Results of 2007 Monitoring of Freshwater Mussel Communities of the Wisconsin River near Orion, Richland County, Wisconsin.

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O. olivaria, L. higginsii, 2 L. cardium. Wi. R., Orion. 25 July 2007. Downstream of boat ramp. CoE Photo. Aged at 4. Same Quad.

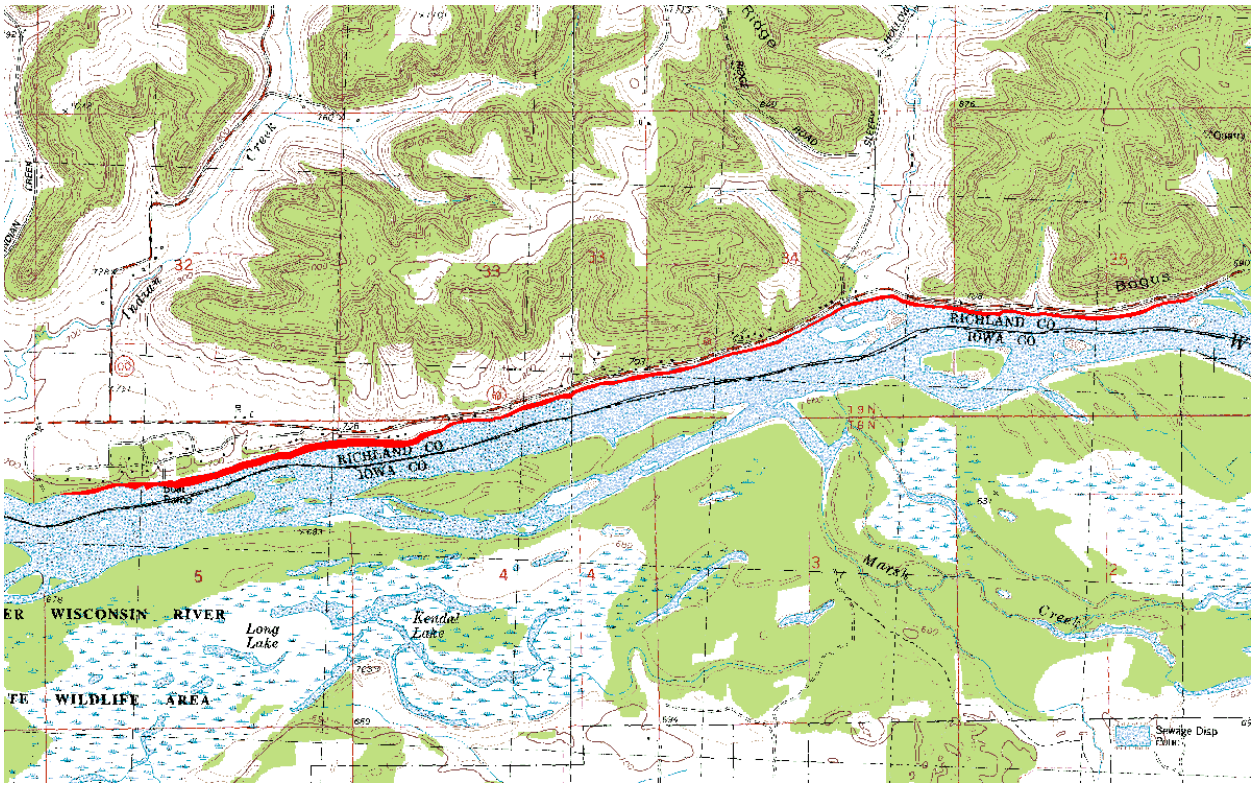
INTRODUCTION

This report briefly summarizes the 2007 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), 2002 (Heath, 2003) as well as 2007. The purpose of this investigation was to repeat the sampling protocols used in the three previous years 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 species listed by the State of Wisconsin as endangered or threatened. This bed is also listed as "essential habitat" in the federal recovery plan for the higgins' eye pearly freshwater mussel (U. S. Fish and Wildlife Service, 2004).

The objectives of this study were to access population density, size structure, taxa richness, community composition, living/dead and sex ratios over time.

