Results of 2002 Monitoring of Freshwater Mussel Communities of the Wisconsin River near Orion, Richland County, Wisconsin.

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October 2003

ACKNOWLEDGEMENTS

This work was supported by the St. Paul District of the U. S. Army Corps of Engineers. Significant in-kind work was contributed by various staff from the Wisconsin Department of Natural Resources.

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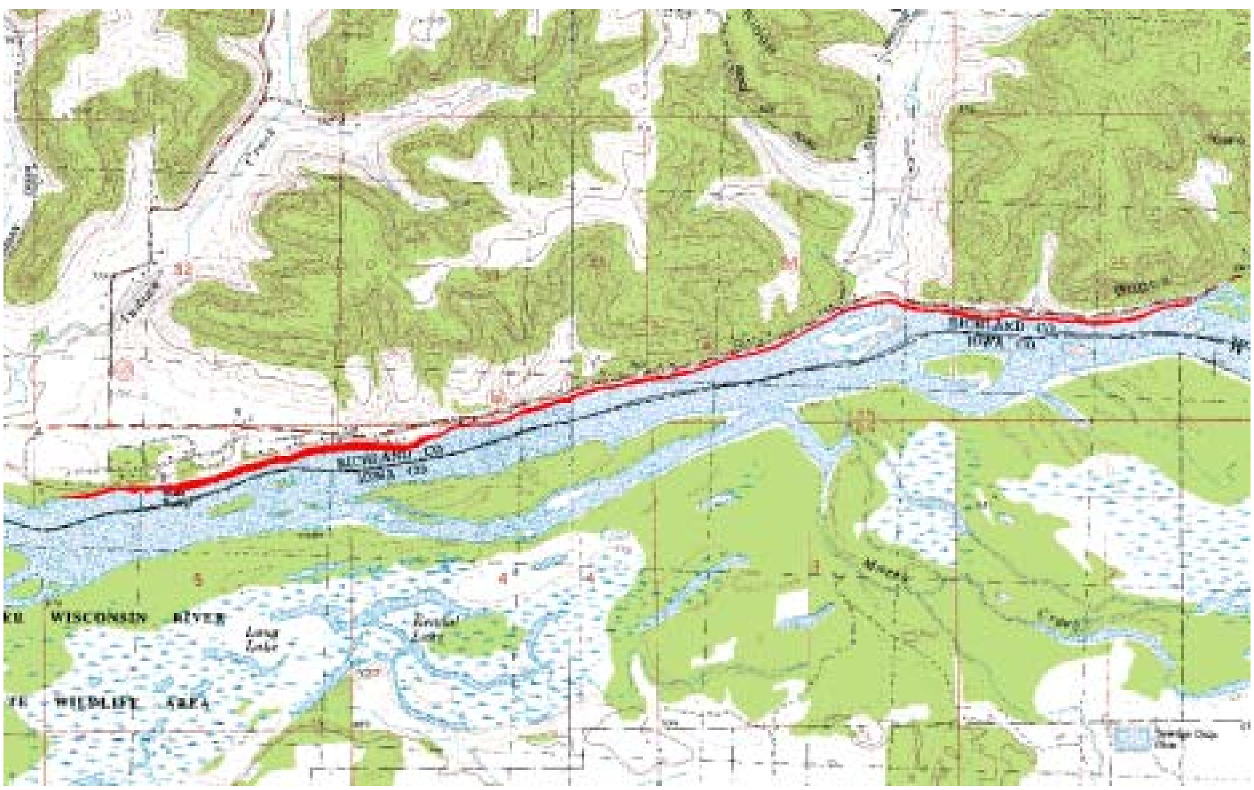
INTRODUCTION

This report briefly summarizes the 2002 results of continuing long-term monitoring of freshwater mussels in the Wisconsin River near Orion, Richland County, Wisconsin. Monitoring was begun in 1988 and was repeated in 1995 (Heath, 1995) as well as 2002. The purpose of this investigation was to repeat the sampling protocols used in 1988 and 1995 and compare results through time.

The Orion mussel bed was chosen, among others, for long-term monitoring due to the presence of one federally endangered mussel (*Lampsilis higginsii* (Lea, 1857)) as well as nine listed by the State of Wisconsin as endangered or threatened. This bed is also being considered for listing as “essential habitat” in the draft recovery plan for the higgins’ eye pearly freshwater mussel.

