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Waterways Experiment
Station

Zebra Mussel Research Technical Notes

Section 1 — Environmental Testing

Technical Note ZMR-1-29

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Introduction and Spread of *Dreissena polymorpha* in the U.S. Inland Waterway System, 1992-1993

Background *Dreissena polymorpha* was first discovered in 1988 in Lake St. Clair, Michigan (Hebert, Muncaster, and Mackie 1989). Since then, researchers have investigated population growth patterns of this species to help develop effective control strategies. In addition, morphological, physical, and chemical characteristics of North American freshwater habitats have been used to predict future dispersion of this species in North America (Ramcharan, Padilla, and Dodson 1991; Schneider 1992; Strayer 1991). Analysis of *D. polymorpha* populations in North American waterways during early introduction provides a rare opportunity to document early population demographics of an introduced, invasive pest species. Such information is not available from European studies.

Purpose The purpose of this technical note is to analyze population structure (as indicated by density and size demography) of recently established zebra mussel populations in the U.S. inland waterway system. Samples were collected between late 1992 and early 1994. Most collections were within 12 months of the first zebra mussel sightings.

Additional information This technical note was prepared by Dr. Andrew C. Miller, Dr. Barry S. Payne, and Ms. Fawn M. Burns. For additional information, contact Dr. Miller, U.S. Army Engineer Waterways Experiment Station (WES), (601) 634-2141. Dr. Ed Theriot, WES, (601) 634-2678, is Manager of the Zebra Mussel Research Program.

Methods Most samples were collected at specific sites at power stations or U.S. Army Corps of Engineers navigation locks and dams in the Niagara, upper and lower Mississippi, Ohio, and Cumberland Rivers (Figure 1). Most samples were obtained when structures were temporarily dewatered for maintenance. This technical note describes zebra mussel populations at the following facilities: Black Rock Lock, Niagara River; Illinois river mile (RM) 162; Lock and Dam 6, upper Mississippi River; Robert C. Byrd Locks and Dam, upper Ohio River; and Old Hickory Lock, Dam, and Hydropower Plant, Cumberland River.

