# Aquatic Invasive Species: The Study of the Ecological and Economic Impacts of Zebra Mussels

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**Abstract:** Zebra mussels have a D-formed, striped shell made out of two pivoted valves joined by a tendon. The shells regularly have stripes that vary between yellow and brownish colors and range in length from a quarter to a half inch, depending on age. Typically, adults are about the size of a fingernail. Zebra mussels are an aquatic invasive species that originated in eastern Europe. The zebra mussel was first found in quite a while of southeast Russia and is now found throughout the Black and Caspian Seas. Zebra mussels get their common names from the zebra-like patterns on their shells. These mussels are small and typically grow to the size of fingernails. These mussels are prolific breeders that can stick to both hard and delicate surfaces in freshwater. Invasions have caused significant harm to the ecosystems where zebra mussels have established themselves. These organisms significantly raise the support costs for water treatment and power plants by stopping up water consumption structures (like lines and screens). Because mussels may heavily encrustate beaches, buoys, boat hulls, anchors, and docks, they negatively impact recreational activities on lakes and rivers.

**Keywords:** Zebra Mussels; Aquatic Invasive Species; Economic Impacts.

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## I. Introduction

Zebra mussels stick to hard surfaces underwater. One quart of water can be filtered daily by a single zebra mussel, which primarily consumes algae. They are attached to moored watercraft, timber, rocks, plants, pipelines, docks, boat lifts, swim rafts, and native mussels, among other natural and man-made substrates, underwater. A female can generate anywhere from 100,000 to 500,000 eggs every year. Fertilized eggs develop into "veligers," which are little, free-living larvae that eventually grow into shells. The veligers settle and use microscopic fibers known as byssal threads to adhere to a hard surface after two to three weeks. Tens of thousands of zebra mussels can be found in a single square yard. Except in cases when a permit is required for disposal, management, study, or education, it is illegal (a misdemeanor) to possess, import, buy, transport, or introduce the zebra mussel (Dreissena polymorpha) as a prohibited invasive species. Movement of water-related equipment is the main way that people spread zebra mussels. Boat lifts, swim rafts, docks, and boats are all places where mussels can be found. They can cling to aquatic vegetation as well. Adult mussels can live without water for up to 21 days in extremely moist settings (such inside dock/lift pipes) but fewer than five days in dry conditions.

Bait buckets, live wells, bilge regions, ballast tanks, engines, and other water-containing equipment can all support microscopic larvae (veligers). Because they may biofoul water supply pipelines in hydroelectric and thermal energy stations, public water supply plants, and modern offices, zebra mussels are well-known for their biofouling abilities. They colonize pipes that restrict flow, which lowers the intake in air conditioning and cooling systems, heat exchangers, condensers, and firefighting apparatus. At one Michigan power station, zebra mussel density reached 700,000/m2, and water treatment facilities have seen a two-thirds reduction in pipe sizes. Despite the paucity of research regarding zebra mussels' impact on irrigation, farms and golf courses may be at risk of infestation. Increased drag from connected mussels can have an impact on recreational and navigational watercraft. Engine cooling systems can become overheated and damaged when small mussels sneak inside. Attached zebra mussels have caused navigational buoys to sink. If fishing gear is left in the water for expanded timeframes, it might turn into fouled. Zebra mussel encrustation has accelerated the deterioration of dock pilings. If zebra mussels are allowed to remain attached, steel and concrete may corrode and lose structural integrity. Zebra Mussels on a Native Mussel shown in Figure 1.