The questions we wanted answered were 1) Has population density changed? 2) Has size structure changed? 3) Was there a change in taxa richness? 4) How has community composition changed? 5) Has there been a change in living/dead or sex ratios?

Figure 1. Location of Orion Mussel Bed, Wisconsin River near Orion, Richland County, Wisconsin.



METHODS AND MATERIALS

The Orion mussel bed is located on the Wisconsin River in southern Richland County, Wisconsin near the unincorporated village of Orion. The mussel bed is along the north shore extending from 43º 12’ 6.2”N 90º 24’ 29.1”W upstream 6060 meters (m) to 43º 12’ 40.5”N 90º 20’ 4.5”W (Figure 1) and

Figure 2. Location of 100 randomly placed m² quadrat samples (red) and qualitative collection done at Orion in 2002. Downstream portion.

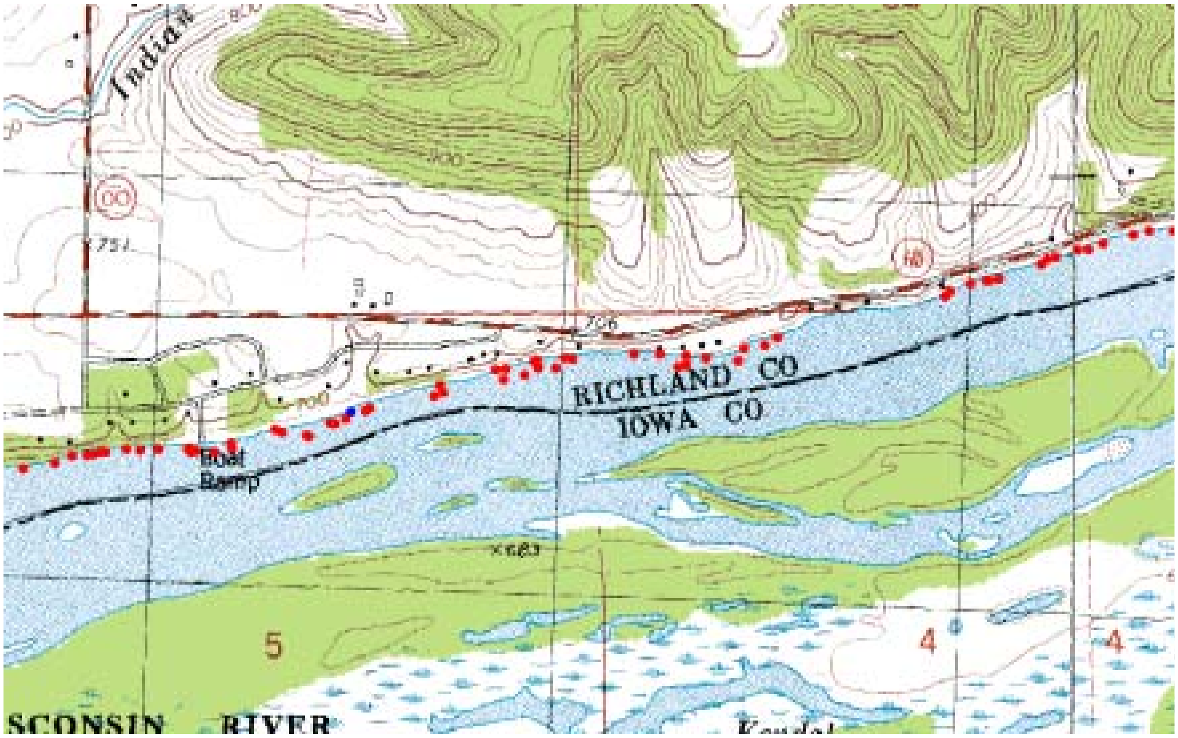
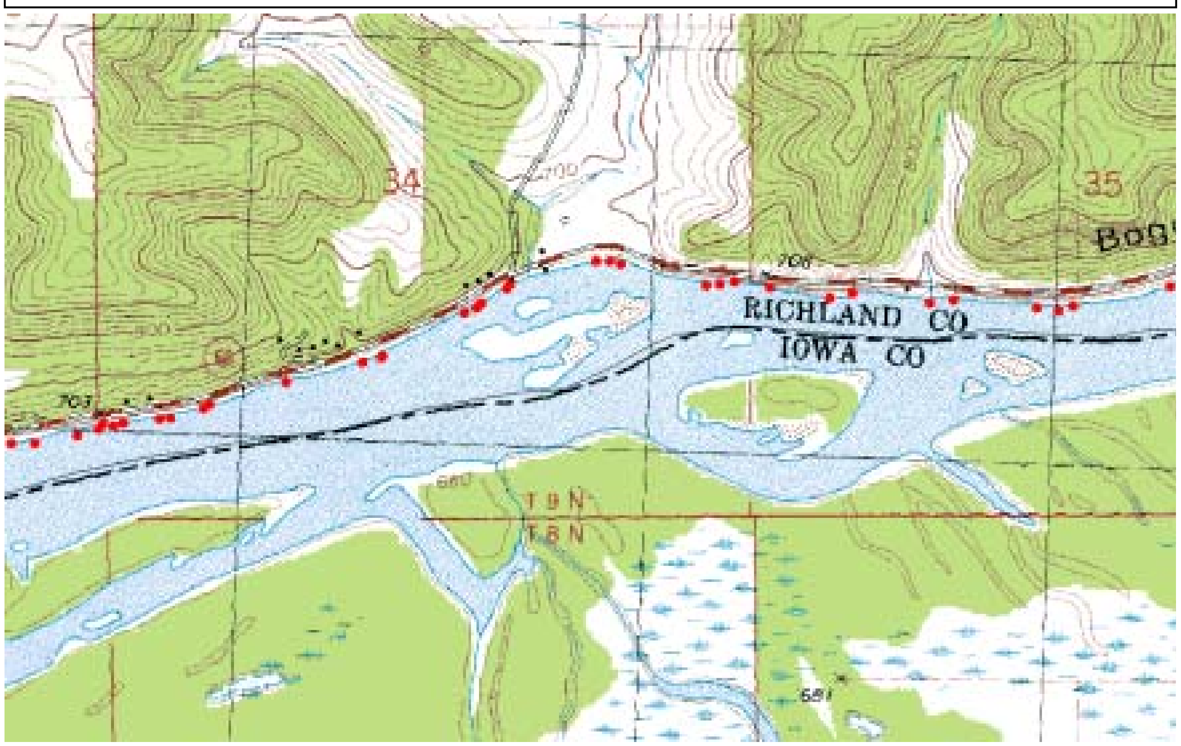