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



METHODS AND MATERIALS

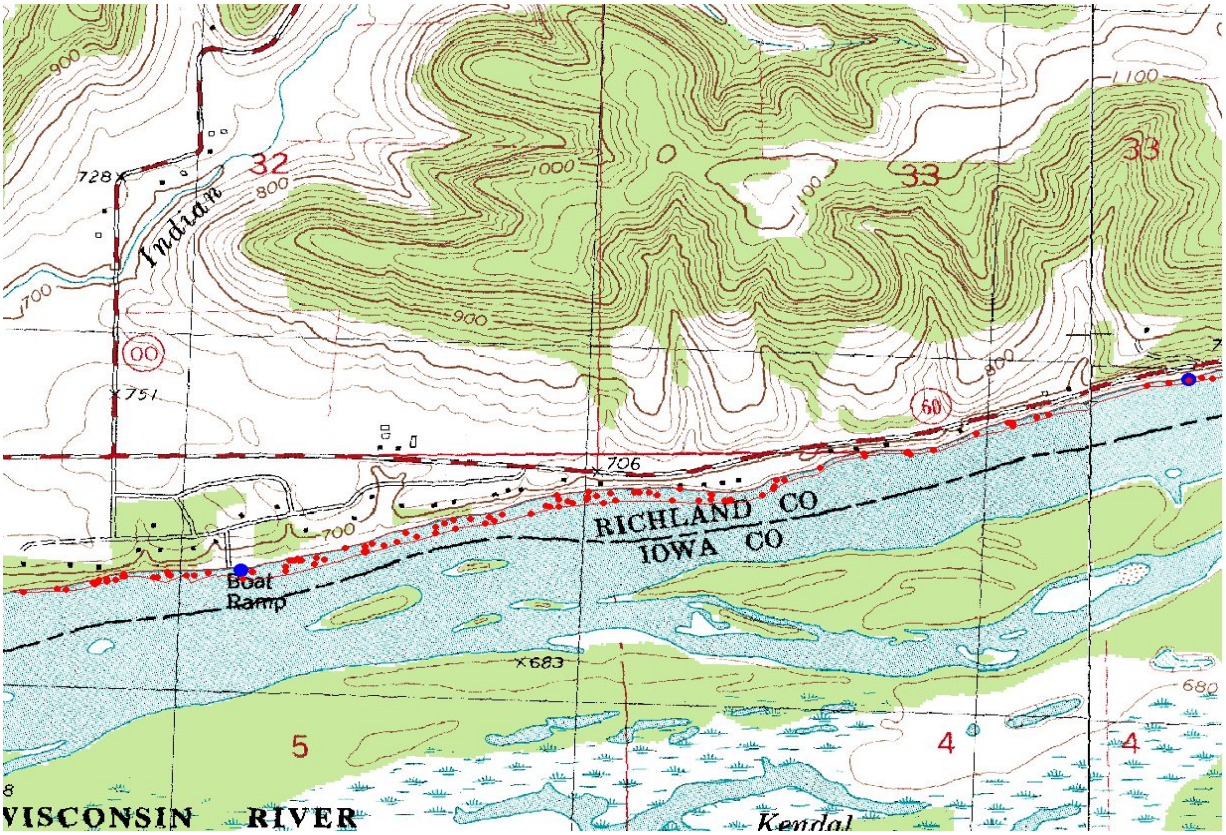
The Orion mussel bed is located on the Wisconsin River in southern Richland County, Wisconsin near the unincorporated village of Orion. The mussel bed is along the north shore extending from 43º 12' 6.2"N 90º 24' 29.1"W upstream 6060 meters (m) to 43º 12' 40.5"N 90º 20' 4.5"W (Figure 1) and includes an area of 114,930m².

A complete description of monitoring sampling methods is included in Heath and Rasmussen (1990). In summary, we took 178 randomly-placed, hand-collected 1m^2 quadrat samples (Figures 2 and 3) on July 24th - 27th, 2007, counted living and dead unionids, margaritiferids, *Corbicula* and *Dreissena*, measured and aged them. In addition to quadrat sampling, we collected larger numbers of mussels using random searches (relative abundance collections) at three locations 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).

