Annual Report:
Quantitative Assessment of Zebra Mussels at Native Mussels Beds in the Lower St. Croix River - 2005.

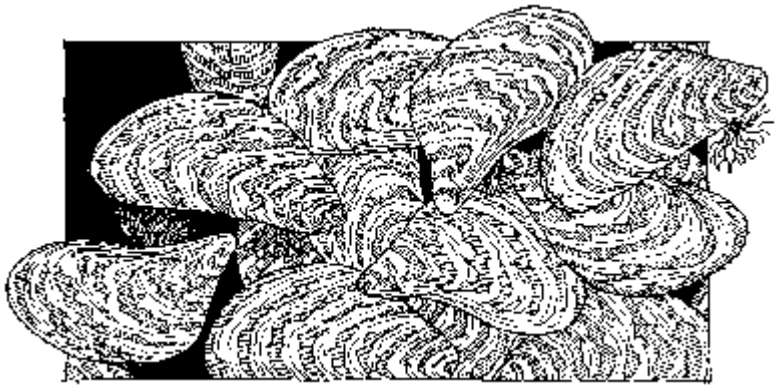

Image from U.S. Coast Guard Auxiliary (www.uscgaux.org/~08531/images/mussels.gif)

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Summary

The St. Croix National Scenic Riverway is a unit of the National Park System with a nationally important resource of native freshwater mussels. Living within the Riverway are two federally endangered mussel species—Higgins' eye pearlymussel (*Lampsilis higginsii*) and winged mapleleaf (*Quadrula fragosa*)—as well as many species listed for protection in Minnesota and Wisconsin. The outstanding diversity and abundance of native mussels within the Riverway is likely to be severely impacted if zebra mussels (*Dreissenia polymorpha)* reach the high densities found in areas of the Upper Mississippi River. This invasive species decimates native species found in the same system, through competition, habitat modification, and physical colonization. Baseline data and future monitoring of zebra mussel population density and distribution in the lower St. Croix River is crucial in order to identify future trends of a zebra mussel infestation and provide aid in the prevention and control of the species spreading.

To expand the monitoring of zebra mussels in the lower St. Croix National Scenic Riverway, a quantitative sample design was developed in 2004 (NPS 2004)and it can be viewed online at www.nps.gov/sacn/management/Final2004ZMDensityonStCroix.pdf. Prior to 2004, quantitative substrate sampling had not been used consistently because the number of zebra mussels throughout the river was too low to justify this labor-intensive method. While the zebra mussel population at Prescott prior to 2004 was detectable in timed searches, in the remainder of the river, zebra mussels had yet to be established. However, the Army Corps of Engineers has a need for specific monitoring and data collection. In addition, the ever increasing zebra mussel populations in the St. Croix River, creates the urgency and need to develop quantitative protocols for extensive monitoring to estimate their presence-absence and the population densities.

This new effort to determine the severity of the zebra mussel infestation augments current monitoring techniques. Qualitative monitoring has been used to assess the extent of zebra mussel colonization (>1m^2) in the St. Croix since the early 1990's. This involves the use of site specific PVC plate samplers to detect settling post-veligers, and SCUBA diving at various locations to search river substrate for the presence/absence of juveniles

and adults. The use of transects has been a tool in the past, as have plankton tows and fixed-amount water sampling for veligers. These methods are still employed to determine distribution and pelagic densities.

Methods

Anecdotal evidence suggests that zebra mussels prefer native mussel beds (Ron Benjamin, personal communication). This may be due to micro-habitat conditions or due to the nature of zebra mussels with the native mussels themselves. In many locations with uniformly sandy substrate, mussel shells are the only hard surfaces present and native mussels may therefore present an ideal substrate for zebra mussel attachment. Thus, we used a 2002 study by Davis and Kelner, which identified over two dozen mussel beds from Stillwater, MN to Prescott, WI. From this list, we chose 6 locations (Appendix F), generally spread within and among the pools that comprise the lower 24 miles of the river, locally known as Lake St. Croix. This comprises the known area with a presence of zebra mussels. In addition to these locations, the two Higgins' Eye Essential Habitat Areas identified near Hudson, WI and Prescott, WI were included. All sites were sampled from up to downstream to avoid contamination. These 8 sites (see Appendix) now comprise the permanent monitoring locations to be used for long term assessments of zebra mussel population expansion.