Figure 3. Location of 100 randomly placed m² quadrat samples (red) and qualitative collection done at Orion in 2002. Upstream portion.



includes an area of 114,930m².

A complete description of monitoring sampling methods are included in Heath and Rasmussen (1990). In summary, we took 100 randomly-placed, hand-collected 1m^2 quadrat samples (Figures 2 and 3) on July 24th and 25th, 2002, counted living and dead unionids, margaritiferids, *Corbicula* and *Dreissena*, measured and aged them, and visually determined gravidity status by slightly prying open the valves. In addition to quadrat sampling, we collected larger numbers of mussels by random searches (relative abundance collections) to increase sample size and complement comparisons of relative abundance and age and total length distributions between years and sites. Evenness calculations were done using the Modified Hill's Ratio as described in Ludwig and Reynolds (1988).

Statistical tests on population density were done using General Linear Models Procedure Tukey's Studentized Range and SAS software (SAS Institute, Inc. 1985).

RESULTS AND DISCUSSION

Streamflow and water elevations were near normal during the 2002 sampling period. During this survey, flow at the Muscoda USGS gage, located about 6000m downstream of the Orion bed, had a mean flow of 7225 cubic feet per second (USGS data). The mean monthly streamflow for July, over the 90 year period of record, is 7400 cubic feet per second.

