Mussel Harvest and Regulations in the Upper Mississippi River System

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Abstract. Commercial harvest of mussels for buttons began in 1891 in the Upper Mississippi River System and continued through the 1940s. Initially, no attempts at conservation were made, and mussel beds were severely depleted by excessive unregulated harvest. From 1912 to the 1930s, management techniques were initiated, but they could not offset the high harvest rates and habitat alterations, and the button industry collapsed. Harvest was revived in the 1960s and continues today for the cultured pearl industry. Meaningful and uniform regulations were not adopted until the mid-1980s, when concern peaked after a major mussel die-off in the Mississippi River from 1982 to 1985. In 1989, 7.1 million pounds of mussels were harvested from the Illinois and Mississippi rivers and had a value of $3.2 million. Over 7.7 million pounds of mussels were harvested in 1990 and were valued at $6.1 million. A two- to threefold increase in the price paid for washboard (*Megalonaias nervosa*), the most valued and increasingly less common commercial species, caused this near doubling in value despite a 23% decrease in the poundage of washboard harvested. As washboard availability decreased, threeridge (*Amblema plicata plicata*) harvest more than doubled. Mussel populations may not be sustainable under these harvest pressures, and trends should be analyzed carefully to determine if further regulations are required.

The Pearl Button Era

John Boepple, a horn button maker from Germany, pioneered the use of freshwater mussels for buttons. In 1891, he began operating the first freshwater pearl button company, which initiated the commercial harvest of mussels for buttons (O'Hara 1980). Muscatine, Iowa, with its nearby mussel beds, was the birthplace of the pearl button industry. By the early 1920s, almost 5,000 people were employed in the button industry in Muscatine. This represented approximately one-third of the city's population (Knott 1980).

The button industry grew rapidly into a multi-million-dollar operation. By 1908, it had a capital investment of over $2 million and an annual output of $6 million (Davidson 1924).

The mussel fishery and button industry rapidly expanded north and south on the Mississippi River and over to the Illinois River as the mussel beds near Muscatine became depleted. Every town along the river, large or small, was in some way connected with the button industry. The rate of expansion was directly correlated with the rate of depletion of the more central territory (Coker 1919).

The supply of mussels seemed endless, as did the demand for pearls and buttons. The pearl button industry was interested in many species (Smith 1899, Coker 1919), but all species and sizes were harvested in search of pearls (O'Hara 1980).

In the early stages of fishing a mussel bed, clammers harvested large and old mussels, and as time progressed, they took smaller and younger ones (Coker 1919). In the early 1890s, when mussel fishing began at New Boston, Illinois, about 20 miles downstream from Muscatine, clammers could harvest up to a ton a day. By 1898, they had difficulty getting a ton in a week (Smith 1899). The clammers just fished until the beds produced no more mussels and then moved to a new area.

Hugh Smith (1899), U.S. Commissioner of Fisheries, believed the depletion of the mussel beds was caused by constant fishing, even during the spawning season; the harvest of small mussels; and the wasteful harvest of mussels, especially in the winter. Harvest rates exceeded the rates at which mussels could grow to harvestable size (Coker 1919). To prevent further depletion of the mussel beds, Smith (1899) recommended a minimum legal size limit, closed seasons, the reduction of wasteful practices at the factories, and antipollution measures. However, there was a pervasive sense in the

mussel industry that the mussel beds were inexhaustible, and Smith's recommendations were not immediately acted upon. Other surveys were made after 1899, and the same conclusion was always reached: the mussel stocks were rapidly diminishing (Carlander 1954).

The Fairport Biological Station near Muscatine, Iowa, was established by the U.S. Bureau of Fisheries in 1908 to address the problem of declining fish and mussel resources (Carlander 1954). Various techniques were used to rejuvenate the mussel fishery, but none was permanently successful. Studies done by Lefevre and Curtis led to the development of a method for propagating mussels artificially by infecting fish with larval mussels or glochidia (Coker 1914). However, the ambitious propagation program undertaken in 1912 by the Fairport Biological Station could not alone offset the high harvest rates.

In an attempt to sustain the mussel stocks, in 1914 Robert Coker, director of the Fairport Bureau of Fisheries Laboratory, recommended the alternate closure of specific areas to harvest for several years before reopening them. Coker (1914) also recommended supplementing natural reproduction with artificial propagation and instituting a 2-inch size limit in the closed areas.