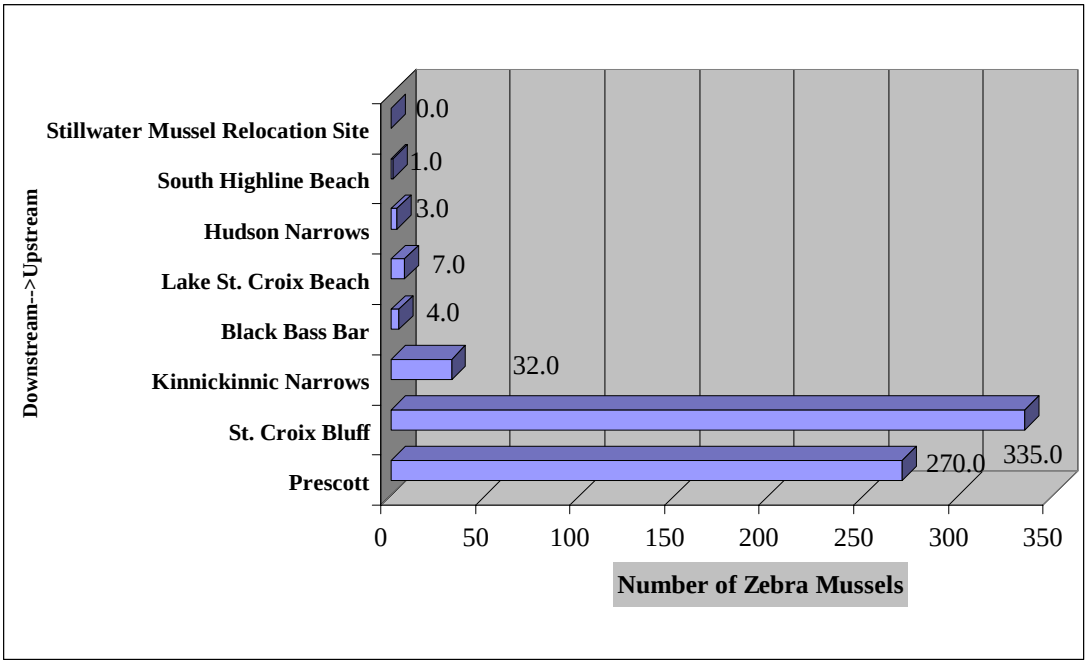
At each location, ten 1/8m^2 quadrats were thrown arbitrarily at three places from the boat within the perimeter (~300 meter circumference) of the mussel bed. Divers then collected all riverbed material within the quadrats to finger depth, and placed it into a plastic pail drilled with 3mm holes. The material was reduced to remove fine particulate matter, all live native mussels were recorded and any zebra mussels attached to native mussels were counted. Any remaining material was then poured into plastic bags for storage. The resulting 240-1 gallon bags (240 samples from the 30 each taken at the 8 locations) were then individually flushed through a 5mm mesh, all material larger than a grain of sand was returned to the bag to freeze. The samples were then checked more closely under light and magnification for a detailed count. All zebra mussels, snails, native mussel shells, and Corbicula were counted. Additionally, zebra mussels are

measured for length, and the live/dead ratio recorded and separated. For more detailed information concerning the methods for this study, please see the initial 2004 report noted above.

Results

From the 8 locations sampled in 2005, a total of 240 substrate samples (30 at each of the 8 locations) were collected and processed. A total of 652 zebra mussels from these samples were collected within a total area of 30 square meters over a river reach of nearly 22 miles. No zebra mussels were collected from sampling efforts at the Stillwater Relocation Location (Fig. 1). One was detected on the south side of Hi Line Beach, across from the Andersen Bay. Only three zebra mussels were found within the Hudson Narrows. As the data in Figure 1 shows, zebra mussel detection remains very low in the river pool from Stillwater, MN to Hudson, WI, Hudson to Afton, MN and Afton to the Kinnickinnic River. It is in the last pool (see Appendix E), from the Kinnickinnic River to the city of Prescott, WI (confluence with the Mississippi River at Pool 3) that the relative abundance of zebra mussels increases notably. Therefore, only the four sites where data was sufficient to capture the age structure of the population have been included for comparison.

Figure 1. Total Number of Zebra Mussels Collected by Location - 2005



In addition to identifying the presence/absence of zebra mussels at the specified locations, two other important components of the data collected include the ratio of dead to live zebra mussels and the rate at which zebra mussels are found on live native mussels. The two Higgins' Eye Essential Habitat Areas were not directly included as part of the results, because the data collected within these areas do not include comparable data from the 2004 sampling. However, as Table 1 suggests, the number of dead zebra mussels found at the other 6 locations was never more than 6 individuals. Colonization rates are an important indicator of the impacts of zebra mussel on native mussels and other fauna (Hunter et. al 1996). The baseline data from 2004 indicate numbers (<5) of zebra mussels attached to native mussels. In 2005, we found 25 zebra mussels covering 22 natives at the Prescott site. The remainder of the locations reflects largely isolated impacts, and the overall numbers of zebra mussels found on native mussels were greater in 2005 than in 2004.