TAXA RICHNESS and EVENNESS

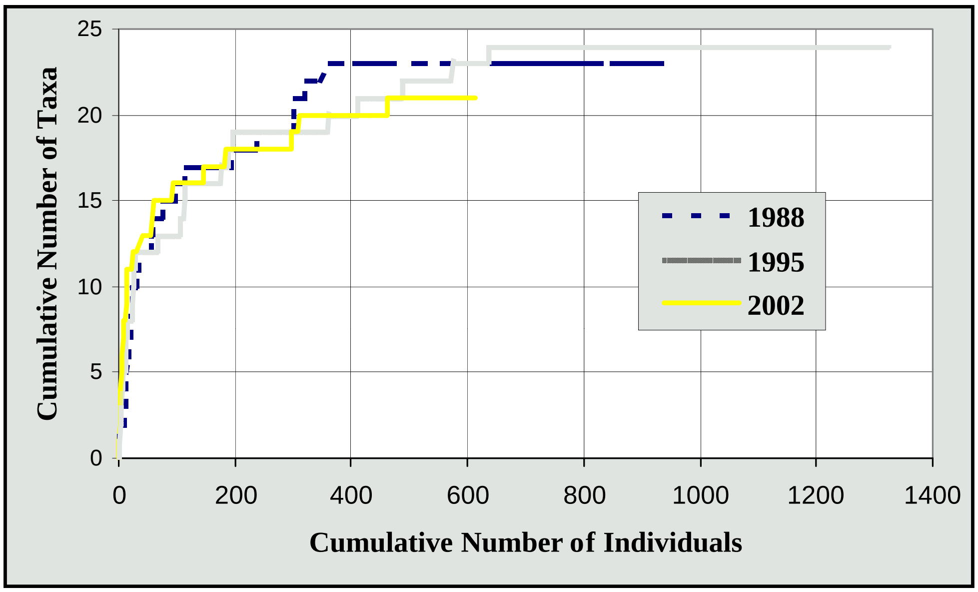
During 2002, we found a total of 21 taxa living and an additional 3 taxa represented by dead

Table 1. Number found Living and Dead of each Species during 2002 Sampling of the Orion Mussel Bed. Includes Quadrat Samples and Relative Abundance Collections.

TAXON	NUMBER LIVE	NUMBER DEAD
Alasmidonta marginata	9	2
Amblema plicata plicata	141	14
Anodonta grandis	1	0
Elliptio dilatata	103	21
Fusconaia flava	21	26
Lampsilis higginsii	0	1
Lampsilis siliquoidea	1	0
Lampsilis teres form anodontoides	2	0
Lampsilis cardium	55	19
Lasmigona complanata complanata	4	0
Leptodea fragilis	9	4
Ligumia recta	53	9
Obliquaria reflexa	0	1
Obovaria olivaria	15	20
Plethobasus cyphyus	10	0
Pleurobema sintoxia	5	5
Potamilus alatus	11	2
Quadrula metanevra	73	20
Quadrula pustulosa pustulosa	43	15
Quadrula quadrula	1	0
Simpsonaias ambigua	0	2
Strophitus undulatus undulatus	2	1
Tritogonia verrucosa	51	6
Truncilla truncata	3	2
TOTAL	613	170

individuals only (Table 1). No federally endangered *L. higginsii* were found living but one dead individual was found. A total of 4 species listed by the State of Wisconsin as endangered or threatened were found. These included *Lampsilis teres* form *anodontoides*, *Plethobasus cyphyus*, *Quadrula metanevra* and *Tritogonia verrucosa*. An additional 2 state listed species, *Simpsonaias ambigua* and *L.*

Figure 4. Cumulative Number of Individuals vs. Cumulative Number of Taxa for Samples at the Orion Mussel Bed, 1988, 1995, 2002.



higginsii were represented by dead individuals only.