From 1914 to 1918, Minnesota, Wisconsin, Iowa, and Illinois enacted legislation on alternate closure areas, size limits, license fees, and gear (Shira 1919). Selected areas of Lake Pepin in the Minnesota-Wisconsin waters of the Mississippi River were closed to mussel harvest from 1919 to 1924 (Southall 1925). Populations of fatmucket (*Lampsilis siliquoidea*) increased 20% during the four years of the closed period. The alternate closure of sections of the Mississippi River in the Illinois-Iowa boundary waters also restored mussel populations (Davidson 1924). The success of the alternate closure program was not long-lived, however, because the beds were rapidly depleted after reopening.

At a 1930 conference in Washington, D.C., the prevailing thoughts on the future of the mussel fishery were that the mussel populations on the Mississippi River were still declining; in most areas, pollution was hindering recruitment; and the proposed 9-foot navigation channel would make conditions worse for mussels (Carlander 1954). Ellis (1931) of the U.S. Bureau of Fisheries considered overharvest to be the greatest single factor contributing to the decline of mussel populations, but he also recognized silt and pollution as major threats to mussel recruitment. As a result of his findings, the U.S. Bureau of Fisheries recommended elimination of all restrictions on mussel harvest in the Mississippi River. This guidance was based on the concept of using a resource rather than wasting it, since the predominant thinking was that the mussels in the Mississippi River were inevitably doomed (Carlander 1954).

By the 1930s the pearl button era was coming to a close (Waters 1980), and commercial clamming had virtually disappeared by the 1940s. Depletion of the mussel beds, the advent of the plastic button, and increasing pollution in the river led to a dramatic decline in the mussel fishery (Thiel 1981). Whether the shell beds nearly exhausted by severe clamming pressure would have later succumbed to loss of habitat, siltation, and pollution is unknown. The species of mussels that suffered the greatest impact from the button industry were probably those which were never common and whose breeding stock was depleted below the level where reproduction could not offset mortality (Knott 1980).

The Cultured Pearl Era

Kokichi Mikimoto of Japan discovered that freshwater mussel shells from the Mississippi River drainage system produced the best nucleus for cultured pearls (Lopinot 1967). This discovery revived clamming in the Mississippi and Illinois rivers during the 1960s. Since that time, millions of pounds of shells have been sent to factories in Japan, where they are processed into spheres and then implanted into oysters as nuclei for cultured pearls.

In 1943, about 20 to 25 years after the heyday of the pearl button industry, the Upper Mississippi River Conservation Committee (UMRCC) was organized by the states of Minnesota, Wisconsin, Iowa, Illinois, and Missouri. The UMRCC's objectives are to promote the preservation and wise utilization of the river's resources and to formulate policies, plans, and programs for conducting cooperative studies (Rasmussen 1980).

In 1975, the UMRCC states began initiating mussel surveys to determine the status of the mussel stocks (Perry 1978). This action was taken because river biologists were concerned that poor water quality, levee construction, channel maintenance activities, and overharvest were seriously depleting the mussel stocks.

In 1979, the first UMRCC-sponsored symposium on bivalve mollusks was held to provide a transfer of information between mussel researchers and river managers. From 1982 to 1985, a mussel die-off occurred over a 720-km stretch from at least as far north as Pool 8 (La Crosse, Wisconsin) down to Pool 25 (Thiel 1987). Mussel surveys in 1983 and 1985 in Pools 14 and 15 of the Upper Mississippi River (Blodgett and Sparks 1987) found high mussel mortality rates. Numerous species were affected,

and the two important commercial species, washboard (*Megalonaias nervosa*) and threeridge (*Amblema plicata plicata*), experienced some of the highest mortality rates (35% and 41%, respectively).

Various state and federal agencies conducted qualitative and quantitative studies on mussel populations analyzing apparently healthy, moribund, and dead specimens for contaminants, parasites, and disease. No causative agent was found (Thiel 1987).

The impact of the die-off on the Mississippi River mussel fauna remains an enigma, but the severity of the die-off has been reflected in the commercial harvest (Fritz 1990). Recent-relic shells resulting from the die-off constitute a large percentage of the harvest.

In 1986, the UMRCC and the U.S. Fish and Wildlife Service jointly sponsored a national mussel die-off workshop to share knowledge about mussel mortality and to seek ways to deal more effectively with mussel management problems (Neves 1987).

Commercial Mussel Harvest Regulations

Alarmed by mussel mortality and intensified harvest, and responding to concern for endangered species, fish managers of the five Upper Mississippi River states met in 1985 to determine what actions should be taken to prevent further degradation of the mussel stocks. They recommended increasing the minimum harvest size, reducing the length of the harvest season, and implementing harvest reporting requirements (Fritz 1990).

