data.

Over half (56%) of all mussels collected live on transects occurred at 21 locations between Township 40N and 43N (Wisconsin baseline).

About 57% of all mussels occurred in the upper sections of the Saint Croix River, the headwater areas, and lower portions of the Namekagon River. The area from river kilometer 88.1 - 78.6 in the Namekagon River lacked of mussel concentrations. This section is a cold water trout stream and this area was poor for mussel species diversity and abundance. Trout waters are probably poor mussel waters.

Bottom Substrate and Depth

About 23% of all the mussels collected live were found in a sand and gravel substrate (see Table 4). Sand, gravel and rock, and any combination thereof consisted of 64.2% of the substrate where mussels were collected on the survey. Detritus, mud and shifting sand constituted 3% of the substrate where mussels were found. Certain species such as T. parvus, Ligumia recta, Anodonta grandis, and Anodonta imbecillis are associate with these soft substrates.

About 96% of all the live mussels collected occurred at a depth between .5m - 3.5m. The greatest proportion (36%) were collected at a 2 meter depth. A single A. grandis was found at a depth of 10m representing the greatest depth were a mussel was found on the riverway. In general the freshwater mussels were found in shallow depths, though this is biased considering the annual variables in river volumes.

Recommendations:

1. Conduct at least one more year's research to refine inventory data to quantify rare species populations so management recommendations for permanent *mussel refuges can be ascertained.

2. Research reproductive parameters of rare mussel species in especially important mussel refuge areas.

3. Monitor rare mussel populations on a 3-5 year basis, while a complete river system survey should be conducted every 10 years by the transect method described by this study.

4. Initiate periodic water chemistry studies that target factors that may effect mussel populations. A present concern would be ammonia's effect on mussel populations in the Saint Croix River. Graczyk (1986) reported that trend analysis for selected parameter loads at the Saint . Croix River at Saint Croix Falls show that water quality has not significantly changed from 1974-81 except for the apparent 26% per year total increase in ammonia. Accompanied by this fact is ammonia's negative effects of mussel populations, as reported by Havlik and Marking (1987). A concentration of 5 ppm of ammonia was lethal to 40% of A. plicata, and A. grandis, in 7 days (Horne and Mcintosh, 1979).

5. Review impacts of "stink baits" by using mussel meats for fishing purposes in select areas of the Saint Croix. Both L. higginsi, and O. fragosa, were found fresh dead that were killed for use as stink bait during the research period. (Havlik in prep. 1987).

6. Actively monitor land use decisions that would potentially impact water quality.

7. Research, monitor, and evaluate the effect of dams on mussel populations and distribution. Special and immediate research should be targeted at the Saint Croix Falls hydro-electric facility considering the area below the dam has a good concentration of rare mussel species that may be adversely effected.

8. Develop and enact mussel eduction programs for a diverse population spectrum. The initial stages of educational directive should be targeted at field personnel, interpreters, and law enforcement.

9. Support research on host species determination and life history work on C. monodonta, O. fragosa, C. tuberculata, E. crassidens, E. triquetra, and S. ambigua.

10. Evaluate mussels as a bio-monitor of riverine ecosystems.

11. Coordinate future fish research, or limnological projects with mussel research.

12. Research, monitor, and evaluate the effects of sewage treatment and Fish Hatchery effluent releases into the Saint Croix River. Considering that each are potentially prime point sources for ammonia contamination. Again the area below the hydroelectric facility in Saint Croix Falls is of immediate concern.

Potential mussel refuge areas and locations of exceptional mussel beds. Location is determined by river kilometer.

1. Saint Croix River

River km - 85.8 - 57.4 Refuge areas
131.8 - 209.9
28.4, 236, 246

2. Namekagon

River km - 48.1, 101.5, 156.9

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Table 1. Taxonomic list of the freshwater mussels and clams collected in the Saint Croix National Scenic Riverway, 1987 (= collected dead only).*