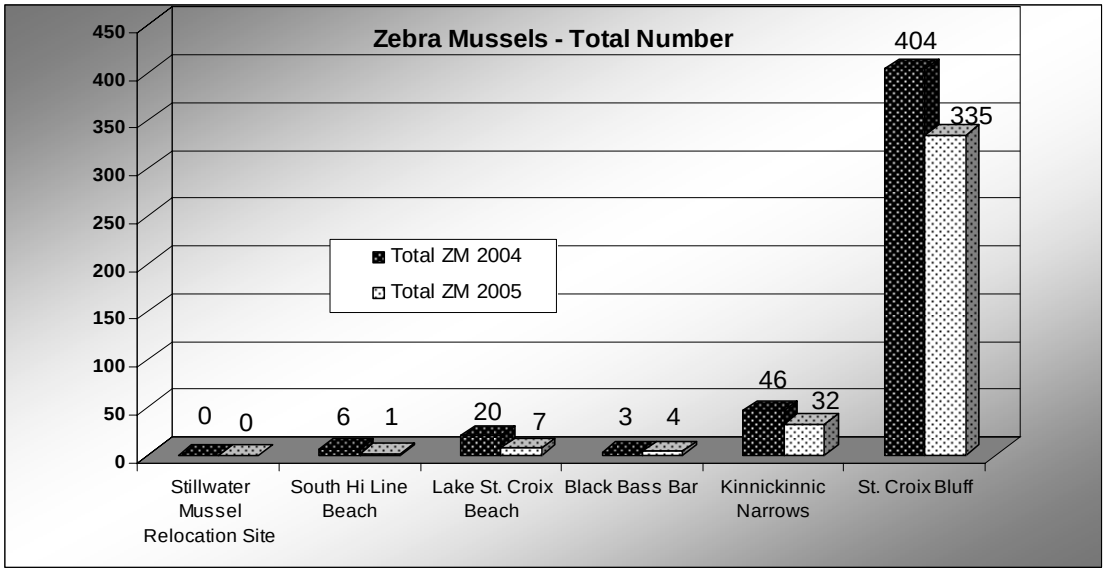
Slightly fewer (379 to 479) total zebra mussels were collected in 2005, compared to 2004. However, the trend remained the same for both years (Fig. 2 *Note: no data was collected during 2004 from Hudson and {Prescott*). Few or no zebra mussels were found in the upstream sample, but numbers slowly increase (perhaps as juveniles drift downstream) until at St. Croix Bluffs and Prescott where more animals were located (Appendix A). This range reflected a mean of 1.9 to 8.5m^2 zebra mussels from the Kinnickinnic Narrows upstream, to 89.3m^2 at St. Croix Bluffs.

Table 1. Number of Zebra Mussels (ZM) on Native Mussels by Year and Number of Live and Dead Zebra Mussels by Location.

Site	Live:Dead Ratio ZM 2005	Colonization of ZM on live native mussels 2004	Colonization of ZM on live native mussels 2005
Stillwater Mussel Relocation Site	0:0	0	0
South Highline Beach	0:0	2	0
Hudson Narrows	0:0	*	0
Lake St. Croix Beach	7:0	16	1
Black Bass Bar	4:0	2	0
Kinnickinnic Narrows	32:0	7	0
St. Croix Bluff	335:9 (37:1)	19	3
Prescott	269:22 (12:1)	*	25

* This information was not collected in 2004.

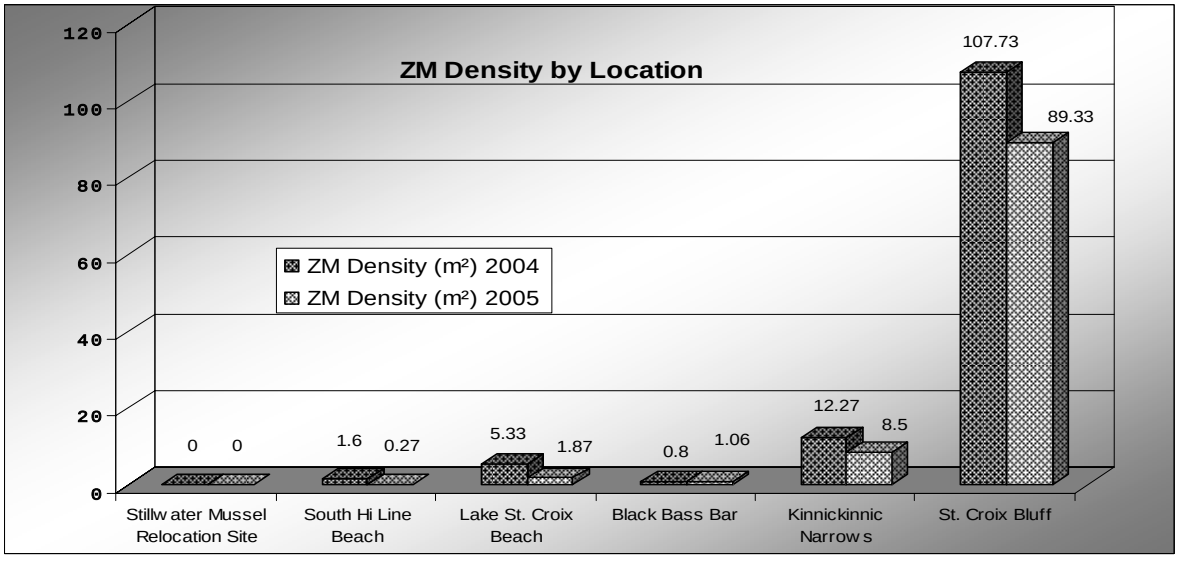
Figure 2. Total Number of Live Zebra Mussels Collected by Location and Year.