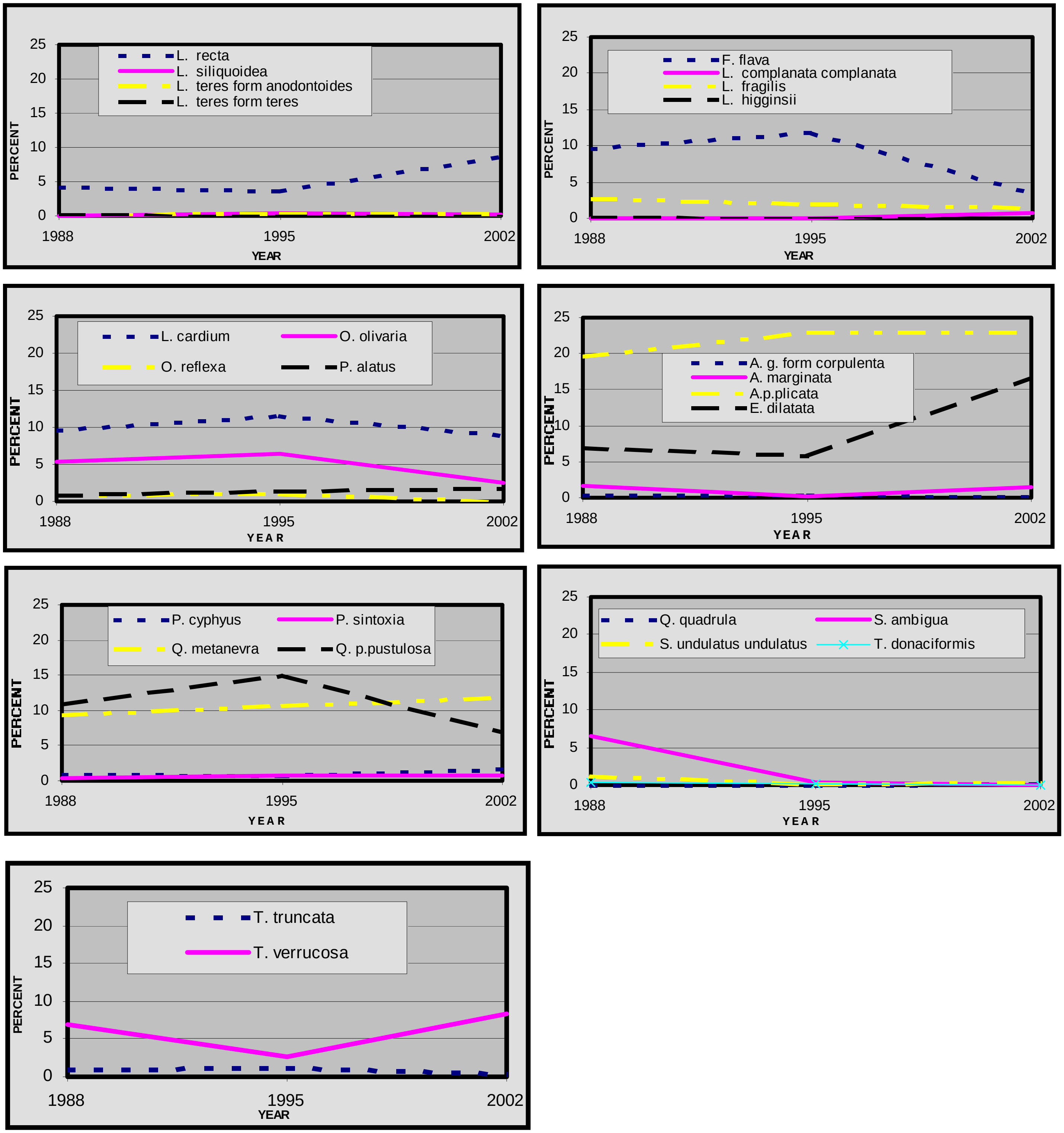
The cumulative number of taxa collected using methods whose results are representative of the community (i.e. quadrat and relative abundance collection methods) is influenced, among other things, by the total number of individuals collected. Considering this, taxa richness has not changed much among the three years (Figure 4) and there does not appear to be a trend. However, we did see two fewer taxa in 2002 compared to 23 found during 1995 and 1988 at a sample size of 600 individuals. This represents an 8.6% decline in richness at this sampling effort. Using the entire sample, we collected 23, 24 and 21 taxa respectively from 1988 (n=934), 1995 (n=1324) and 2002 (n=613). There was no trend in evenness. The Modified Hill's Ratio was 0.783, 0.735 and 0.744 for those years respectively.

NUMERICAL RELATIVE ABUNDANCE

Few trends in numerical relative abundance were apparent among the years 1988, 1995 and 2002. Only three trend points were available and therefore, these "trends" should be interpreted cautiously. More definitive trends can be established using six temporal points. Also, rarity of some taxa in the samples makes determination of real trends more difficult.

A total of five taxa showed an increasing trend in relative abundance. These included *Amblema p. plicata*, *Lampsilis teres* form *anodontoides*, *Lasmigona c. complanata*, *Quadrula metanevra* and *Q. quadrula* (Figures 5-11). All of these increases were fairly small; the greatest of which were 3.3 percentage points seen for *A. p. plicata*. For *L.* . f. *anodontoides*, *L. c. complanata and Q. quadrula*, it is

Figures 5-11. Changes in Relative Abundance of Mussel Taxa, 1988, 1995 and 2002 at the Orion Mussel Bed, Wisconsin R.



unclear whether they actually comprised a greater percentage of the community since they were so rare (< 1%) in all samples.