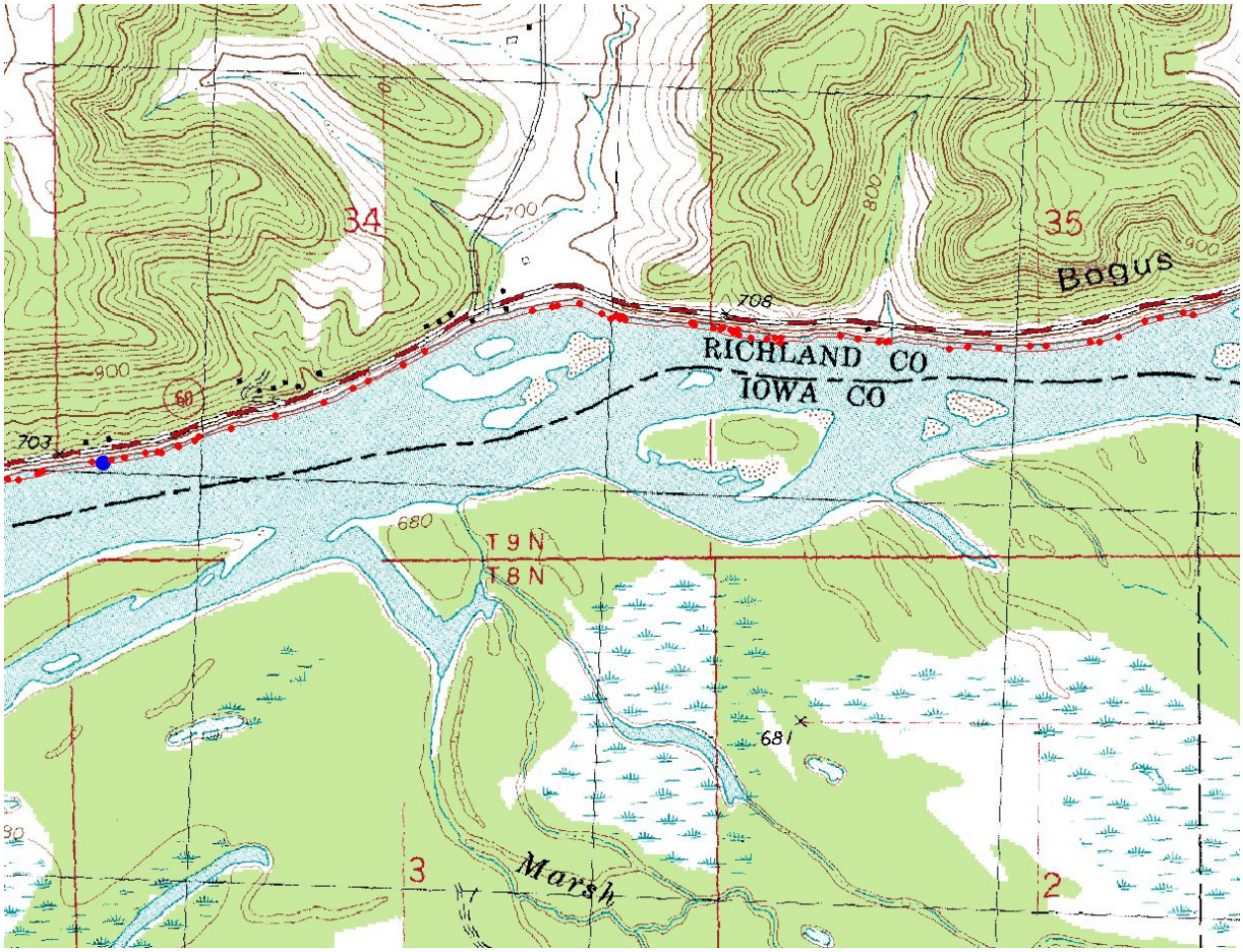
Figure 2. Location of 178 randomly placed m² quadrat samples (red) and qualitative (blue) collections done at Orion in 2007. Downstream portion.