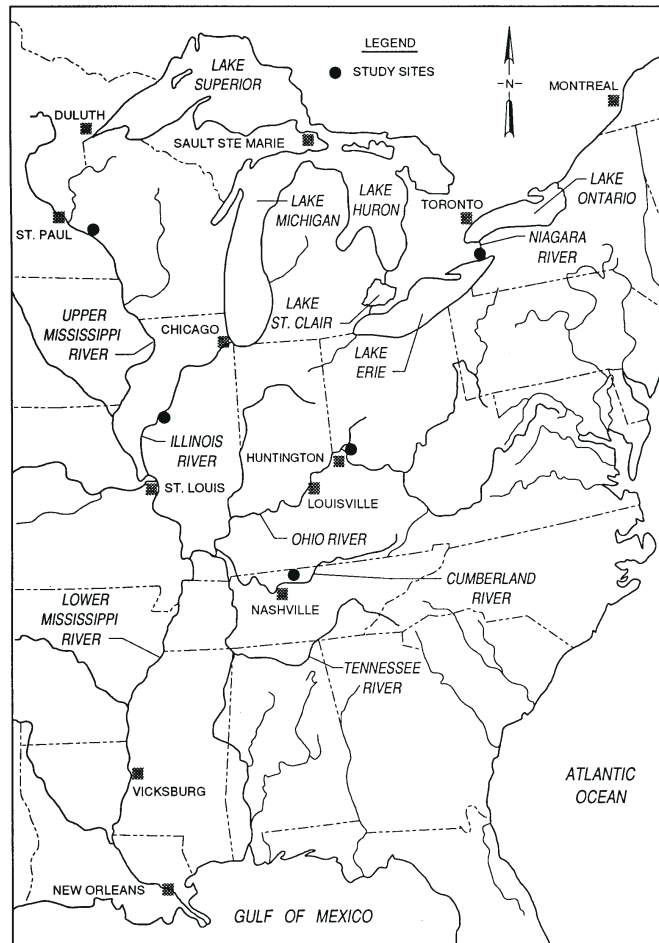
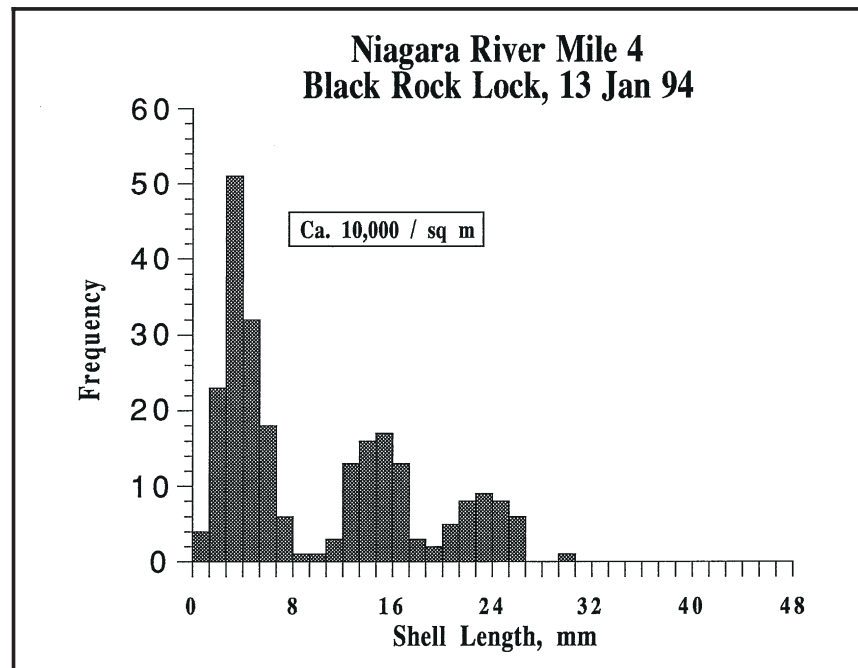


Figure 1. Study sites on the island waterway system

At sites with density less than 100 individuals/m², individual mussels were removed from the surface by hand. At high-density sites, mussels were scraped from premeasured areas. All *D. polymorpha* were preserved in 10-percent formalin, returned to the laboratory, counted, and measured to the nearest 0.1 mm with a digital caliper. Quagga mussels (*Dreissena bugensis*) were excluded from this analysis. Length-frequency histograms were plotted in 1-mm increments.

Results and discussion **Examples of moderate to high density, complex population structure**

A high-density, complex *D. polymorpha* population was sampled from the upper approach guidewall of Black Rock Lock, Niagara River, in January 1994 (Figure 2). Adult zebra mussels were first found in western Lake Ontario in 1989; therefore, Black Rock Lock had been colonized approximately 5 years before the 1994 sample was collected. This population had three distinct cohorts, with the smallest (0.4 to 9.5 mm; mean shell length (SL), 3.97 mm) comprising 56.7 percent of the sample. The second cohort ranged from 11.3 to 18.0 mm (mean SL, 14.58 mm) and comprised 26.7 percent of the population. The remaining cohort included organisms 18.5 to 29.5 mm (mean SL, 23.24 mm) and comprised 16.67 percent of the sample. Total density where this sample was



**Figure 2. Size demography of *D. polymorpha*
at Black Rock Lock, 1994**

collected was estimated at approximately 10,000 individuals/m². Similar densities have been found at this lock since the winter of 1991-92 (personal communication, Gary Dye, Lock Master, U.S. Army Engineer District, Buffalo, NY).