(upstream to downstream)

The zebra mussel densities at the specified locations (Fig. 3), shows St. Croix Bluffs with a modest infestation relative to Lake Pepin (zms found >1000m^2) and other locations on the Mississippi River, but reflects the upward trend in the number of zebra mussels collected from upstream to downstream. At four of the five sites where zebra mussels were present, densities appeared to declined slightly from 2004 to 2005. Only at Black Bass Bar did densities appear to slightly increase. However, none of these differences were significant ($p=1.07x10^{-5}$).

Figure 3. Density of Zebra Mussels by Location and Year.



In areas where zebra mussels were sparse (Stillwater, Hi Line, Hudson, Lake St. Croix Beach, Black Bass Bar), the amount of available habitat and lack of competition should allow these species to grow larger and live longer at low densities. In Hudson, zebra mussels were found in the narrow channel with current where ample food and suitable substrate produced ideal conditions for these mussels to reach full maturity of ~35mm. Elsewhere, lengths between 10 and 20 mm indicates zebra mussel generally less than 2 years old, based on growth rates of 10mm per year. (Neumann, et al. 1992).

The histograms in Appendix E (sites with n=>10) suggests that in the locations where more significant settlement occurred, the zebra mussels were slightly larger (and older) from upstream to downstream. However, the mean length (17, 11, 14, 12mm respectfully) at each of the four locations was below 20 mm, indicating most zebras found were less than 2 years old, suggesting a recent infestation.

An animal approximately 10 mm in length is assumed to be of adult age and of reproducing potential (Claudi and Mackie 1993). Zebra mussels continue to grow as they age and typically during optimal growth periods can grow a millimeter a week. 10 to 15 millimeters is considered size of reproductive maturity and 35 to 40 mm is about maximum size at the typical age limit of 3 to 4 years.

Throughout the sampling reach, native mussels were collected at densities generally considered to be within a "bed" (>4-5 native mussels/m^2), as shown in Appendix C. This sampling design is intended to place sites in areas most likely to reflect maximum zebra mussel colonization. Appendix B provides a comparison of the dead and live native mussels collected over the last two seasons. There is a trend from up to downstream in the number of dead native mussel shells found. This was true for both the 166 collected in 2004 and the 380 collected in 2005, although the sampling size was larger in 2005. The number of live mussels collected was greater at the two upstream locations at Stillwater (21) and Hi Line Beach (28) and though less downstream, among the sites beyond the I-94 bridge, are similar between years.

Finally, at the 6 locations where year-to-year comparisons are possible, the numbers of Asiatic clams (*Corbicula spp.*) is generally the same between years and remains in the same rank order from 2004 to 2005. The high numbers of this invasive clam at Hi Line beach may be a reflection of the water discharge channel directly across the river. The electric power plant on the Minnesota shore provides a constantly higher annual mean temperature than the rest of the river. As the Asiatic clam reaches the northern part of its range on the St. Croix River, this suggests that warmer waters in this section may aid their winter survival (Appendix D.)

Discussion and Conclusion:

In addition to the six locations and 180 samples sites collected in 2004, in 2005 we added the two Essential Habitat Areas at Hudson and Prescott. These two locations are now part of the ongoing monitoring program that will allow us to track the changes in zebra mussel densities on the Lower St. Croix River in the future. The numbers of native mussels collected at all locations during the two sampling seasons is consistent with the mussel beds identified in the study design.

The 2004-2005 data suggest no difference in zebra mussel recruitment between years or locations. There are still few to very few zebra mussels in the sampling locations upstream of Hudson. Zebra mussels increase in density progressively downstream, becoming more abundant within the Kinnickinnic to Prescott pool.

Zebra mussels continue to be found mostly live, reflecting a young population and the lack yet of a significant year class die-off as has happened on other rivers. (Neumann et al. 1992) Additionally, the infestation rate of zebra mussels on native mussels still remains generally less than 1 zebra mussel per native mussel. While there were a greater number of dead native mussels found at downstream locations, there is no evidence to link an impact from zebra mussels.