RESULTS AND DISCUSSION

Stream flow and water elevations were below normal during the 2007 sampling period. During this survey, flow at the Muscoda USGS gage, located about 6000m downstream of the Orion bed, had a mean flow of 3205 cubic feet per second (USGS data). The mean monthly stream flow for July, over the 90 year period of record, is 7300 cubic feet per second.

Figure 3. Location of 178 randomly placed m² quadrat samples (red) and qualitative collection done at Orion in 2007. Upstream portion.



TAXA RICHNESS and EVENNESS

During 2007, we found a total of 25 taxa living and an additional 4 taxa represented by dead individuals only (Table 1). Seven living and one dead specimen of the federally endangered *L. higginsii* were found. A total of 7 taxa listed by the State of Wisconsin as endangered or threatened was found. These included *Lampsilis teres* form *anodontoides, Plethobasus cyphyus, L. higginsii, Quadrula metanevra, Simpsonaias ambigua, Q. nodulata,* and *Tritogonia verrucosa*. An additional state listed

Table 1. Number found Living and Dead of each Species during 2007 Sampling of the Orion Mussel Bed. Includes Quadrat Samples and Relative Abundance Collections.

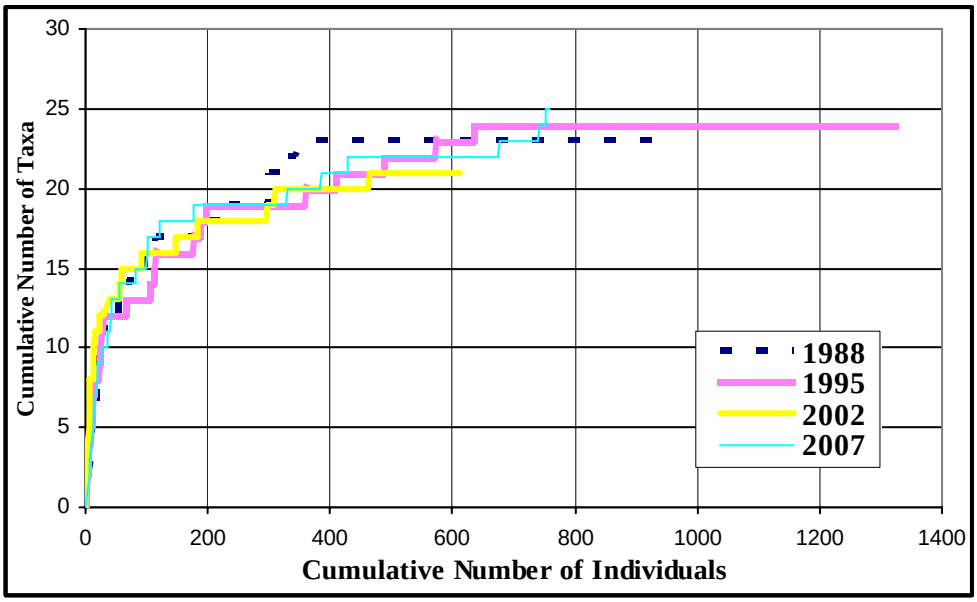
TAXON	NUMBER LIVE	NUMBER DEAD
Actinonaias ligamentina carinata	0	1
Alasmidonta marginata	8	1
Amblema plicata plicata	141	16
Pyganodon grandis form corpulenta	1	0
Elliptio dilatata	86	30
Fusconaia flava	37	49
Lampsilis higginsii	7	1
Lampsilis siliquoidea	3	2
Lampsilis teres form anodontoides	3	0
Lampsilis teres form teres	0	2
Lampsilis cardium	147	30
Leptodea fragilis	19	9
Ligumia recta	44	23
Obliquaria reflexa	9	3
Obovaria olivaria	65	48
Plethobasus cyphyus	2	3
Pleurobema coccineum	3	5
Potamilus alatus	22	6
Potamilus ohiensis	0	2
Quadrula metanevra	31	42
Quadrula nodulata	1	0
Quadrula pustulosa pustulosa	71	33
Quadrula quadrula	1	0
Simpsonaias ambigua	1	0
Strophitus undulatus undulatus	3	4
Toxolasma parvus	0	3
Tritogonia verrucosa	43	16
Truncilla donaciformis	1	2
Truncilla truncata	10	6
TOTAL	759	337

taxon, *Lampsilis teres* form *teres* was 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 four sampling events (Figure 4) and there does not appear to be a trend. Per 600 individuals, we

observed 22 taxa in 2007, 21 in 2002, 23 in 1995 and 23 in 1988. During all years a total of 28 taxa were found. There was no trend in evenness. The Modified Hill's Ratio was 0.739, 0.744, 0.735 and 0.783 for those years, respectively.