Two years after adults were first reported in the Illinois River, a moderately dense population (1,793 individuals/m²) was collected by divers on natural substratum at RM 162. The demography of this population (Figure 3) was similar to that found at Black Rock Lock. The mussels that were collected on August 10, 1993, consisted of three cohorts that comprised 18.6, 56.0, and 25.4 percent of the population. Minimum, maximum, and mean SLs for the three cohorts were 0.5, 4.4, and 1.9 mm; 4.9, 16.1, and 12.2 mm; and 16.5, 27.5, and 19.8 mm. This slightly smaller average size of each cohort versus that at Black Rock Lock probably reflects differences between January and early August sampling. Zebra mussel densities on natural substratum near the mouth of the Illinois River continued to increase through 1993; densities close to 100,000 individuals/m² were measured (personal communication, Douglas Blodgett, Aquatic Biologist, Illinois Natural History Survey, Havana, IL). Immature mussels were probably carried on water currents from Lake Michigan into the Illinois River.

Example of low-density, complex population structure

Like the two previously discussed populations, zebra mussels collected at Lock and Dam 6 in the upper Mississippi River in January 1994 consisted of three cohorts (Figure 4). However, average density was comparatively low (21.1 individuals/m²). Two cohorts comprised 84.4 and 14.9 percent of the population; organisms in the two cohorts had shell lengths that ranged from 3.5 to 14.8 mm and 21.5 to 30.4 mm. Zebra mussel veligers reached the mouth of the Illinois River by passive transport, although adults had to be carried upriver to Lock and Dam 6, located approximately 496 miles from the mouth of the Illinois River.

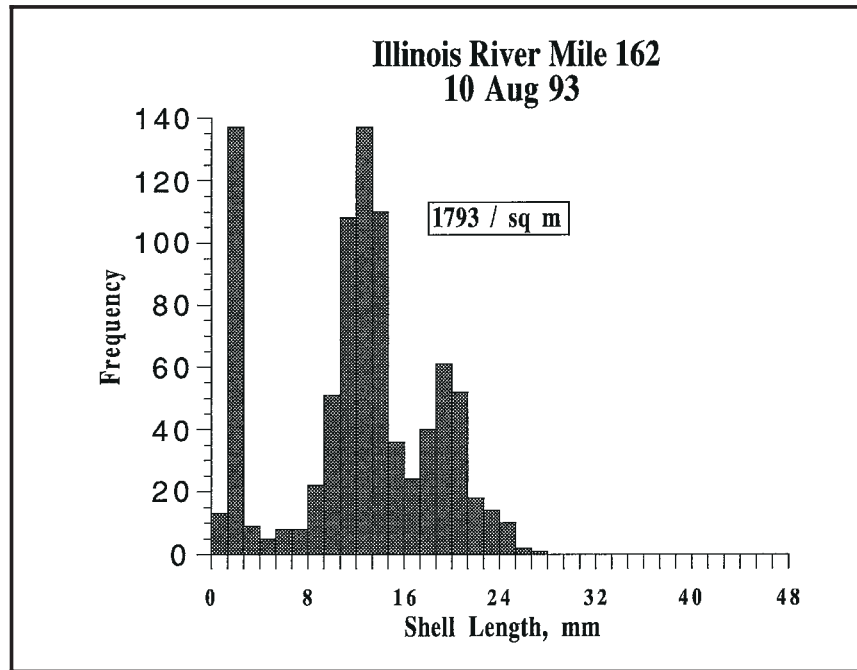


Figure 3. Size demography of *D. polymorpha* at Illinois Rive Mile 162, August 1993

