Zebra Mussels in the Eastern United States

Life History, Ecology, and Distribution of the Zebra Mussel

Dreissena polymorpha (Pallas), commonly referred to as the zebra mussel, or the traveling mussel, is a bivalve mollusc with a 2 to 5-year life span and a maximum adult size of about 1 inch. Females begin to spawn by the end of their first year of life, at a minimum water temperature of 54°F. A single female can release at least 30,000 to 40,000 eggs per year. The eggs are fertilized in the water and hatch into a larval stage called a veliger. The veliger, with an initial diameter of 0.002 to 0.003 in., is a temporary member of the plankton community, but after 14 to 21 days, it develops a shell and seeks an appropriate substrate on which to settle.

Once settled, zebra mussels attach to a surface by means of byssal threads. This "byssus" comprises an elastic protein coated by an adhesive secretion and is produced by a gland in the foot. In the juvenile and early adult stages, zebra mussels can move over short distances by dissolving and reforming the byssus.

Once mature, zebra mussels tend to move less but are still motile. Individuals typically aggregate, and densities exceeding 500,000 adults per square yard have been observed in water intakes within the Great Lakes. Although hard surfaces, such as rock and wood, are preferred, zebra mussels also will settle on soft substrates, including sand and aquatic weeds.

As a settled juvenile and later as an adult, the zebra mussel uses its gills to filter water through the mantle cavity, removing and consuming phytoplankton (algae in the water) and other suspended material. Zebra mussels also produce a substance called pseudofeces, which consists of particles that are taken in through the inhalant siphon, rejected as food, wrapped in mucus, and expelled. Pseudofeces commonly contain higher concentrations of metals and other contaminants than do ambient sediment particles because of this process of aggregation.

Zebra mussel distribution is limited by water-quality conditions. In general, they are found at a salinity of 0 to 4 parts per thousand, a pH of 7.4 to 9.0, a calcium concentration of 20 to 125 milligrams per liter, a dissolved-oxygen concentration of 8 to 10 mg/L, and a turbidity of 15 to 78 in. Secchi disc depth. Optimum filtration and growth occurs at 68°F and decreases rapidly at temperatures above 77°F. Settlement and attachment generally do not occur when water velocities exceed 4.0 feet per second.

The zebra mussel is native to the Black, the Caspian, and the Azov Seas of southern and eastern Europe, indicating that it is a temperate, cold-water-adapted species. By the mid-1800's, it had spread to Great Britain, Germany, eastern Europe, and western Russia. From there it spread to Scandanavia and other western European countries. It generally is accepted that the zebra mussel has lower population densities in European rivers because of the poor water quality of rivers when compared with that of many North American rivers.

Adult zebra mussels were found for the first time in North America in Lake St. Clair in June 1988. It is presumed that they were unintentionally introduced as veligers in ballast water from trans-Atlantic commercial vessels originating from Black Sea ports in 1985 or 1986. The spread of the zebra mussel in North America has been rapid. As of January 1994, it has been identified in the Great Lakes, as well as in the the Arkansas, the Cumberland, the Hudson, the Illinois, the Kanawha, the upper and lower Mississippi, the Ohio, the St. Lawrence, and Tennessee Rivers. The rapid spread has been largely attributed to the unintentional dispersal of adults attached to the hulls of barges used for commercial navigation in the inland waterways. It also is likely that recreational boaters transported zebra mussels on their hulls to uninfested waters, In addition to being carried in a downstream direction by current, veligers may have been transported randomly in bait buckets by recreational fishermen.

A second, closely related species, *Dreissena bugensis* (Andrusov), was discovered in Lake Erie in 1992. Although similar in appearance to the zebra mussel, the quagga mussel may have a different optimal temperature range, salinity tolerance, and habitat preference.

ZEBRA MUSSEL DISTRIBUTION IN THE UNITED STATES
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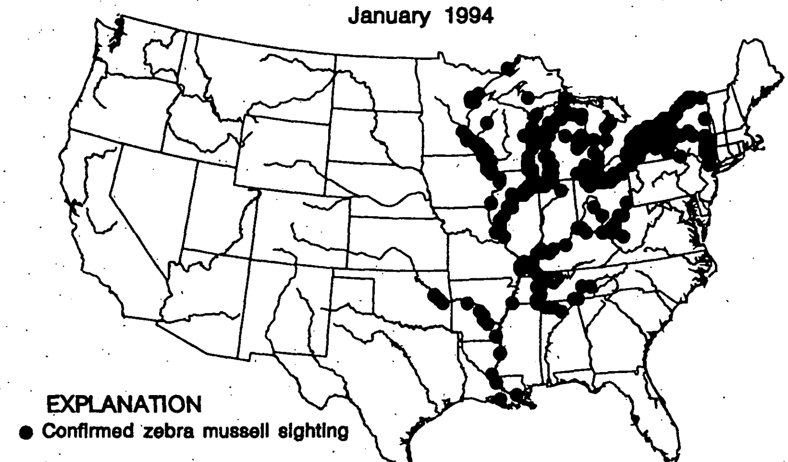

New laws have been enacted in the United States and Canada in the wake of the zebra mussel invasion to prevent further introductions of exotic species. Implementation of these laws, which include the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (Public Law 101–646), should help avoid future environmentally and economically costly introductions of exotic aquatic species.