Figure 4. Cumulative Number of Individuals vs. Cumulative Number of Taxa for Samples at the Orion Mussel Bed, 1988, 1995, 2002, 2007.



NUMERICAL RELATIVE ABUNDANCE

Few trends in numerical relative abundance were apparent among the years 1988, 1995, 2002 and 2007. Only four 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 two taxa showed an increasing trend in relative abundance. These included *Quadrula nodulata* and *Lampsilis teres* form *anodontoides* (Table 2). Both of these increases were very small; less than 0.17 percentage points. *L. higginsii* showed a marked increase in relative abundance in 2007. In the previous three sampling periods relative abundance varied from 0.00% to 0.21%. In 2007, this species comprised 5.67% of the community.

A total of two taxa showed a decreasing trend in relative abundance. These included *Pyganodon grandis* and *L. teres* form *teres*.

Table 2. Changes in Relative Abundance of Mussel Taxa, 1988, 1995, 2002 and 2007 at the Orion Mussel Bed, Wisconsin R.

TAXON	1988	1995	2002	2007
A. marginata	1.61	0.23	1.47	0.99
A.p.plicata	19.70	22.96	23.00	17.51
E. dilatata	6.96	5.97	16.80	10.85
F. flava	9.64	11.86	3.43	4.56
L. c. complanata	0.00	0.08	0.65	0.00
L. fragilis	2.68	2.04	1.47	2.47
L. higginsii	0.21	0.08	0.00	5.67
L. recta	4.18	3.70	8.65	5.67
L. siliquoidea	0.00	0.38	0.16	0.49
L. teres form anodontoides	0.21	0.30	0.33	0.37
L. teres form teres	0.11	0.00	0.00	0.00
L. cardium	9.64	11.56	8.97	18.13
O. olivaria	5.35	6.42	2.45	8.14
O. reflexa	0.86	1.06	0.00	1.11
P. alatus	0.96	1.36	1.79	2.71
P. cyphyus	0.86	0.76	1.63	0.25
P. grandis	0.32	0.30	0.16	0.12
P. sintoxia	0.32	0.68	0.82	0.62
Q. metanevra	9.42	10.73	11.91	3.95
Q. nodulata	0.00	0.00	0.00	0.12
Q. p.pustulosa	10.81	15.03	7.01	9.00
Q. quadrula	0.00	0.00	0.16	0.12
S. ambigua	6.53	0.30	0.00	0.12
S. u. undulatus	1.28	0.23	0.33	0.37
T. donaciformis	0.32	0.15	0.00	0.12
T. truncata	1.07	1.28	0.49	1.23
T. verrucosa	6.96	2.57	8.32	5.30
TOTAL	100.00	100.00	100.00	100.00

POPULATION DENSITY

Arithmetic population densities for the four time periods at the Orion mussel bed are given in Table 3. Total mussel population densities in 2007 have decreased since 1988 by 4.34 mussels/m² or 71.8%. During the first three sampling events, there was a clear downward trend in densities; they were 6.05/m², 2.52/m² and 1.34/m² in 1988, 1995 and 2002, respectively. During 2007, there was a slight but insignificant (see below) increase in densities to 1.71 /m².

Table 3. Population Density of Mussels at the Orion Mussel Bed., Wisconsin River, 1988, 1995, 2002, 2007 .