The length frequencies of zebra mussels at various locations appear to suggest that there are older (and larger) mussels found more at upstream locations than downstream. However, because most of the zebra mussels collected were not yet sexually mature, it is likely that the different year-classes do not necessarily represent parents and their progeny. Zebra mussel veligers (the larval form) are planktonic for approximately two weeks before settling on a hard substrate as sub-adults. Veliger densities can thus be indicative of future recruitment. Veligers were collected using fixed-volume sampling at the Hudson and Prescott sites. These data will be reviewed when it becomes available to determine the extent of reproduction last season.

At this time, direct management action on the part of the native mussel fauna does not appear to be necessary. Colonization of native mussels by zebra mussels is below 2 per native. This is below the threshold suggested as lethal to native mussels (Schloesser, et al. 1996). However, the data we collected are an important tool for future intervention, thus continued monitoring is crucial.

Literature Cited

Claudi, R. and G.L. Mackie. 1993. Practical manual for zebra mussel monitoring and control. Boca Raton: Lewis Publishers. 227pp.

Doolittle, T. C. J., D. J. Heath, and P. W. Rasmussen. 1995. Second sampling of freshwater mussel communities for long-term monitoring of the Saint Croix National Scenic Riverway, Minnesota and Wisconsin-phase I. Sigurd Olson Environmental Institute, Northland College, Ashland, WI. WI Department of Natural Resources, Madison, WI.

Hornbach, D. J. 2001. Macrohabitat factors influencing the distribution of naiads in the St. Croix River, Minnesota and Wisconsin, USA. Ecological Studies, Vol. 145, 213-230pp.

Hove, M. and D. Hornbach. 2002. Mussel communities in the St. Croix National Scenic Riverway: an outstanding natural resource - 2002 field season. Annual report to the St. Croix National Scenic Riverway, National Park Service. St. Croix Falls, Wisconsin. 55pp.

Hunter, R. D. and J. F. Bailey. 1992. *Dreissena polymorpha* (Zebra Mussel): Colonization of soft substrata and some effects on unionid bivalves. Oakland University

Hunter, R.D., S. A. Toczylowski, and M. G. Janech, 1996. Zebra mussels in a small river: Impact on Unionids. *in* F. D'itri, (ed). *Zebra Mussels and Other Aquatic Nuisance Species.* Boca Raton: Lewis Publishers. pp. 161-186.

Karns, B. 2005. The St. Croix River zebra mussel response plan: 2003 annual report. Report (unpub.) from National Park Service to the St. Croix River Zebra Mussel Task Force, 15pp.

Kelner, D and M. Davis. 2002. Mussels (Bivalvia: Unionidae) surveys 2001. Final report (unpub.) by the Minnesota DNR to the U.S. Army Corps of Engineers, St. Paul District. 45pp.

McMahon R. F. 1991. Mollusca: Bivalvia. In: Thorp, J.H., Covich, A.P. (eds*) Ecology and classification of North American freshwater invertebrates*. Academic Press, San Diego, pp 315±399.

Neumann, D., J. Borcherding, B. Jantz. 1992. Growth and seasonal reproduction of Dreissena polymorpha in the Rhine River and adjacent waters. *in* Nalepa, T.F., and D.W. Schloesser, (eds). *Zebra mussels: biology, impacts, and control.* Lewis Publishers, Boca Raton, FL. pp. 95-109.

Robertson, D. M., and B. Lenz. 2003. Response of the St. Croix River Pools, Wisconsin and Minnesota, to various phosphorus-loading scenarios. United States Geological Survey. Water-Resources Investigations Report 02-4181.

Schloesser, D. W., T. F. Nalepa and G. L. Mackie. 1996. Zebra Mussel Infestation of Unionid Bivalves (Unionidae) in North America. Amer. Zool.., 36:300-310

U.S. Fish and Wildlife Service (USFWS). 2000. Biological opinion for the operation and maintenance of the 9-foot navigation channel on the Upper Mississippi River system. U.S. Fish and Wildlife Service, 15 May 2000, 243 pages.

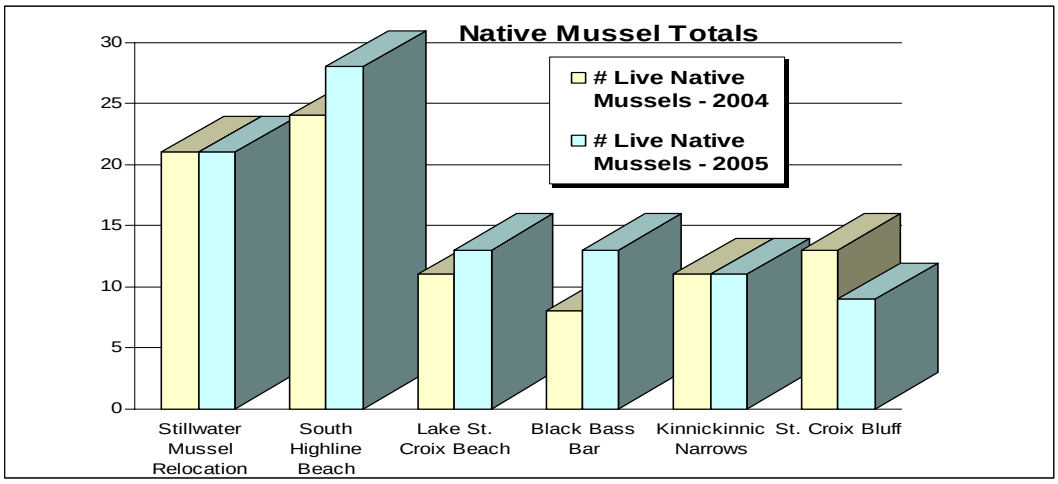
Whitney, S. D., K. D. Blodgett and R. E. Sparks. 1996. A comprehensive mussel survey of the Illinois River, 1993-1995. Illinois Natural History Survey Aquatic Ecology Tech. Rpt. 1997(11), Havana Il. 31 pp + Appen. A-J.