A total of six taxa showed a decreasing trend in relative abundance. These included *Anodonta grandis* form *corpulenta*, *L. higginsii*, *L. teres* form *teres*, *Leptodea fragilis*, *Simpsonaias ambigua* and *Truncilla donaciformis*. The greatest downward change occurred for *S. ambigua*, which decreased 6.5 percentage points. This change could easily be explained by its characteristically clumped spatial distribution. When one happens to sample a spatially rare aggregation, many mussels can be found. These aggregations are rarely chosen in random samples and this lithophilic mussel is very rarely found outside of these aggregations. The change in *L. higginsii* was very small, -0.21 percentage points. The decrease in *T. donaciformis* is of some concern since it also decreased in relative abundance in the St. Croix River (Heath, Benjamin and Endris, 2001).

Of the five taxa that showed an increasing trend in relative abundance, three of these we previously categorized as “exploitive” taxa and the remaining two as “sensitive” (see Heath and Rasmussen, 1990). Of the six taxa that showed a decreasing trend in relative abundance, one was “exploitive”, two were “sensitive” and three were “indifferent”. This suggests that there may have been a general relative increase in “exploitive” taxa and a combined decrease in “sensitive” and “indifferent” taxa. Future sampling may confirm this assumption.

POPULATION DENSITY

Arithmetic population densities for the three time periods at the Orion mussel bed are given in Table 2. Total mussel population densities have decreased since 1988 by 4.7 mussels/m² or 78%. There was a clear trend in densities; they were 6.05/m², 2.52/m² and 1.34/m² in 1988, 1995 and 2002, respectively.

Table 3. Results of tests of significance among years (1988, 1995-96, 2000) for natural log tranformed total mussel mean population density. Years with the same letter are not significantly different p=0.06).

	Year		
Category	**1988**	**1995**	**2002**
Total mussels	A	B	C
Sensitive Taxa	A	B	B
Indifferent Taxa	A	B	B
Exploitive Taxa	A	AB	B

Summaries of tests of significance among all years for the mean of the natural log transformed data for total mussels and taxa subgroups are given in Table 3. Mean of the natural log transformed total mussel population densities were significantly different among all three years (p=0.06) (Table 3). Means for taxa subgroups (“sensitive”, “indifferent” and “exploitive”) were different between years 1988 and 2002 for each subgroup but these two years were not significantly different from 1995 (p=0.06).

The federally endangered *L. higginsii* was not found in quadrat samples during 2002 or 1995. It

Table 2. Population Density of Mussels at the Orion Mussel Bed., Wisconsin River, 1988, 1995, 2002.

	1988. N=43			1995. N=50			2002. N=100		
TAXON	MEAN # LIVE	STD DEV	COEFFICIENT OF VARIATION	MEAN # LIVE	STD DEV	COEFFICIENT OF VARIATION	MEAN # LIVE	STD DEV	COEFFICIENT OF VARIATION
A. l. carinata	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
A. marginata	0.12	0.39	3.36	0.00	0.00	.	0.02	0.14	7.04
A. p. plicata	0.86	1.64	1.91	0.84	2.12	2.53	0.31	1.15	3.72
A. g. form corpulenta	0.02	0.15	6.56	0.04	0.20	4.95	0.00	0.00	.
A. confragosus	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
E. dilatata	0.70	1.67	2.39	0.20	0.49	2.47	0.12	0.83	6.93
F. flava	0.74	1.18	1.58	0.28	0.54	1.91	0.03	0.17	5.71
L. higginsii	0.02	0.15	6.56	0.00	0.00	.	0.00	0.00	.
L. siliquoidea	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
L. t. form anodontoides	0.00	0.00	.	0.02	0.14	7.07	0.00	0.00	.
L. cardium	0.63	0.98	1.56	0.22	0.51	2.30	0.19	0.66	3.48
L. c. complanata	0.00	0.00	.	0.00	0.00	.	0.03	0.17	5.71
L. costata	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
L. fragilis	0.19	0.50	2.69	0.14	0.53	3.82	0.03	0.17	5.71
L. recta	0.23	0.53	2.27	0.10	0.36	3.64	0.14	1.11	7.93
O. reflexa	0.12	0.39	3.36	0.00	0.00	.	0.00	0.00	.
O. olivaria	0.40	1.26	3.18	0.12	0.33	2.74	0.08	0.31	3.84
P. cyphyus	0.07	0.34	4.84	0.02	0.14	7.07	0.01	0.10	10.00
P. sintoxia	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
P. alatus	0.05	0.21	4.58	0.10	0.36	3.64	0.04	0.20	4.92
Q. metanevra	0.60	1.68	2.78	0.14	0.35	2.50	0.13	0.54	4.19
Q. pustulosa pustulosa	0.65	1.38	2.12	0.16	0.42	2.64	0.09	0.38	4.21
S. ambigua	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
S. u. undulatus	0.12	0.39	3.36	0.00	0.00	.	0.01	0.10	10.00
T. parvus	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
T. verrucosa	0.35	0.90	2.57	0.10	0.30	3.03	0.09	0.32	3.56
T. donaciformis	0.05	0.21	4.58	0.02	0.14	7.07	0.00	0.00	.
T. truncata	0.14	0.56	4.01	0.02	0.14	7.07	0.02	0.14	7.04
Sensitive Taxa	1.16	2.67	2.30	0.28	0.54	1.91	0.25	0.77	3.08
Indifferent Taxa	4.00	5.97	1.49	1.36	2.18	1.61	0.75	2.52	3.37
Exploitive Taxa	0.88	1.65	1.87	0.88	2.15	2.45	0.34	1.21	3.55
ALL TAXA	6.05	9.13	1.51	2.52	4.32	1.71	1.34	3.90	2.91