A monumental effort has been made by the five Upper Mississippi River states to promulgate uniform mussel regulations. This endeavor has not always been easy, since proposed regulations have to move through the respective conservation agencies and legislatures. Great strides toward uniformity have been made, but there are still some hurdles to overcome.

Waters' (1980) overview of the commercial mussel regulations in 1979 is the most recent published record of the status of regulations in all five states. Season length for legal harvest has changed greatly since 1979, when some of the states had liberal or continuous seasons.

Current seasons for mussels in the five states are fairly uniform and were developed with special concern for the washboard spawning season. The peak gravidity period for washboard in Wisconsin waters is from 27 August to 27 October (Heath et al. 1988).

In all aspects, Minnesota has the most restrictive mussel regulations of the five states. Their season is from 16 May to 31 August. In Iowa and the Wisconsin boundary waters across from Iowa, the season is from 1 April to 31 August, and in Wisconsin boundary waters across from Minnesota the season is from 1 April to 30 September. In Illinois and Missouri, the season is from 15 April to 31 August.

As recently as 1979, there were no species restrictions (Waters 1980); instead, the harvest was dictated by the market. Washboard and threeridge are the two most important commercial species on the Upper Mississippi River. The washboard is the most highly prized because of its large size and thick shell.

With the exception of Minnesota, where washboards are not commonly found, both threeridge and washboards are legal species. In Minnesota, harvesting species other than threeridge requires a special permit. In Wisconsin, three other species can be harvested in addition to threeridge and washboard; in Iowa five other species can be harvested; in Illinois 10 other species can be taken; and in Missouri all other species except endangered and threatened species can be kept. Missouri is currently revising its mussel regulations, not just for legal species but in other areas as well, in order to conform with the other states.

Prior to the 1980s, individual states had either no size limits or size limits that were too small to protect the resource (Waters 1980). Today, size limits are the management tool used to regulate the industry.

The two important commercial species are very slow-growing. In Wisconsin waters it takes a washboard an average of 21 years to reach the legal size limit and a threeridge an average of 23 years (Heath et al. 1988).

The size limits for 1992 are for the smallest dimension or height. For threeridge, the size limit is 2.75 inches in height for all the states except Wisconsin, where the size limit is 2.63 inches.

In the four states where washboard is a legal species, the size limit is 4 inches in height for live washboard. For dead washboard, the size limit is also 4 inches, except in Iowa, where it is 3.5 inches.

In 1979, more harvest techniques were allowed in more areas than are allowed today (Waters 1980). However, diving was not allowed in Illinois and Minnesota in 1979.

The 1992 legal harvest methods in all five states include hand-collecting and diving. All states allow brailing except Minnesota. Illinois is the only state to still allow the use of a hand fork.

In 1979, there were significant differences among the states in license requirements, ranging from no license being necessary to licenses being available only to residents (Waters 1980). The details of the status of commercial licenses are still quite different for the five states, but a permit or license is required for all shellers and they must provide a monthly or annual report (Table 1). The information

Table 1. Status of commercial mussel licenses for the Upper Mississippi River, 1992.

	MN	WI	IA	IL	MO
Resident sheller	permit	$30	$100	$25	
Resident sheller helper	permit	NF	$50	$25	
Nonresident sheller	NS	NS	$2,500	NS	
Nonresident sheller helper	NS	NS	$200	NS	
Resident commercial fishing license					$25
Nonresident commercial fishing license					$200
Mussel tag					$5
Report required	X	X	X	X	X

NS: not sold or applicable.
NF: no fee; license required.

Table 2. Status of commercial mussel buyer's license for the Upper Mississippi River, 1992.

	MN	WI	IA	IL	MO
Resident buyer	NS	$300	$1,000	$300	NS
Resident buyer helper	NS	NF	NS	NS	NS
Nonresident buyer	NS	NS	$5,000	$1,000	NS
Report required	NS	X	X	X	X

NS: not sold or applicable.
NF: no fee; license required.

required in this report varies greatly from state to state and makes comparison of the data difficult. Reporting is an area where uniformity is essential.

In Minnesota, only residents can clam and only with a permit issued by the Department of Natural Resources. In Wisconsin, licenses are sold to residents only, and a sheller's helper license is also required, at no fee. In Iowa, sheller licenses and sheller's helper licenses are issued to both residents and nonresidents for a fee. In Illinois, resident shellers and sheller's helpers need to purchase a license, and licenses are not available to nonresidents. To harvest mussels in Missouri, a resident or nonresident commercial fishing license and a mussel tag are required.