Figure 1: Zebra Mussels on a Native Mussel

## II. Literature Review

The habitats that zebra mussels infiltrate can be significantly impacted. Although their primary food source is phytoplankton, they also filter out microscopic organisms, protozoans, zebra mussel veligers, other microzooplankton, and residue from the water column. After invasion, zebra mussel populations in the Incomparable Lakes and Hudson Stream radically diminished phytoplankton biomass (Feniova et al., 2020). In Lake Erie, during the initial years of the invasion, diatom abundance decreased what's more, not entirely settled by Secchi profundity rose by 100 percent. High zebra mussel population sampling stations in Saginaw Bay saw a 60-70% reduction in chlorophyll-an and a multiplying of Secchi profundity. After the Hudson River was invaded by mussels, the biomass of phytoplankton decreased by 85%. It is unclear to what degree zebra mussels can modify the species structure of the phytoplankton local area. Light may enter the water more easily when it is clearer, which may encourage the growth of macrophytes. Veligers have the ability to colonize macrophytes; if this colonization becomes harmful, the macrophyte community may be changed. Although these impacts have not yet been reported, increased light penetration may also result in deeper thermoclines and warmer water. The concentration of dissolved organic carbon (DOC) may decrease as phytoplankton is digested. In fact, it has been discovered that zebra mussels in inland lakes result in decreased DOC concentrations. Since macrophytes are also a source of DOC, they may eventually make up for this, although there might be a lag between the proliferation of macrophytes and the decline in phytoplankton biomass (Karpowicz et al., 2023). Because DOC absorbs UV-B radiation, this could result in a timeframe when UV-B light enters the water segment more deeply. Recently, it has also been demonstrated that zebra mussels may directly absorb DOC. Despite their preference for bigger particles, zebra mussels can filter particles less than 1µm in diameter. Bacteria could therefore be a significant food source. Zebra mussels are far more effective than unionids and Asiatic clams at filtering such tiny particles, with an efficiency rate of 90%. The temperature, suspended matter concentration, phytoplankton abundance, and mussel size all affect the filtering rate, which varies greatly. This seasonal pattern is dictated by temperature, even though European zebra mussels are less dynamic in the colder time of year. Filtration rate diel patterns have not been discovered. Filtration rates increase sharply between 5 and 10 degrees Celsius in the spring, level off with temperature, and may try and be obstructed at temperatures over 20 degrees. The amount of filtration activity needed to maintain oxygen demand can be decreased by increased suspended materials. Filtration rate and size have a sigmoidal connection, however age may have an impact on this. Zebra mussels either consume or expel material they have filtered as excrement or bodily fluid covered pseudofeces. Genuine waste pellets are greater, denser, and go through synthetic changes. Although to a considerably smaller amount, pseudofeces generation rises as temperature and suspended solids concentration rise. In Lake Erie, the formation of pseudofeces under murky conditions resulted in a very high rate of biosedimentation, supporting the idea that zebra mussels are to blame for the improved water clarity seen since mussel introduction. Although they filter material as well, veligers have a far smaller effect than sessile adults. Benthic deposition of feces and pseudofeces has been hypothesized to increase bacterial productivity and create a source culture that zebra mussels can consume. Additionally, it has been hypothesized that observed increases in benthic macro invertebrate populations could be due to biodeposition of feces and pseudofeces (Peterson et al., 2023).

## III. Ecological Impacts of Zebra Mussels

Filter-feeding creatures, zebra mussels and their ecologically comparable quagga mussels extract the water column's constituent particles. Up to one liter of water may be digested daily by each zebra mussel. The lake floor is littered with excrement, and some of the particles are consumed (Vanderbush et al., 2021). Nonfood particles end up on lake bottoms as pseudo feces after combining with mucus and other materials. The zebra mussel's establishment in Lake Erie has caused the water's clarity to rise from 6 inches (15 cm) to up to 3 feet (0.91 m) in certain places. The growth of submerged macrophytes is made possible by the deeper penetration of sunlight made possible by the higher water clarity. As these plants decompose, they wash up on coastlines, reducing water quality and fouling beaches. Zebra mussels filter pollutants out of the water, enriching the food sources on the lake floor. Both bottom-feeding organisms and the fish that consume them can access this biomass. Following zebra mussel invasion, yellow perch catches increased fivefold. Typically, juvenile zebra mussels prefer harder, rockier substrates to cling to, but they can connect to most substrates, including sand, silt, and tougher substrates (Søndergaard et al., 2024). Zebra mussels cling to and commonly kill other mussel species, which are often the most steady things in silty substrates. Their ability to migrate, feed, and procreate is diminished when they establish provinces on local unionid shellfishes, eventually coming about in their demise.

## IV. Zebra Mussels as an Invasive Species

Because the water intakes allow the microscopic, free-swimming larvae to enter the facilities directly, water-treatment plants are the ones most impacted. Additionally, zebra mussels stick to and obstruct pipelines underwater. British waters are home to zebra mussels. Due to the mussels' tendency to adhere to pipework, numerous water providers are reporting issues with their water treatment facilities (Beason & Schwalb, 2022). Life Cycle of Zebra Mussel shown in Figure 2.