	1988. N=43			1995. N=50			2002. N=100			2007. N=178		
TAXON	MEAN # LIVE	STD DEV	COEFF. OF VAR.	MEAN # LIVE	STD DEV	COEFF. OF VAR.	MEAN # LIVE	STD DEV	COEFF. OF VAR.	MEAN # LIVE	STD DEV	COEFF. OF VAR.
A. l. carinata	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
A. confragosus	0.00	0.00	.	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	0.01	0.07	13.34
A. p. plicata	0.86	1.64	1.91	0.84	2.12	2.53	0.31	1.15	3.72	0.31	0.94	3.04
E. dilatata	0.70	1.67	2.39	0.20	0.49	2.47	0.12	0.83	6.93	0.15	0.74	4.88
F. flava	0.74	1.18	1.58	0.28	0.54	1.91	0.03	0.17	5.71	0.08	0.40	5.15
L. c. complanata	0.00	0.00	.	0.00	0.00	.	0.03	0.17	5.71	0.00	0.00	.
L. cardium	0.63	0.98	1.56	0.22	0.51	2.30	0.19	0.66	3.48	0.31	0.80	2.53
L. costata	0.00	0.00	.	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	0.05	0.24	4.83
L. higginsii	0.02	0.15	6.56	0.00	0.00	.	0.00	0.00	.	0.02	0.15	6.61
L. recta	0.23	0.53	2.27	0.10	0.36	3.64	0.14	1.11	7.93	0.07	0.30	4.12
L. siliquoidea	0.00	0.00	.	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	.	0.01	0.07	13.34
O. olivaria	0.40	1.26	3.18	0.12	0.33	2.74	0.08	0.31	3.84	0.22	0.50	2.29
O. reflexa	0.12	0.39	3.36	0.00	0.00	.	0.00	0.00	.	0.03	0.25	8.82
P. alatus	0.05	0.21	4.58	0.10	0.36	3.64	0.04	0.20	4.92	0.04	0.21	4.62
P. cyphyus	0.07	0.34	4.84	0.02	0.14	7.07	0.01	0.10	10.00	0.00	0.00	.
P. grandis	0.02	0.15	6.56	0.04	0.20	4.95	0.00	0.00	.	0.00	0.00	.
P. ohiensis	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
P. sintoxia	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.	0.01	0.11	9.41
Q. metanevra	0.60	1.68	2.78	0.14	0.35	2.50	0.13	0.54	4.19	0.08	0.52	6.16
Q. nodulata	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.	0.01	0.07	13.34
Q. pustulosa pustulosa	0.65	1.38	2.12	0.16	0.42	2.64	0.09	0.38	4.21	0.19	0.71	3.72
S. ambigua	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.	0.01	0.07	13.34
S. u. undulatus	0.12	0.39	3.36	0.00	0.00	.	0.01	0.10	10.00	0.00	0.00	.
T. donaciformis	0.05	0.21	4.58	0.02	0.14	7.07	0.00	0.00	.	0.01	0.07	13.34
T. parvus	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.	0.00	0.00	.
T. truncata	0.14	0.56	4.01	0.02	0.14	7.07	0.02	0.14	7.04	0.02	0.15	6.61
T. verrucosa	0.35	0.90	2.57	0.10	0.30	3.03	0.09	0.32	3.56	0.08	0.33	4.15
Sensitive Taxa	1.16	2.67	2.30	0.28	0.54	1.91	0.25	0.77	3.08	0.20	0.71	4.15
Indifferent Taxa	4.00	5.97	1.49	1.36	2.18	1.61	0.75	2.52	3.37	1.20	2.80	2.33
Exploitive Taxa	0.88	1.65	1.87	0.88	2.15	2.45	0.34	1.21	3.55	0.31	0.94	3.04
ALL TAXA	6.05	9.13	1.51	2.52	4.32	1.71	1.34	3.90	2.91	1.71	3.77	2.21

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 4. Mean of the natural log transformed total mussel population densities were significantly different among the first three sampling events (p=0.05) while the mean for 2007 was different only from the 1988 mean. Means for each taxa subgroup ("sensitive", "indifferent" and "exploitive") were generally different between 1988 and all other years.

The federally endangered *L. higginsii* was found in 2007 and 1988 quadrat samples and not in 2002 and 1995 samples. It had a mean population of $0.02/m^2$ during 1988 and 2007. Mean densities were not significantly different among all four sampling events. Although densities of *L. higginsii* were not significantly different among years, the densities were so low that detection of differences was difficult.