Minnesota and Missouri do not sell commercial mussel buyer's licenses (Table 2). In Wisconsin, resident buyer's licenses and resident buyer's helper licenses are required, but at no fee. In Iowa and Illinois, resident and nonresident buyer's licenses are required. All states except Minnesota require a report. The buyer's report, like the sheller's report, varies among states and needs to become standardized.

The 1992 regulations demonstrate that great strides have been made toward uniformity since 1979, but additional changes are still needed, especially in regard to reporting.

Commercial Mussel Harvest

Iowa has the longest recorded history of mussel harvest, from 1920 to 1942, resuming in 1976 (G. Ackerman, Iowa Department of Natural Resources, personal communication 1992). Annual harvest was over a million pounds from 1920 to 1926, peaked in 1928 at almost 2.5 million pounds, remained over a million pounds until 1930, and then declined (Table 3). These values underestimate the real harvest due to a lack of reporting by some licensees. From 1922 to 1928, the reporting percentage varied from 70% to 80%. In 1928, only 52% of licensed shellers reported their harvest. If the reported harvest value is expanded to reflect 100% of the take, more than 4.5 million pounds were harvested in the peak year of 1928.

Because of differences in reporting requirements and the availability of reports, the period from 1988 to 1990 is the only time span with harvest data available from all five states (Table 4). The total harvest for the three-year period is 17.8 million pounds, valued at $9.6 million. Illinois represents the largest percentage of the harvest (42%), followed by Iowa (34%), Wisconsin (20%), Missouri (5%), and Minnesota (< 1%).

The most recent year for which data are available for all five states is 1990 (Table 4). Over 6.5 million pounds of mussels were harvested. Partial data for 1991 and 1992 indicate a sharp decline in total pounds harvested.

Table 3. Iowa mussel harvest, value, number of licenses, and percentage of licensees reporting from the Mississippi River.

Year	Harvest (lb)	Value ($)	Number of licenses	Percentage reporting
1920	1,866,580	54,295	575	—*
1921	1,043,894	13,131	302	—
1922	1,002,355	16,808	241	80
1923	1,424,933	31,162	380	70
1924	1,165,657	21,633	223	77
1925	1,144,687	45,432	388	79
1926	2,058,626	63,641	1,076	73
1927	888,982	31,167	608	75
1928	2,422,897	61,833	862	52
1929	1,020,484	21,444	609	93
1930	1,482,679	22,810	—	—
1931	858,334	10,798	—	—
1932	299,181	2,313	—	—
1933	—	—	—	—
1934	435,269	4,813	—	—
1935	324,344	3,599	—	—
1936	128,499	1,164	—	—
1937	192,438	3,262	350	37
1938	266,449	4,228	194	59
1939	148,665	1,714	92	39
1940	296,735	3,072	66	55
1941	225,960	3,658	69	41
1942	365,852	8,312	79	86
1943-74	—	—	—	—
1975	145,015	6,482	53	42
1976	529,559	29,529	110	43
1977	612,000	37,170	124	50
1978	247,332	17,313	55	73
1979	183,511	14,775	51	61
1980	—	—	—	—
1981	—	—	—	—
1982	355,900	27,134	158	31
1983	57,655	4,282	56	32
1984	262,500	26,250	129	18
1985	1,167,416	154,513	220	39
1986	774,800	155,000	219	24
1987	2,033,930	671,000	130	83
1988	1,704,878	727,000	124	85
1989	1,868,175	1,000,000	231	72
1990	2,388,514	2,169,736	469	84
1991	1,228,526	1,296,000	328	87

* Data not available.
Note: Data in this table were obtained from the Iowa Department of Natural Resources.

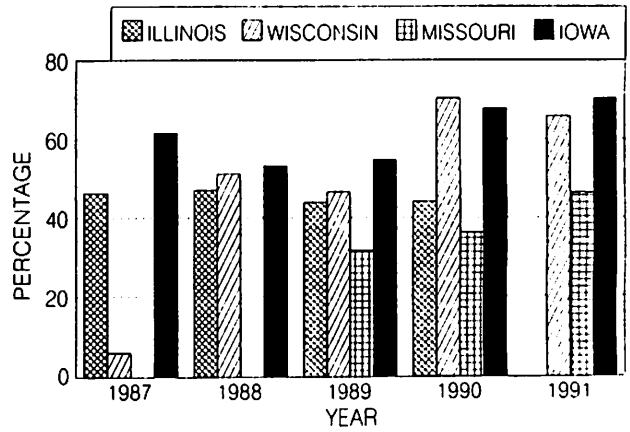

Figure 1. Percentage of washboard harvest from the Mississippi River composed of dead shells.