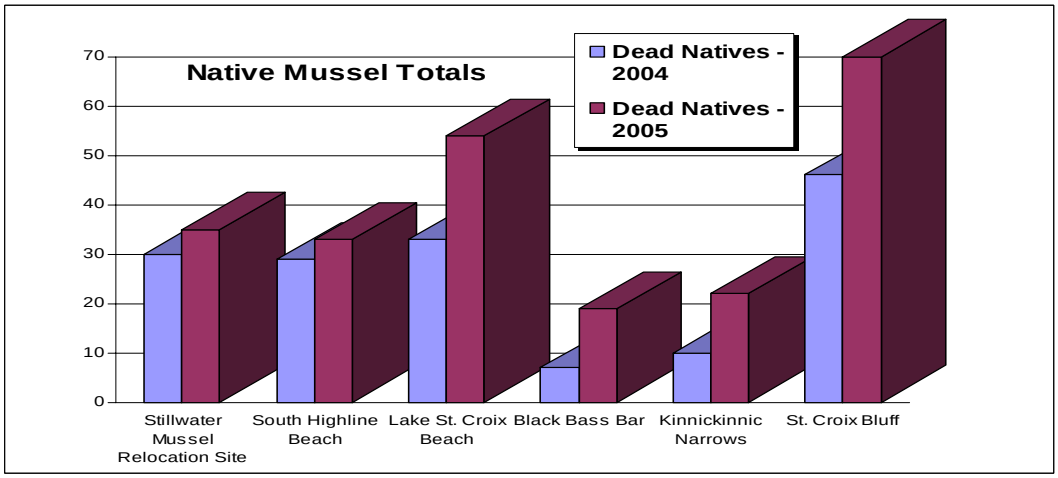
Appendix

A. Data Collected Related to Zebra Mussels, Native Mussels and Asiatic Clams – by Location (includes data from single cluster found on a rock).

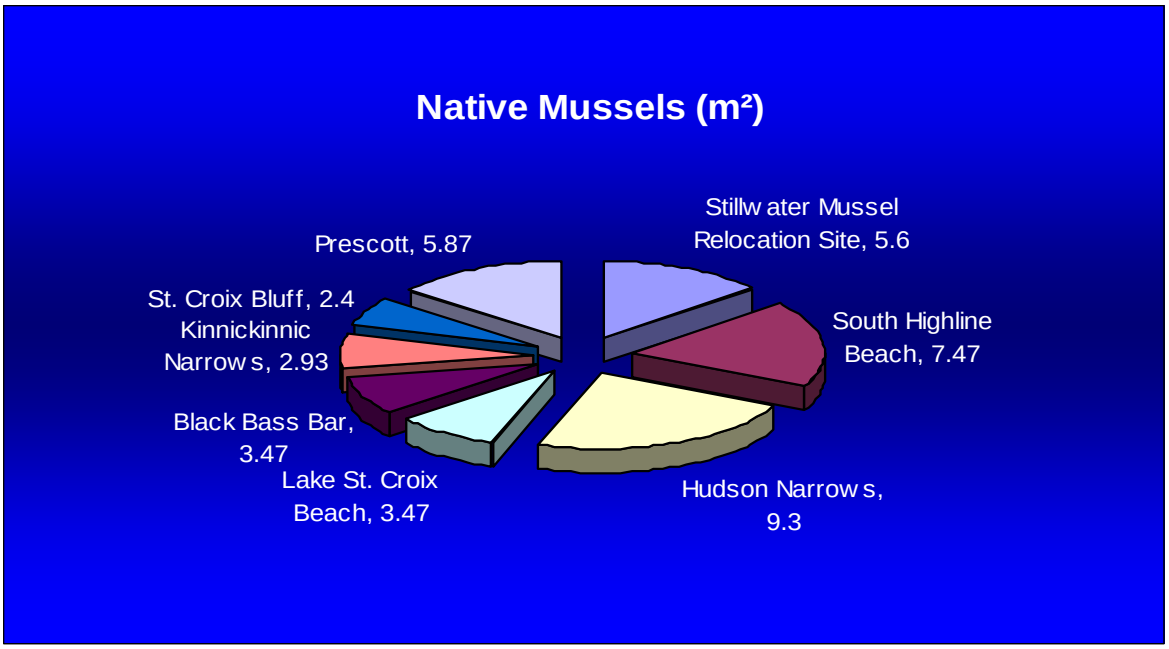
Site Name	Corbicula	Dead Natives	# Live Native Mussels	Live Native Mussel Densities (m²)	zm on live mussels	Byssal Treads	ZM Density [Total ÷ 3.75m² = m²]	Total zm	Zebra Mussel Live to Dead Ratio	ZM Size Mean	ZM <mm	ZM >mm
Stillwater Mussel Relocation Site	2	35	21	5.6	0	0	0.00	0	0:0	0	0	0
South Highline Beach	87	33	28	7.47	0	0	0.27	1	0:0	18.9	0	0
Hudson Narrows	20	89	35	9.3	0	0	0.80	3	3:0	33.1	0	0
Lake St. Croix Beach	51	54	13	3.47	1	0	1.87	7	7:0	11.7	0	0
Black Bass Bar	30	19	13	3.47	0	0	1.06	4	4:0	12.9	12.7	13.1
Kinnickinnic Narrows	1	22	11	2.93	0	16	8.50	32	32:0	11	8.5	19.4
St. Croix Bluff	53	70	9	2.4	3	37	89.33	335	335:9	14.0	9.5	17.6
Prescott	62	58	22	5.87	25	34	71.73	269	269:22	12.2	7.8	17.1
Totals	306	380	152	5.07	29	87	21.70	651		14.2	4.8	8.4
Black Bass Bar - Cluster Example								49		17.4	10	22.3