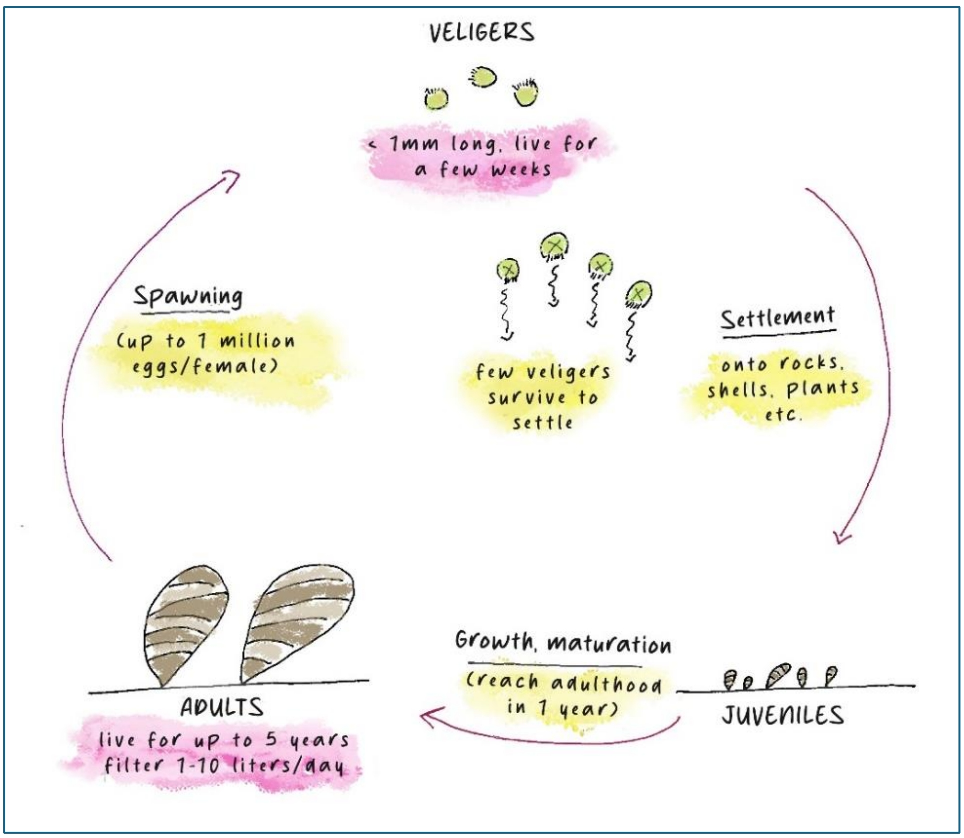


Figure 2: Life Cycle of Zebra Mussel

Although they most likely arrived in Ireland in 1994 or earlier, zebra mussels were first documented there in 1997. They may have entered Ireland through a number of vectors, but they have subsequently expanded throughout a large portion of the River Shannon and its surrounding waters after being first discovered close to Lough Derg. The largest body of freshwater in the United Kingdom, Lough Neagh, experienced a significant bloom of toxic cyanobacteria in the summers of 2023 and 2024, partly due to zebra mussels. Similar quagga mussels that can withstand a greater variety of environmental conditions were found in the Shannon (Rantala et al., 2022). Over time, it is anticipated that the introduction of quagga mussels will decrease zebra mussel populations while increasing the overall environmental effect.

### *Economic Impact and Management*

The need to aggressively and consistently control zebra mussel infestations comes at a high financial expense. It has been estimated that the annual cost of managing mussels on boats and docks in the Great Lakes, as well as in power plants, water systems, and industrial complexes, exceeds $500 million (US). It is anticipated that California's yearly management costs will be similar. For example, quagga mussels might cost the Lake Tahoe region $22 million year if they settle there, according to a 2009 Army Corps of Engineers assessment. The analysis suggests that there may be negative effects on tourism, a drop in real estate values, and increased maintenance costs. There are several strategies for controlling problematic mussel populations in California. For instance, according to a 2009 Army Corps of Engineers assessment, quagga mussels may cost the Lake Tahoe region $22 million a year if they settle there. According to the analysis, there could be harm to tourism, a decline in property prices, and more maintenance expenses. In California, there are various approaches to managing troublesome mussel populations. By drying them out, water drawdowns in canals and aqueducts could be utilized to kill mussels. Under some circumstances, poisons that are poisonous to quagga and zebra mussels, like chlorine and copper sulfate, could be used (Meder & Johnson, 2021). Every year, zebra mussels in Canada destroy watercrafts and clog intake structures in power plants and water treatment facilities, costing millions of dollars.