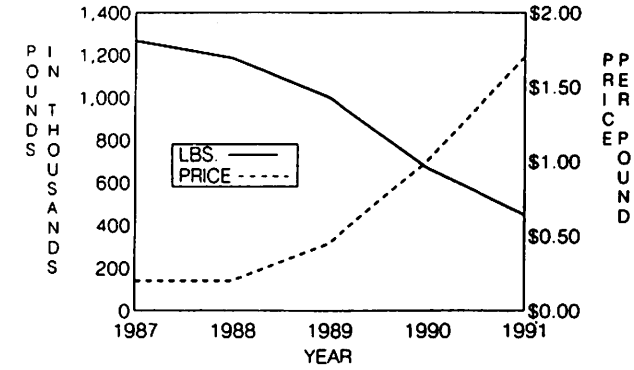

Figure 2. Amount and average price of live washboards harvested in Wisconsin and Iowa from the Mississippi River.

Washboard is the foundation of the current mussel industry. Before the die-off, shell buyers did not buy dead or relic shells (Sparks et al. 1990). However, the amount of dead washboard in the harvest is increasing, and the amount of live washboard harvested is decreasing. The percentage of dead shell harvested in Illinois from the Mississippi River has remained relatively constant (45–48%) from 1987 to 1990 (Figure 1). In the other three states where washboard can be legally harvested, the percentage of dead washboard has increased. The Missouri dead washboard harvest increased from 32 to 47%. In both Wisconsin and Iowa, the percentage of dead shell in the total harvest has been as high as 71%. The increasing percentage of washboard harvest made up of dead shells is a reflection of the market, the impact of the 1982–1985 mussel die-off, and the decreasing numbers of live washboard available for harvest.

As the amount of live washboard harvested decreased from 1987 to 1991, the price increased (Figure 2). Wisconsin and Iowa are the only two states with this kind of data for the time period, but Illinois and Missouri also have shown a declining trend in live washboard harvest and a concurrent increase in price. The live washboard harvest decreased 65% from 1987 to 1991. By contrast, the price for live washboard has increased from 20 cents a pound in 1987 to an average of $1.70 in 1991. The price has thus increased 8.5 times.

The demand, coupled with the decreasing

Table 4. Reported or estimated mussel harvest (green weight) and value from the Mississippi and Illinois rivers in the five Upper Mississippi River states, 1987–1991.

	Washboard				Threeridge				Other species		Annual total	
	Live (lb)	Dead (lb)	Total (lb)	Value ($)	Live (lb)	Dead (lb)	Total (lb)	Value ($)	Total (lb)	Value ($)	Harvest (lb)	Value ($)
Minnesota												
1987 *												
1988					2,194		2,194	263	32	4	2,226	267
1989					6,590		6,590	2,175			6,590	2,175
1990					9,373	1,719	11,092	3,882	12	4	11,104	3,886
1991					34,087	1,935	36,022	10,807			36,022	10,807
Wisconsin												
1987	526,674	35,521	562,195	114,215			54,945	2,747	1,572	314	618,712	117,276
1988	414,918	446,933	861,851	194,717	56,032		56,032	5,603			917,883	200,320
1989	272,116	243,870	515,986	256,168			574,530	190,014			1,090,516	446,182
1990	78,863	192,715	271,578	367,936	1,063,158	275,869	1,339,027	401,708			1,610,605	769,644
1991	109,292	217,177	326,469	430,595	275,226	13,574	288,800	78,284	4,741	4,677	620,010	513,556
Iowa												
1987	739,723	1,227,736	1,967,459				66,110		361		2,033,930	671,000
1988	769,118	902,634	1,671,752				32,838		288		1,704,878	727,000
1989	727,318	912,110	1,639,428				228,417		330		1,868,175	1,000,000
1990	590,474	1,283,348	1,873,822				510,269		4,423		2,388,514	2,169,736
1991	337,915	825,791	1,163,706				62,244		2,576		1,228,526	1,296,000
Illinois–Mississippi River												
1987	1,092,330	967,441	2,059,771	534,583	210,552	35,614	246,166	63,338	7,700	2,339	2,313,637	600,260
1988	1,010,026	919,810	1,929,836	620,624	339,518	9,142	348,660	65,704	5,715	1,168	2,284,211	687,496
1989	1,363,482	1,099,875	2,463,357	1,061,530	330,396	84,244	414,640	132,517	5,038	2,299	2,883,035	1,196,346
1990	822,117	667,798	1,489,915	1,524,486	347,624	325,131	672,755	340,915	57,763	18,428	2,220,433	1,883,829
1991 **												
Illinois–Illinois River												
1987			143,178	49,580			211,026	75,675	15,261	5,473	369,465	130,728
1988			151,915	52,371			203,682	68,664	6,361	2,233	361,958	123,268
1989	490,336	31,227	521,563	196,973	302,047	17,391	319,438	123,374	1,408	727	842,409	321,074
1990	234,392	99,101	333,493	347,210	613,792	162,004	775,796	606,820	58,251	47,961	1,167,540	1,001,991
1991 **												
Missouri												
1987 **												
1988			84,706				13,952		996		99,654	47,878
1989	217,633	104,310	321,943		68,608	9,179	77,787		80		399,810	192,086
1990	151,110	88,747	239,857		53,118	3,511	56,629		2,523		299,009	240,000
1991	145,007	128,591	273,598		27,249	25,052	52,301		1,448		327,347	545,033