B. Comparison of Native Mussels Collected at Six of Eight Sampling Locations (comparable data), by Year and Condition



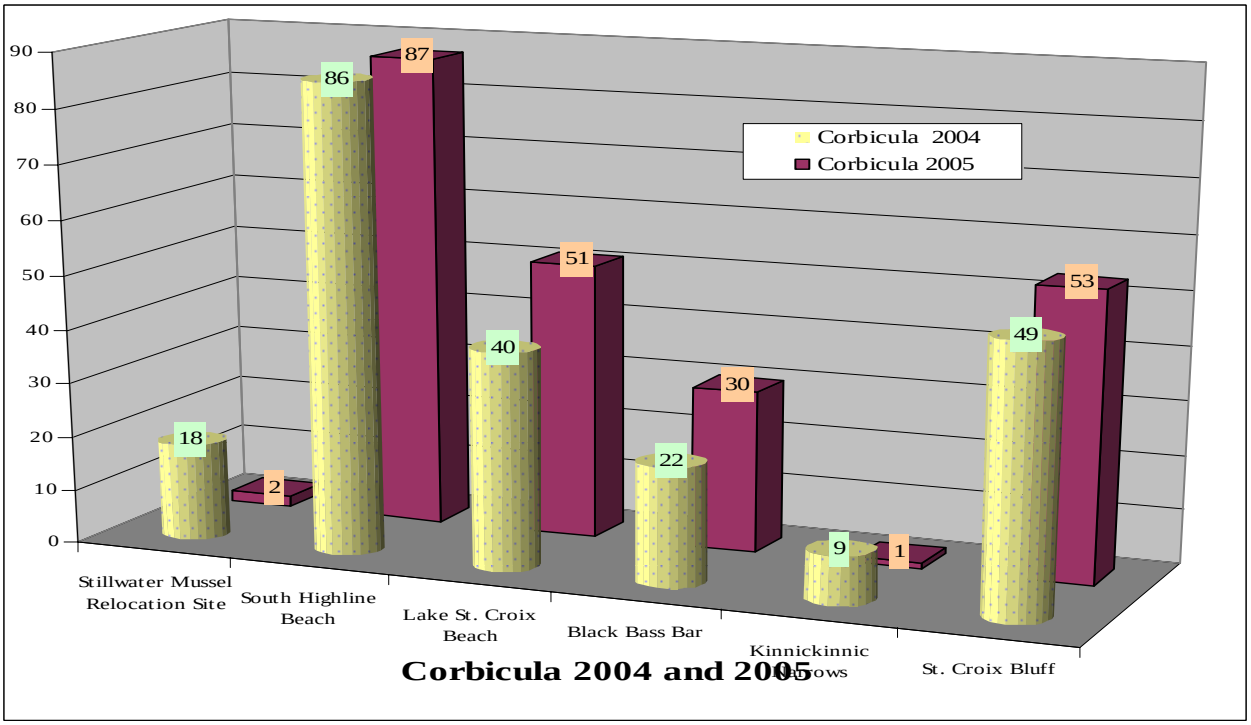


C. Native Mussel Densities by Location – 2005

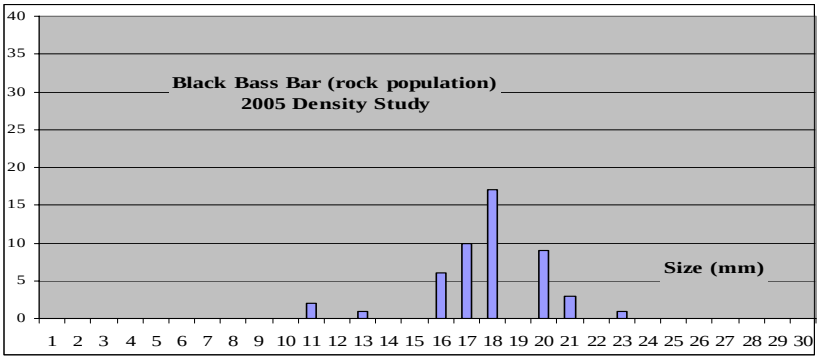


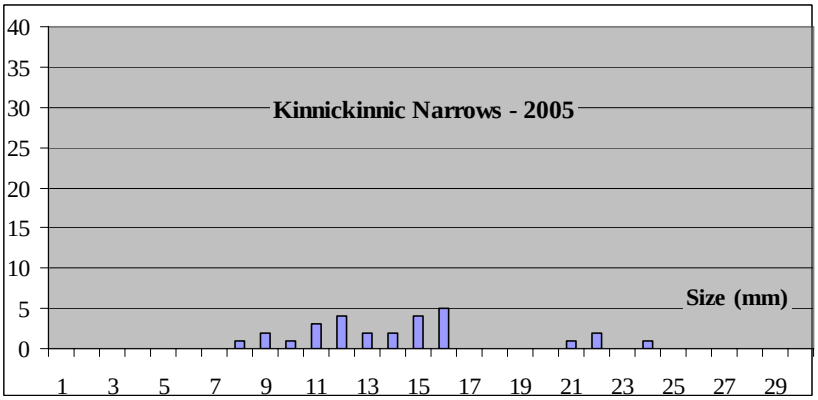
D. Asiatic Clams (Corbicula) Collected by Location and Year (table by density per m^2)