had a mean population of 0.02/m^2 during 1988. Mean densities were not significantly different among all three years. Although densities of *L. higginsii* were not significantly different among years, the densities were so low that detection of differences was difficult.

LIVING/DEAD AND SEX RATIOS

Nearly all taxa for which living/dead ratios were calculated for the three study periods had a decreasing trend (Table 4). None had a clear upward trend. Total mussel ratios had a downward tendency as well. These ratios were 2.05, 0.47 and 0.79 for the years 1988, 1995 and 2002, respectively. These trends suggest a decrease in living mussels, an increase in empty shells or a combination of both.

We were only able to calculate sex ratio (# of females/# of males) for six taxa. These taxa were *L.*

Table 4. Living/Dead Ratios for the Orion Mussel Bed, Wisconsin River, 1988, 1995 & 2002.

	1988			1995			20002		
TAXON	**#LIVE**	**# DEAD**	**L/D Ratio**	**#LIVE**	**# DEAD**	**L/D Ratio**	**#LIVE**	**# DEAD**	**L/D Ratio**
A. l. carinata	0	1	0.00			.	0	0	.
A. marginata	5	1	5.00	0	5	0.00	2	2	1.00
A. p. plicata	37	6	6.17	42	13	3.23	31	14	2.21
A. g. form corpulenta	1	0	.	2	0	.			
A. confragosus	0	1	0.00						
E. dilatata	30	11	2.73	10	24	0.41667	12	21	0.57
F. flava	32	15	2.13	14	56	0.25	3	26	0.12
L. higginsii	1	0	.				0	1	0.00
L. siliquoidea	0	5	0.00						
L. t. form anodontoides				1	0	.			
L. cardium	27	17	1.59	11	20	0.55	19	19	1.00
L. c. complanata							3	0	.
L. costata	0	1	0.00						
L. fragilis	8	6	1.33	7	6	1.17	3	4	0.75
L. recta	10	3	3.33	5	8	0.63	14	9	1.56
O. reflexa	5	1	5.00	0	9	0.00	0	1	0.00
O. olivaria	17	13	1.31	6	28	0.21	8	20	0.40
P. cyphyus	3	2	1.50	1	1	1.00	1	0	.
P. sintoxia	0	1	0.00	0	6	0.00	0	5	0.00
P. alatus	2	0	.	5	3	1.67	4	2	2.00
Q. metanevra	26	9	2.89	7	37	0.19	13	20	0.65
Q. pustulosa pustulosa	28	8	3.50	8	12	0.67	9	15	0.60
S. ambigua	0	1	0.00	0	25	0.00	0	2	0.00
S. u. undulatus	5	4	1.25				1	1	1.00
T. parvus	0	1	0.00	0	5	0.00			
T. verrucosa	15	5	3.00	5	1	5.00	9	6	1.50
T. donaciformis	2	11	0.18	1	2	0.50			
T. truncata	6	4	1.50	1	5	0.20	2	2	1.00
All	**260**	**127**	**2.05**	**126**	**266**	**0.47**	**134**	**170**	**0.79**

higginsi, L. siliquoidea, L. teres form *anodontoides, L. cardium, Ligumia recta,* and *T. verrucosa* (Table 5). None of the individual taxa or combined taxa showed any trend in sex ratios over the three study periods.