## V. Conclusion

Numerous strategies for controlling and eliminating zebra mussels are currently being investigated. Although they are costly and time-consuming, manual scraping and abrasive blast cleaning have shown success. With varying degrees of success, oxidizing and non-oxidizing biocides as well as UV light have been employed. "To Control the Spread of Zebra Mussels and Other Aquatic Nuisance Species," which warns of the possible threat posed by zebra mussel transit to divers, hunters, fishermen, and other recreational users of water resources. Zebra mussels have significant and varied effects on aquatic ecosystems and human activities, as evidenced by research on their ecological and economic repercussions. By outcompeting native species for food and habitat, zebra mussels ecologically upset food webs, reducing biodiversity and changing the dynamics of nutrients in aquatic bodies. Zebra mussels are a major financial burden because they foul pipes, infrastructure, and water intake systems, requiring expensive mitigation and maintenance. The results highlight the need for ongoing study and public awareness to safeguard vulnerable water systems by highlighting the need of prevention, early identification, and management techniques to reduce the ecological harm and financial costs associated with zebra mussel invasions.

## References

[1] Feniova, I., Sakharova, E. G., Gorelysheva, Z. I., Karpowicz, M., Gorniak, A., Petrosyan, V., & Dzialowski, A. R. (2020). Effects of zebra mussels (Dreissena polymorpha) on phytoplankton community structure under eutrophic conditions. *Aquat. Invasions*, *15*(3), 435-454. https://doi.org/10.3391/ai.2020.15.3.05

[2] Karpowicz, M., Feniova, I. Y., Sakharova, E. G., Gorelysheva, Z. I., Więcko, A., Górniak, A., & Dzialowski, A. R. (2023). Top-down and bottom-up control of phytoplankton communities by zebra mussels Dreissena polymorpha (Pallas, 1771). *Science of the Total Environment*, *877*, 162899. https://doi.org/10.1016/j.scitotenv.2023.162899

[3] Peterson, S. J., Glade, K. C., Hafs, A. W., Guelda, D. L., & Koch, R. W. (2023). Effects of artificial zebra mussel druses on macroinvertebrate communities and benthic carbon accumulation. *Northeastern Naturalist*, *30*(3), 347-367. https://doi.org/10.1656/045.030.0305

[4] Vanderbush, B., Longhenry, C., Lucchesi, D. O., & Barnes, M. E. (2021). A review of zebra mussel biology, distribution, aquatic ecosystem impacts, and control with specific emphasis on South Dakota, USA. *Open Journal of Ecology*, *11*(2), 163-182. https://doi.org/10.4236/oje.2021.112014

[5] Søndergaard, M., Johansson, L. S., Andersen, P., & Jeppesen, E. (2024). Ecosystem changes in eight Danish lakes after zebra mussel invasion. *Hydrobiologia*, 1-18. https://doi.org/10.1007/s10750-024-05542-1

[6] Beason, E., & Schwalb, A. N. (2022). Impact of zebra mussels on physiological conditions of unionid mussels in Texas. *Aquatic Sciences*, *84*(2), 21. https://doi.org/10.1007/s00027-022-00853-8

[7] Rantala, H. M., Branstrator, D. K., Hirsch, J. K., Jones, T. S., & Montz, G. (2022). Simultaneous invasion decouples zebra mussels and water clarity. *Communications biology*, *5*(1), 1405. https://doi.org/10.1038/s42003-022-04355-z

[8] Meder, M. E., & Johnson, M. (2021). The Effects of Zebra Mussel Infestations on Property Values: Evidence from Wisconsin. *Measuring Amenities and Disamenities in the Housing Market: Applications of the Hedonic Method*, 93-104.