



Lawrence M. Riley and Rory K. Aikens – Arizona Game and Fish Department

For more than a decade, a small but wary group of scientists have been preparing for an invasion everyone hoped would never happen: the infestation of an aquatic nuisance species such as zebra mussels in our western waters, especially the giant reservoirs along the Colorado River. Most scientists thought the odds of these mussels making the 1,000-mile journey from the Great Lakes were fairly remote, but recognized that large boats from the Midwest routinely are brought to lakes Powell and Mead on the Colorado River, making those the most likely places of introduction.

Theory and speculation made way for an unwelcome reality this year. On Jan. 6, 2007, a diver at the Las Vegas Boat Harbor in Lake Mead discovered quagga mussels, a relative of the zebra mussel, on a submerged anchor cable. Within a few weeks, they were discovered in lakes Havasu and Mohave further downstream. Then they were detected at the intakes for the Central Arizona Project (CAP) and the Colorado River Aqueduct. They were quickly determined to be widespread, although their numbers were not large everywhere.

In August 2007, a single adult quagga was collected from a monitoring device in the CAP aqueduct near Phoenix. Its size implied a single season of growth. While scientists expected larvae to move into and through the aqueduct, they hoped the high-velocity environment would prove inhospitable. Inspections of distribution lines, canal surfaces, and siphons on

the canal during scheduled outages last summer did not reveal any additional quaggas. But their presence in the CAP implies a direct path to Lake Pleasant in central Arizona, connected to CAP, and the potential for spread to nearby reservoirs. Elsewhere, adult quagga mussels have been reported in the Colorado River Aqueduct in California and an interconnected reservoir near San Diego.

Monitoring for the presence of adult zebra and quagga mussels has been ongoing for a number of years on a dispersed basis. But strategies are now shifting to earlier detection techniques, including monitoring for veligers, or quagga larvae, in concentrated plankton collections from 1,000-liter water samples.

Veliger monitoring at Lake Powell prompted announcement of their detection there in mid-August. However, no adult mussels had been found as of September, and some uncertainty remains regarding their identification. It is hoped that further investigation will resolve this uncertainty soon, and clarify the process of veliger monitoring in lakes as yet unoccupied by quagga mussels.

Why the Concern?

Dreissena species, including the closely related zebra and quagga mussels, are less than an inch long but reproduce by the millions. These rapidly spreading invaders can coat nearly every available surface, clog pipelines, damage machinery, harm fishery resources, change ecosystems, and foul water with their waste.

Quagga and zebra mussels have already caused multimillion-dollar problems in the Great Lakes and the Mississippi River Basin. They often settle in massive colonies that can block water intakes and threaten to affect municipal water supplies and agricultural irrigation and power plant operations. In the Southwest, a region dependent upon irrigation, hydropower, and municipal transmission, these mussels could impair water conveyance efficiency by increasing roughness in canals and distribution lines. Small apertures, such as small-diameter intakes, irrigation lines, and cooling water lines, could be susceptible to blockage. Congressional researchers estimated that zebra mussels alone cost industries, businesses, and communities more than \$5 billion from 1993 to 1999.

Quaggas are efficient filter feeders that consume large amounts of plankton, removing it from the water and potentially causing shifts in the ecological balance of lakes. Their feeding habits often increase water clarity, favoring different species. Some evidence suggests that quaggas may act as bioconcentrators of contaminants like heavy metals; it is unknown if they become a sink for these contaminants or if they facilitate cycling and transfer of them back into the wildlife food chain.

Quaggas don't pose a public health threat, but can change the water taste and odor. As selective feeders, they can favor blue-green algae, which may affect taste and perceived quality of the water. In addition, treatment to deter settlement of quagga mussels in conveyance facilities often

includes chlorination, which affects the taste and odor of water, or use of potassium permanganate, which can impart coloration.

The Quagga Lifestyle

Quaggas live three to five years, and a single female can produce up to a million eggs each year. The fertilized eggs become veligers that are carried in the water current for around three weeks before settling and becoming adults.

Quaggas can colonize both hard and soft substrates, but prosper on rocky bottoms and hard surfaces. They live in waters ranging from warm and shallow to deep and cold, but seem to prefer deeper water. In Lake Mead, they have been found at depths greater than 100 feet. Quaggas appear to avoid light, preferring deep shaded areas, making their detection more difficult.

Rays of Hope?

Some scientists see a slim ray of hope that we might escape a massive, Great Lakes-style invasion. Because the Colorado River reservoirs are not as nutrient-rich as the Great Lakes, some think quaggas might not reproduce as prolifically or reach similar densities. Unfortunately, evidence from the Colorado River suggests that their populations are on a definite upswing.

Reservoirs such as Lake Mead stratify during summer months, developing zones of lower oxygen levels in deeper waters. Although the dissolved oxygen level in Lake Mead never reaches the point of lethality for the quaggas, it might slow their reproduction. Similarly, winter water temperatures in the reservoir may fall sufficiently to slow, but not stop, reproduction.

Arizona rivers may be less susceptible to quagga mussels than its lakes. While quaggas have proliferated in the Great Lakes, they have not entered into river systems there the way zebra mussels have. A recent risk assessment conducted by the U.S. Geological Survey for the Colorado River in Grand Canyon suggests that velocity and turbidity attributable to suspended inorganic material may make that area less hospitable to quagga occupation.

Subtle differences in shell morphology appear to make zebra mussels more adept at “stacking,” a behavior that exacerbates the problems those mussels cause in clogging water distribution systems. Thus, we may be fortunate to have “only” quaggas so far, but continued vigilance for zebra mussels is critical.

Can They Be Controlled?

Quaggas and zebras do have predators in western waters. A few resident fish species, such as the redear sunfish, will likely feed upon adults, as will some waterfowl. Many fish may feed upon the larvae. However, it is unlikely that predators will control mussel populations.

Eradication of existing populations seems unlikely at this point. The State of Virginia successfully eradicated the zebra mussels from an isolated quarry using potassium salts, which proved lethal to the mussels while the remaining aquatic wildlife were unharmed. However, the transfer in scale from a small quarry to Lake Mead is huge.

Chlorination and use of potassium permanganate are the most common treatments for localized control of quagga and zebra mussels on equipment and in water distribution systems. However, the amount of chlorine needed for mussel control in very large conveyance systems may be costly and create other challenges. Nevertheless, alertness to the presence of quagga mussels and preventative maintenance of facilities is necessary.

The Arizona Game and Fish Department is collaborating with the Central Arizona Project, Salt River Project, several federal agencies, and Nevada and California state agencies to actively monitor the movement of quagga mussels in the West. The agencies have also launched publicity campaigns on the importance of adopting best practices to stop hitchhiking plants and animals. We may not be able to prevent the spread of quagga mussels, but public awareness and action can help slow it down.

Contact Larry Riley at lriley@azgfd.gov.



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