POPULATION LENGTH AND AGE STRUCTURES

We used the first quartile (Q_1) of the length distribution as a measure of relative recruitment. The first quartile is that length below which the lowest 25% of the observations lie. In a year of strong young-of-the-year recruitment, the Q_1 should be small because of the large proportion of small individuals; in a year of low recruitment, on the other hand, the Q_1 should be larger because of the small proportion of

Table 5. Female/male sex ratios, 1988, 1995, 2002, Orion Mussel bed, Wisconsin R.

	1988			1995			20002		
TAXON	#Female	# Males	F/M Ratio	#Female	# Males	F/M Ratio	#Female	# Males	F/M Ratio
L. higginsii	1	1	1.00	0	1	0.00	0	0	
L. siliquoidea	0	0		1	2	0.50	0	0	
L. t. form anodontoides	0	2	0.00	2	2	1.00	0	2	0.00
L. cardium	31	51	0.61	52	76	0.68	18	36	0.50
L. recta	10	27	0.37	16	31	0.52	8	44	0.18
T. verrucosa	28	36	0.78	16	16	1.00	21	26	0.81
All	**70**	**117**	**0.60**	**87**	**128**	**0.68**	**47**	**108**	**0.44**

small individuals.

Most taxa for which calculations were made at Orion had a three-year Q_1 trend (Table 6). *A. p. plicata, E. dilatata, F. flava, L. cardium* and *Q. metanevra* had increasingly greater Q_1 from 1988 to 2002. These suggest gradually decreasing relative young recruitment.

Table 6. First quartile of Length (mm) Distribution for taxa with n>30.

Taxon	1988	1995	2002
A. p. plicata	64	74	89
E. dilatata	80	79	97
F. flava	40	43	54
L. cardium	92	96	105
Q. metanevra	63	48	82

SUMMARY

In 2002, we repeated freshwater mussel samples on the Orion mussel bed on the Wisconsin River The purpose was to determine changes in population and community characteristics over time. Monitoring was also done in 1988 and 1995.

From 1988-2002, mean population densities of total mussels (#/m^2) dropped 78% from 6.05 to 2.52 to 1.34. These population densities were significantly different among years. Taxa subgroups (“sensitive”, “indifferent” and “exploitive”) declined significantly between 1988 and 2002. Between 1988 and 2002 “sensitive” taxa population density declined 78.4%, “indifferent” 81.3% and “exploitive” 61.4% and there appeared to be a general increase in relative abundance of exploitive species over time. We were not able to directly measure any changes in *L. higginsii* population density because of its extreme rarity. However, we did find one living individual in the 1988 quadrat samples, and none during 1995 and 2002 in spite of larger sample sizes.

Even though taxa richness varied, it did not change much among the three years and there was no trend observed. During 1988, 1995 and 2002, we collected 23, 24 and 21 taxa respectively. However, taxa richness appeared to have declined 8.6% from 23 in 1988 and 1995 to 21 in 2002 when the sample is normalized for 600 individuals. There was no trend in evenness over the three time periods.

For the five taxa that have greater than 30 individuals, we saw gradually decreasing young recruitment relative to adults. These taxa included *A. p. plicata, E. dilatata, F. flava, L. cardium* and *Q. metanevra.* No increasing young recruitment was seen for any taxa measured.

Changes in community composition were mixed. Five taxa showed an increasing trend in relative abundance. All of these increases were fairly small; the greatest of which were 3.3 percentage points seen for *A. p. plicata*, an exploitive species. Six taxa showed a decreasing trend in relative abundance. The change in *L. higginsii* was very small (-0.21 percentage points) and this coupled with its rarity suggests it remains speculative as to whether the species has declined. There has generally been a relative increase in "exploitive" taxa and a combined decrease in "sensitive" and "indifferent" taxa albeit overall population density of exploitive taxa has declined.

Based on this information, it appears that the Orion Mussel bed has declined in quality since at least 1988. Population densities have declined greatly along with the proportion of younger mussels. Taxa that are more tolerant of environmental degradation declined less than those more sensitive ones. It appears at least part of this decline is due to the reduction on younger recruitment into the adult population. This loss of recruitment may explain our inability to locate recently artificially propagated *L. higginsii* juveniles at this location.

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