PHYLUM MOLLUSCA (Linne, 1758) Cuvier, 1797
- **CLASS BIVALVIA** Linne, 1758 (after Bonnani, 1681)
  - **ORDER UNIONOIDA** Stoliczka, 1871
    - **FAMILY MARGARITIFERIDAE** Haas, 1940
      - *Cumberlandia monodonta* (Say, 1829)
    - **FAMILY UNIONIDAE** (Fleming, 1828) Ortmann, 1911
      - *Andonta imbecillis* Say, 1829
      - *Anodonta grandis* form *grandis* Say, 1829
      - *Anodonta grandis* form *corpulenta* Cooper, 1834
      - *Anodontoides ferussacianus* (Lea, 1834)
      - *Strophitus undulatus* (Say, 1817)
      - *Alasmidonta marginata* Say, 1818
      - *Simpsonaias ambigua* (Say, 1825)
      - *Lasmigona complanata* (Barnes, 1823)
      - *Lasmigona costata* (Rafinesque, 1820)
      - *Lasmigona compressa* (Lea, 1829)
      - *Tritogonia verrucosa* (Rafinesque, 1820)
      - *Quadrula quadrula* (Rafinesque, 1820)
      - *Quadrula fragosa* (Conrad, 1835)
      - *Quadrula metanevra* (Rafinesque, 1820)
      - *Quadrula pustulosa pustulosa* (Lea, 1831)
      - *Amblema plicata* (Say, 1817)
      - **Fusconaia ebena* (Lea, 1831)
      - *Fusconaia flava* (Ráfinesque, 1820)
      - *Cyclonaias tuberculata* (Rafinesque, 1820)
      - *Pleurobema sintoxia* (Rafinesque, 1820)
      - *Elliptio crassidens* (Lamarck, 1819)
      - *Elliptio dilatata* (Rafinesque, 1820)
      - *Obliquaria reflexa* Rafinesque, 1820
      - *Actinonaias ligamentina* (Barnes, 1823)
      - *Ellipsaria lineolata* (Rafinesque, 1820)
      - *Obovaria olivaria* (Rafinesque, 1820)
      - *Truncilla truncata* Rafinesque, 1820
      - *Truncilla donaciformis* (Lea, 1827)
      - *Leptodea fragilis* (Rafinesque, 1820)
      - *Potamilus alatus* (Say, 1817)
      - *Potamilus laevissima* (Lea, 1830)
      - *Toxolasma parvus* (Barnes, 1823)
      - *Ligumia recta* (Lamarck, 1819)
      - *Lampsilis radiata* (Lamarck, 1819)
      - *Lampsilis higginsi* (Lea, 1857)
      - *Lampsilis ventricosa* (Barnes, 1823)
      - *Epioblasma triquetra* (Rafinesque, 1820)
  - **ORDER VENEROIDA** H. and A. Adams, 1856
    - **FAMILY CORBICULIDAE** Gray, 1847
      - *Corbicula fluminea* (Muller, 1774)

Table 2 : Relative Abundance of Live Mussels on the Saint Croix National Scenic Riverway-1987.

	Relative Abundance Transect (34 Transects)		Regular Transect (50 Transects)	
Species	Ave. Percent of Abundance	Standard Deviation	Ave. Percent of Abundance	Standard Deviation
Actinonaias ligamentina	23.1	0.280	23.1	0.276
Alasmidonta marginata	1.5	0.027	0.0	0.021
Amblema plicata	8.3	0.178	5.6	0.160
Anodonta g. grandis	0.6	0.013	0.0	0.000
Anodonta g. corpulenta	0.2	0.009	2.6	0.143
Anodonta imbecillis	0.0	0.002	0.0	0.000
Anodontoides ferussacianus	1.1	0.042	0.0	0.000
Corbicula fluminea	0.0	0.001	2.0	0.141
Cumberlandia monodonta	0.3	0.019	0.6	0.040
Cyclonaias tuberculata	2.7	0.054	0.2	0.008
Ellipsaria lineolata	0.0	0.002	0.0	0.000
Elliptio dilatata	6.6	0.080	4.5	0.200
Epioblasma triquetra	0.4	0.017	0.0	0.000
Fusconaia ebena	0.0	0.000	0.0	0.000
Fusconaia flava	15.6	0.206	3.6	0.104
Lampsilis higginsi	0.0	0.001	0.0	0.000
Lampsilis radiata	7.8	0.118	4.3	0.109
Lampsilis ventricosa	4.6	0.082	11.4	0.274
Lasmigona complanata	0.1	0.002	0.0	0.000
Lasmigona compressa	2.4	0.065	0.0	0.000
Lasmigona costata	5.2	0.087	1.1	0.029
Leptodea fragilis	5.8	0.012	0.9	0.035
Ligumia recta	1.8	0.046	0.7	0.018
Obliquaria reflexa	0.3	0.011	0.9	0.055
Obovaria olivaria	1.7	0.038	0.1	0.004
Pleurobema sintoxia	1.5	0.034	1.0	0.027
Potamilus alatus	0.7	0.024	0.7	0.032
Potamilus laevissima	0.0	0.000	0.0	0.000
Quadrula fragosa	0.0	0.000	0.0	0.000
Quadrula metanevra	0.6	0.018	0.3	0.016
Quadrula pustulosa	2.8	0.043	1.4	0.059

Table 2 (continued): Relative Abundance of Live Mussels on the Saint Croix National Scenic Riverway-1987.

Species	Relative Abundance Transect (34 Transects)		Regular Transect (50 Transects)	
	Ave. Percent of Abundance	Standard Deviation	Ave. Percent of Abundance	Standard Deviation
Quadrula quadrula	0.6	0.000	0.0	0.000
Simpsonaias ambiqua	0.0	0.000	0.0	0.000
Strophitus undulatus	3.5	0.064	3.6	0.156
Toxolasma parvus	1.4	0.085	0.0	0.000
Tritigonia verrucosa	0.7	0.021	0.6	0.030
Truncilla donaciformis	0.0	0.003	0.5	0.029
Truncilla truncata	3.2	0.078	1.1	0.046

Table 3: Average Density of Live Mussels for all Transects on the Saint Croix National Scenic Riverway-1987.