Table 4. Results of tests of significance among years (1988, 1995, 2002, 2007) for natural log tranformed total mussel mean population density. Years with the same letter are not significantly different p=0.05).

	Year			
Category	**1988**	**1995**	**2002**	**2007**
Total mussels	A	B	C	BC
Sensitive Taxa	A	B	B	B
Indifferent Taxa	A	B	B	B
Exploitive Taxa	A	AB	B	B

LIVING/DEAD AND SEX RATIOS

We calculated living/dead ratios for those 10 taxa with larger sample sizes (Table 5). Two of these ten may have had decreasing trends over the four sampling events. These two were *T. verrucosa* and *F. flava*. None had a clear upward trend. Total mussel ratios appeared to have increased since the 1988 sampling event. These ratios were 0.56, 0.80 and 0.93 for the years 1995, 2002 and 2007, respectively. These data suggest the relative number of living mussels may have increased during the last three sampling periods or the relative number of dead has decreased.

We were only able to calculate sex ratio (# of females/# of males) for three taxa. These taxa were *L. cardium*, *Ligumia recta*, and *T. verrucosa* (Table 6). None of the individual taxa or combined taxa showed any trend in sex ratios over the four study periods.

Table 5. Living/Dead Ratios for the Orion Mussel Bed, Wisconsin River, 1988, 1995, 2002 & 2007.

	1988			1995			2002			2007		
TAXON	**#LIVE**	**# DEAD**	**L/D Ratio**	**#LIVE**	**# DEAD**	**L/D Ratio**	**#LIVE**	**# DEAD**	**L/D Ratio**	**#LIVE**	**# DEAD**	**L/D Ratio**
A. p. plicata	37	6	6.17	42	13	3.23	31	14	2.21	55	16	3.44
E. dilatata	30	11	2.73	10	24	0.41667	12	21	0.57	27	31	0.87
F. flava	32	15	2.13	14	56	0.25	3	26	0.12	14	49	0.28
L. cardium	27	17	1.59	11	20	0.55	19	19	1.00	56	31	1.81
L. recta	10	3	3.33	5	8	0.63	14	9	1.56	14	23	0.61
O. olivaria	17	13	1.31	6	28	0.21	8	20	0.40	39	49	0.80
P. alatus	2	0	.	5	3	1.67	4	2	2.00	8	6	1.33
Q. metanevra	26	9	2.89	7	37	0.19	13	20	0.65	15	42	0.36
Q. p. pustulosa	28	8	3.50	8	12	0.67	9	15	0.60	34	33	1.03
T. verrucosa	15	5	3.00	5	1	5.00	9	6	1.50	14	16	0.88
All	**224**	**87**	**2.57**	**113**	**202**	**0.56**	**122**	**152**	**0.80**	**276**	**296**	**0.93**

Table 6. Female/male sex ratios, 1988, 1995, 2002, 2007 Orion Mussel bed, Wisconsin R.

	1988			1995			2002			2007		
TAXON	#Fem.	#Male	F/M Ratio	#Fem.	#Male	F/M Ratio	#Fem.	#Male	F/M Ratio	#Fem.	#Male	F/M Ratio
L. cardium	31	51	0.61	52	76	0.68	18	36	0.50	56	85	0.66
L. recta	10	27	0.37	16	31	0.52	8	44	0.18	11	22	0.50
T. verrucosa	28	36	0.78	16	16	1.00	21	26	0.81	13	22	0.59
All	**69**	**114**	**0.61**	**84**	**123**	**0.68**	**47**	**106**	**0.44**	**80**	**129**	**0.62**

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 small individuals.

All taxa had a smaller Q_1 in 2007 compared to 2002 (Table 7). This suggests a greater relative recruitment of smaller mussels since 2002. This compares to a trend of decreasing relative recruitment prior to 2007 (Table 7).