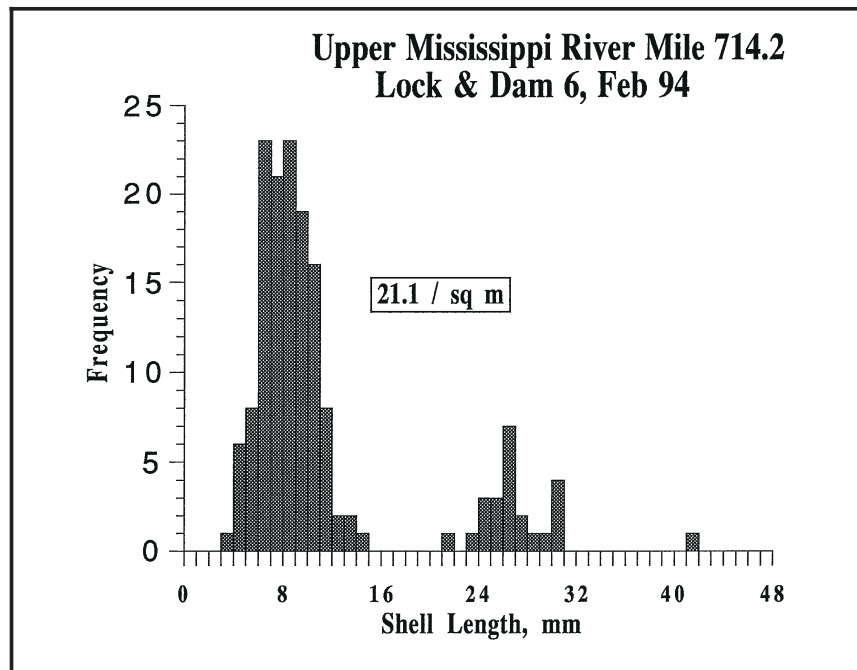


Figure 4. Size demography of *D. polymorpha* at Lock and Dam 6 on the upper Mississippi River, February 1994

Example of low-density, simple population structure

At Robert C. Byrd Locks and Dam, located at RM 279.2 in the upper Ohio River, two samples were collected during the summer and fall of 1993 (Figure 5). In 1993 this location was near the eastern limit of the zebra mussel

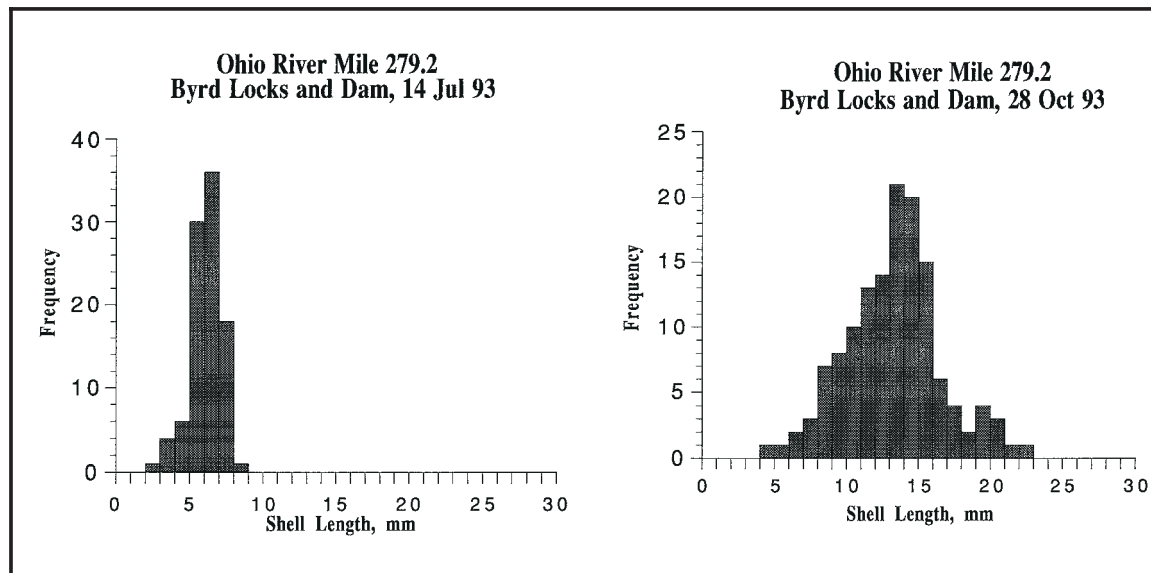


Figure 5. Size demography of *D. polymorpha* at Byrd Locks and Dam, July and October 1993

range in the inland waterway system. This site is 600 river miles from the mouth of the Ohio River and an additional 551 miles from Lake Michigan. On July 14, a unimodal young population with a mean shell length of 6.1 mm was collected; by October 28, that population had a mean shell length of 13.1 mm. It is likely that mussels settled early in 1993 and were probably produced from adults that settled in 1992 or earlier. During the 106 days that separated collection of these two samples, the range of shell lengths increased by nearly a factor of three, and mean shell length more than doubled. Average growth rate was estimated at 0.07 mm per day.