	Relative Abundance Transect (34 Transects)			Regular Transect (50 Transects)		
Species	Ave. No./ 60 sq. meters	Standard Deviation	Range	Ave. No./ 60 sq. meters	Standard Deviation	Range
Actinonaias ligamentina	33.94	80.61	0-449	10.16	40.61	0-286
Alasmidonta marginata	1.79	3.38	0-016	0.34	1.15	0-006
Amblema plicata	6.67	15.44	0-070	0.82	1.83	0-007
Anodonta g. grandis	0.67	2.02	0-010	0.02	0.14	0-001
Anodonta g. corpulnta	0.08	0.28	0-001	0.10	0.36	0-002
Anodonta imbecillis	0.05	0.23	0-001	0.00	0.00	0-000
Anodontoides ferussacianus	0.32	1.29	0-007	0.00	0.00	0-000
Corbicula fluminea	0.32	0.17	0-001	0.10	0.70	0-005
Cumberlandia monodonta	0.29	0.17	0-001	0.40	2.82	0-020
Cyclonaias tuberculata	2.79	5.52	0-021	0.22	0.86	0-005
Ellipsaria lineolata	0.14	0.60	0-003	0.00	0.00	0-000
Elliptio dilatata	6.76	10.04	0-040	2.52	6.20	0-029
Epioblasma triquetra	0.41	1.63	0-009	0.00	0.00	0-000
Fusconaia ebena	0.00	0.00	0-000	0.00	0.00	0-000
Fusconaia flava	30.38	138.02	0-810	1.06	2.75	0-016
Lampsilis higginsi	0.02	0.17	0-001	0.00	0.00	0-000
Lampsilis radiata	9.11	25.45	0-127	0.58	1.48	0-008
Lampsilis ventricosa	3.14	7.06	0-039	0.56	1.07	0-006
Lasmigona complanata	0.14	0.70	0-004	0.00	0.00	0-000
Lasmigona compressa	0.91	2.73	0-015	0.00	0.00	0-000
Lasmigona costata	4.44	9.31	0-047	0.78	3.12	0-021
Leptodea fragilis	0.50	1.13	0-005	0.14	0.49	0-003
Ligumia recta	1.91	5.41	0-031	0.48	1.56	0-010
Obliquaria reflexa	0.47	1.74	0-010	0.14	0.75	0-005
Obovaria olivaria	1.52	3.19	0-014	0.06	0.31	0-002
Pleurobema sintoxia	1.41	3.37	0-019	0.24	0.65	0-003
Potamilus alatus	0.41	0.92	0-003	0.16	0.59	0-002
Potamilus ohiensis	0.00	0.00	0-000	0.00	0.00	0-000
Quadrula fragosa	0.00	0.00	0-000	0.00	0.00	0-000
Quadrula metanevra	0.58	1.84	0-008	0.04	0.19	0-001

Table 3 (continued): Relative Density of Live Mussels for all Transects on the Saint Croix National Scenic Riverway-1987.

Species	Relative Abundance Transect (34 Transects) Ave. No./ 60 sq. meters	Standard Deviation	Range	Regular Transect (50 Transects) Ave. No./ 60 sq. meters	Standard Deviation	Range
Quadrula pustulosa	3.00	6.83	0-036	0.38	1.45	0-009
Quadrula quadrula	0.02	0.17	0-001	0.00	0.00	0-000
Simpsonaias ambigua	0.01	0.68	0-004	0.00	0.00	0-000
Strophitus undulatus	2.14	4.96	0-025	0.42	1.27	0-008
Toxolasma parvus	0.02	0.17	0-001	0.00	0.00	0-000
Tritigonia verrucosa	0.50	1.44	0-007	0.08	0.34	0-002
Truncilla donaciformis	0.26	0.96	0-004	0.06	0.31	0-002
Truncilla truncata	6.00	19.93	0-088	0.16	0.61	0-003

Table 4 : Relative Abundance of Mussels by Bottom Type for all Transects on the Saint Croix National Scenic Riverway- 1987.

Bottom Type	Percent of Mussels Found
Sand/Gravel	22.6
Sand/Gravel/Mud	17.9
Sand/Rock	10.7
Gravel/Rock	6.0
Sand	3.6
Drifting Sand	3.6
Drifting Sand/Rock	3.6
Sand/Muck	2.4
Gravel	2.4
Drifting Sand/Gravel	2.4
Muck	2.4
Rock/Muck	2.4
Silt/Muck	1.2
Gravel/Silt/Rock	1.2
Gravel/Muck	1.2
Drifting Sand/Gravel/Mud	1.2
Drifting Sand/Gravel/Rock	1.2
Drifting Sand/Muck	1.2
Rock	1.2
Sand/Silt	1.2
Sand/Detritus	1.2
Sand/Gravel/Silt	1.2
Sand/Gravel/Muck	1.2
Sand/Mud	1.2
Sand/Rock/Muck	1.2
Sand/Rock/Mud	1.2
Sand/Wood	1.2