* No mussels harvested.

** No data available.

Note: Data in this table were obtained from the Minnesota Department of Natural Resources (DNR), the Wisconsin DNR, the Iowa DNR, the Illinois Department of Conservation (DOC), and the Missouri DOC.

Table 5. Harvest per unit effort by Iowa shellers in the Mississippi River.*

	1987	1988	1989	1990	1991
Live washboard	41.6	46.1	43.6	17.3	13.0
Dead washboard	69.1	54.1	54.7	37.6	31.8
Threeridge	3.7	2.0	13.7	15.0	2.4
All species	114.5	102.2	112.1	70.1	47.2

* Catch per unit in pounds per hour.
From Ackerman and DeCook (1992).

availability of legal-sized washboards, drove the price higher. Slow-growing washboard populations may no longer be able to keep up with these harvest pressures.

Catch-per-unit-effort values were calculated from Iowa commercial clammer reports (Ackerman and DeCook 1992). The catch-per-unit-effort for live washboard was fairly steady from 1987 to 1989 but dropped greatly in 1990 and 1991 (Table 5). This marked change can at least be partially attributed to an increase in the minimum size limits for live washboard in 1990.

Catch-per-unit-effort for dead washboard shells has shown a steady but slow rate of decrease. In contrast to increasing size limits on live washboard, Iowa removed size limit restrictions on dead shells of commercial species in 1990 and 1991. Therefore, the decreasing catch-per-unit-effort on dead washboard probably reflects a decrease in the amount of salable dead shells available for harvest.

The large variation in catch-per-unit-effort for threeridge was due primarily to changes in buyer demand rather than to population changes. For the combination of all species harvested, there has been a decline in catch-per-unit-effort since 1987.

The Future of Mussel Management

Explaining all the changes in the commercial mussel fishery over the past 10 years and predicting what will happen in the next 10 years is difficult because of the large number of influencing variables, including market demand, cost of licenses, changes in minimum size limits, the mussel die-off, and river conditions. Another factor that clouds the future of the Mississippi River mussel fauna is the introduction of the zebra mussel (*Dreissena polymorpha*) in 1991. The greatest immediate effect of zebra mussels in the Upper Mississippi River ecosystem will be on the native mussels. The significance of the effect of zebra mussels on the native mussel fauna is uncertain, but current information from the Great Lakes indicates a possible devastating impact (Hunter and Bailey 1992).

In the late 1980s, concern for the Upper Mississippi River mussel fishery was the impetus for the formation of a mussel committee within the UMRCC (Fritz 1990). The committee developed a strategic plan that documented the problems which are barriers to effective mussel management efforts and prescribed a strategic plan of action that would provide river managers with the necessary information to effectively manage the mussel resource. This symposium, "The Conservation and Management of Freshwater Mussels," was a direct result of the UMRCC's strategic mussel plan.

Recommendations for future mussel management on the Upper Mississippi River include standardized sheller and buyer report forms, development of more uniform regulations, and continued implementation of the strategic mussel plan goals. Some of the high-priority objectives are to develop a solid base for funding and to continue research in areas such as life histories and exploitation. If there is a future for the Upper Mississippi River mussel resource 101 years after the birth of the commercial mussel industry, there must be sound scientific management.

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