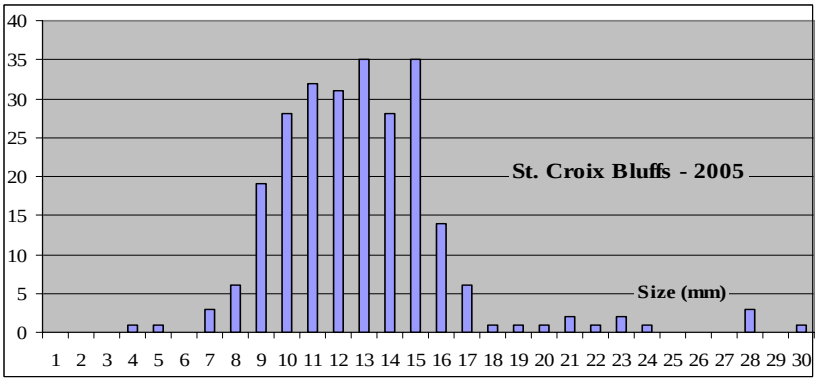
	Stillwater	Hi Line	Lake SCB	Black BB	Kinni	SC Bluffs
2004	4.8	22.93	10.67	5.87	2.4	13.1
2005	0.53	23.2	13.6	8.0	0.27	14.13

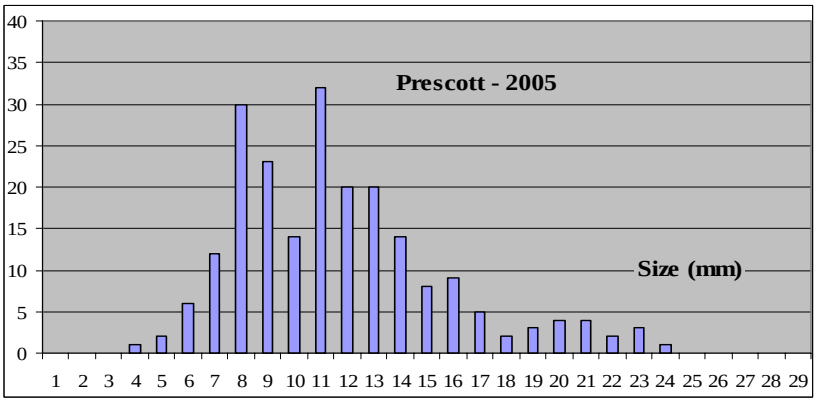


E. Histograms of Zebra Mussel Sizes at Four Locations (upstream to downstream)









F. Map of the Eight Native Mussel Beds Locations where Substrate for Long Term Zebra Mussel Density Monitoring Occurs