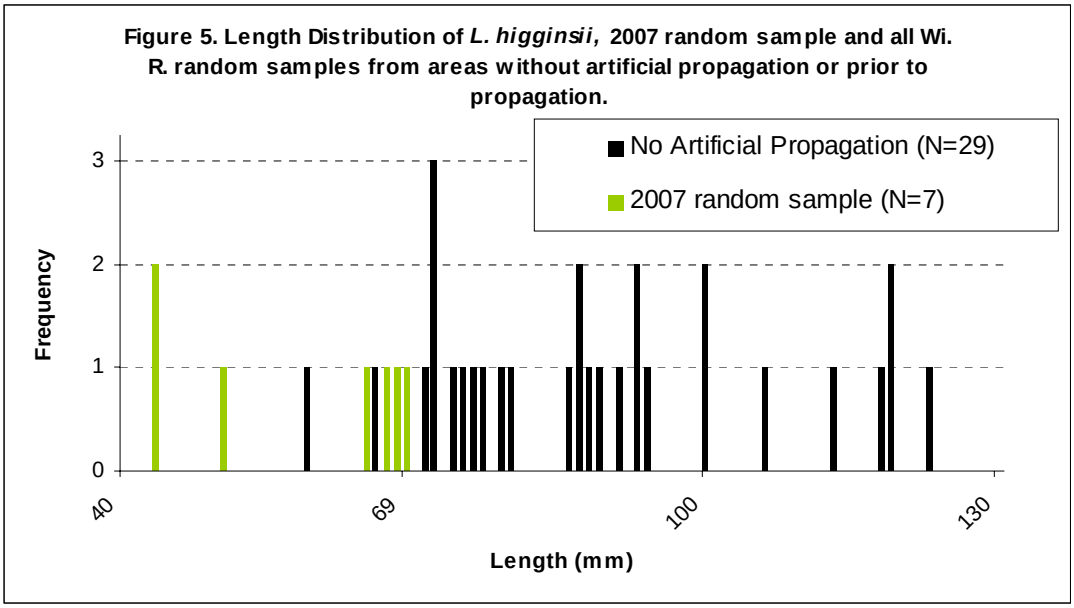
Table 7. First quartile of Length (mm) Distribution for taxa with n>30.

Taxon	1988	1995	2002	2007
A. p. plicata	64	74	89	78
E. dilatata	80	79	97	95
F. flava	40	43	54	52
L. cardium	92	96	105	97
Q. metanevra	63	48	82	76

Interestingly, the mean total length of randomly collected *L. higginsii* may be substantially less in 2007 than data collected from times and places where artificial propagation (see Wisconsin Department of Natural Resources, 2005) has not occurred (Figure 5). The mean total length for all lower Wisconsin River mussels collected prior to the initiation of artificial propagation in 2001 plus those collected after 2001 but in mussel beds at least 10 river miles from a bed influenced by propagation was 88.93mm (N=29, standard deviation = 17.44). This compares to a mean of 60.33mm (N=7, standard deviation = 11.02). This recent, small mean size of *L. higginsii*, may be due to artificial propagation efforts at Orion initiated in 2001. This comparison also assumes that the pre-artificial propagation length distributions in the entire lower Wisconsin River not different from that of the Orion mussel bed.

SUMMARY

In 2007, we sampled 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. We



repeated what was done in 1988, 1995 and 2002.

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. During 2007, this total mussel density decline stabilized when we found 1.71 mussels/m^2 which was not significantly different from 1995 or 2002, but was from 1988. There was no statistically significant difference in the population density of the federally endangered *L. higginsii* among years. This species had a density of 0.02/m^2 in 1988 and 2007 and 0.00 during 1995 and 2002.

Taxa richness varied, but did not change significantly among the four years and there was no trend observed. There was no trend in evenness over the four time periods.

For the five taxa that have greater than 30 individuals, we saw increased young recruitment relative to adults in 2007. This compares to a decreasing trend over the three previous sampling events.

Changes in community composition were small except for *L. higginsii*. This species numerical relative abundance varied from 0.00%-0.21% during the three previous sampling events. During 2007 it comprised 5.67% of the community. .

Based on this information, it appears that the Orion Mussel bed's previous decline may have stabilized in 2007. Population densities increased slightly along with the proportion of younger mussels.

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