On September 17, 1993, zebra mussels were collected at Old Hickory Lock, Dam, and Hydropower Plant, located at RM 216.2. This low-density, old population consisted of one or two cohorts that ranged between 24 and 43 mm with a mean SL of 34.9 mm (Figure 6). It is likely that this population, not yet supported by natural recruitment, settled in early 1991 and 1992. It is also possible that adults could have been carried to the site by barge and dislodged from the hull in the lock chamber.

Density of recently introduced *D. polymorpha* populations

An examination of density data collected during early invasion in the Great Lakes indicates that an increase by one-to-two orders of magnitude per year is not unexpected. During their first year in Lake St. Clair, zebra mussels achieved densities of 0.5, 0.8, 48.0, and 196.5 individuals/m² at different locations (Hebert, Muncaster, and Mackie (1989). Twelve months later, Hebert and others (1991) resampled Lake St. Clair and reported a mean density of 5,496 (maximum, 10,520 individuals/m²).

Griffiths (1993) sampled in June 1991 and reported that densities were approximately 20,000 individuals/m² at one site. MacIsaac, Sprules, and Leach (1991) reported that juveniles and adults in Lake Erie approached 400,000 individuals/m² in 1990, 1 year after they were first found. A small number of recently settled zebra mussels were found at the Monroe Power Plant intake in early August 1988 (Kovalak, Longton, and Smithee 1993). By late summer 1989, densities were 700,000 to 800,000 individuals/m². High-density populations can

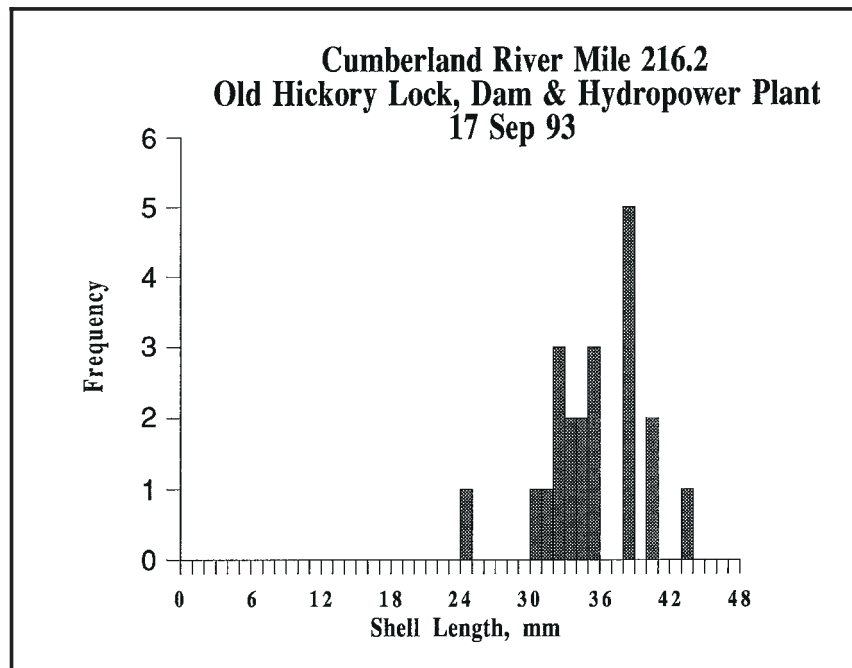


Figure 6. Size demography of *D. polymorpha* at Old Hickory Lock, Dam, and Hydropower Plant, Cumberland River Mile 216.2, September 1993

usually develop quickly in constricted areas with high water flow, such as screens, trash racks, and intake pipes.