Effects of the Zebra Mussel Invasion

The invasion of North America by the zebra mussel has created short- and long-term effects on the aquatic environment, as well as on millions of water users. Unfortunately, these effects have been largely negative, as is common with invading species. Eventually, we can expect that zebra mussels will reach equilibrium with other aquatic invertebrate species and become a permanent member of freshwater ecosystems in North America.

Zebra mussels interfere with the normal food-chain interactions of filter feeders in rivers by competing successfully for phytoplankton. Thus, larger zooplankton, which are food for fish, have less to eat and may be reduced in numbers. Zebra mussels will attach to native mussels, many of which are already threatened or endangered, and can prevent them from opening or properly closing their shells. Also, large infestations will reduce the food and dissolved-oxygen supplies to native mussels. Zebra mussels also attach to crayfish and snails and can kill them. Settlement of adult zebra mussels on spawning grounds of sport fish may reduce their reproductive success.

The ability to extract suspended-sediment particles from the water column means that zebra mussels have the capacity to increase water clarity and, thereby, algal growth. In addition, suspended-sediment particles typically have organic compounds and metals adsorbed to their surfaces. As filter feeders, zebra mussels can bioaccumulate these materials in their body tissues and pseudofeces. Concentrations of contaminants, including polyaromatic hydrocarbons and metals, and total organic carbon are found to increase in soft sediments where zebra mussels are attached. Large infestations of zebra mussels have the potential to significantly reduce the dissolved-oxygen concentrations in rivers. This effect has been documented in the Illinois River under low-flow conditions in late summer.

By 2000, the potential economic disruption to businesses, municipalities, and public utilities, particularly those with water intakes, has been estimated to exceed $5 billion. Zebra mussels can prevent proper closure of lock and dam structures. When they attach to the hulls of boats, they increase drag and fuel consumption. Zebra mussels have the potential to sink navigation buoys because they weigh 20 to 30 pounds per square yard. Large colonies attached to docks and piers accelerate deterioration. On beach areas, colonies of zebra mussels can cut the feet of bathers. Furthermore, the dead and decomposing animals create an aesthetic nuisance and a health hazard.

Control Options for the Zebra Mussel

Before malfunction of equipment or interruption of water flow, the need for zebra mussel mitigation or control measures can be assessed by various types of monitoring or inspections. Periodic examination of artificial substrates or inspection of exposed or submersed surfaces can reveal the presence of zebra mussel colonies. Plankton sampling will indicate the presence of veligers in the water and the potential for their settlement.

Various types of mechanical controls are available. Most commonly used screens have mesh sizes too large to prevent entry of veligers. Separator filters or automatic backwash filters can be used to exclude some sizes of veligers. Buried intakes or sand filters also can be used. Replaceable screens can be used as a substrate for settlement of veligers and exchanged for clean ones at appropriate intervals. It may be possible to create and maintain current velocities exceeding 6.5 ft/s, which will prevent settling of veligers. A related strategy uses in-line, high-speed agitators to kill veligers. Pulsed-shock (acoustic) waves have been used experimentally to clean surfaces encrusted with zebra mussels. Scraping, high-pressure hosing, and other means of physical removal of settled adults are useful techniques. However, these options entail the transportation and disposal of adult animals, which may be considered to be hazardous waste.

Exposure to hot water at 98°F for 1 hour or 104°F for 15 minutes results in 100-percent mortality. Freezing can be an effective method for removing zebra mussel infestations. At temperatures of less than 41°F, tissue-freezing time is less than 4.5 hours. If surfaces can be dewatered during periods of subfreezing temperatures, then infestations can be eliminated. Electrically charged surfaces are effective in preventing settlement of veligers. Several commercially available silicone-based paints with low to very low surface tension can be applied to prevent settlement or result in such weak attachment that zebra mussels are detached by high current velocity or minimal surface abrasion.

Numerous oxidizing agents are effective against zebra mussels, including chlorine, chlorine dioxide, ozone, potassium permanganate, and hydrogen peroxide. Typically, treated water must be dechlorinated before it is discharged to the environment to protect native organisms from harm. Several other materials can act as molluscicides, including copper sulfate, zinc, and tributylin oxide. Research is underway to incorporate copper in various structural materials to be used in areas of zebra mussel infestation. All these substances may leach into the water and harm nontarget organisms.

No predators have been found in North America that feed exclusively on zebra mussels. The freshwater drum (a fish) and some species of waterfowl feed on zebra mussels, but feeding will not be sufficient to noticeably reduce the populations of zebra mussels. Efforts are underway to find strains of pathogenic bacteria that could be used against the zebra mussel, but this work is only in the initial stages.

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