Zebra mussel densities measured at Black Rock Lock in 1993 (33,354 individuals/m²) probably approximate the maximum density likely to be observed. The next highest densities were at Smithland Locks and Dam (approximately 250 individuals/m²), located relatively close to the mouth of the Ohio River at RM 923, and at the Andrus Power Station, located in northern Mississippi near Greenville at RM 537. This density is moderately low and should increase by 1 to 2 orders of magnitude within 12 months. All of the other facilities with fewer than 100 individuals/m², including Harvey Lock and Dam (located near New Orleans at RM 98.2) should achieve maximal densities within 12 to 24 months. The trend that locations closer to the initial infestation have higher mussel density is further supported by 1993 zebra mussel density data. Black Rock Lock had 3,354 individuals/m²; Smithland and Andrus Lock and Dam had 259 and 257/m², respectively; and Harvey Lock and Dam had 31/m². It would appear that high-density, complex populations should be found in the upper Mississippi and much of the Ohio River drainage in 1994 or 1995. If they are not limited by elevated water temperatures (Schneider 1992, Strayer 1991), high-density populations should be found in the lower Mississippi River at about the same time.

Conclusions High-density, complex populations are commonly collected 24 months after *D. polymorpha* is first sighted. Such populations existed in the Illinois and Niagara River in 1993. Low-density, structurally simple populations characterized sites that were some distance from the Illinois River, the connecting link between the Inland Waterway System and the Great Lakes. Zebra mussel populations became structurally simple moving up the Ohio and Cumberland Rivers. A low-density population with three cohorts was found in the upper Mississippi River in early 1994, presumably the result of barge traffic in 1992 or 1993.

Low-density, structurally simple populations were found in the lower Mississippi River in 1993. Although sites downriver of Illinois have the potential for rapid colonization by river currents, in 1994 they were too far from the source of introduction to achieve high-density populations. Additional sampling for the next 3 to 5 years will clarify population dynamics of this newly introduced species.

- References** Griffiths, R. W. 1993. "Effects of zebra mussels (*Dreissena polymorpha*) on the benthic fauna of Lake St. Clair." *Zebra mussels: Biology, impacts, and control*. T. F. Nalepa and D. W. Schloesser, ed., Lewis Publishers, 415-37.
- Hebert, P. D. N., Muncaster, B. W., and Mackie, G. L. 1989. "Ecological and genetic studies on *Dreissena polymorpha* (Pallas): A new mollusc in the Great Lakes," *Canadian Journal of Fisheries and Aquatic Sciences* 46, 1587-91.
- Hebert, P. D. N., Wilson, C. C., Murdoch, M. H. and Lazar, R. 1991. "Demography and ecological impacts of the invading mollusc *Dreissena polymorpha*," *Canadian Journal of Zoology* 69, 405-9.
- Kovalak, W. P., Longton, G. D., and R. D. Smithee. 1993. "Infestation of power plant water systems by the zebra mussel (*Dreissena polymorpha pallas*)." *Zebra mussels: Biology, impacts, and control*. T. F. Nalepa and D. W. Schloesser, ed., Lewis Publishers, 359-80.
- MacIsaac, H. J., Sprules, W. G., and J. H. Leach. 1991. "Ingestion of small-bodied zooplankton by zebra mussels (*Dreissena polymorpha*): Can cannibalism on larvae influence population dynamics?" *Canadian Journal of Fisheries and Aquatic Sciences* 48, 2051-60.
- Ramcharan, C. E., Padilla, D. K., and Dodson, S. I. 1991. "Predicted population dynamics of *Dreissena polymorpha* in the Great Lakes based on analysis of European data," American Society of Limnology and Oceanography Conference, Halifax, Nova Scotia.
- Schneider, D. W. 1992. "A bioenergetic model of zebra mussel, *Dreissena polymorpha*, growth in the Great Lakes," *Canadian Journal of Fisheries and Aquatic Sciences* 49, 1406-16.
- Strayer, D. L. 1991. "Projected distribution of the zebra mussel, *Dreissena polymorpha*, in North America," *Canadian Journal of Fisheries and Aquatic Sciences* 48, 1389-95.