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Zebra Mussel Research Technical Notes

Section 1 — Environmental Testing   Technical Note ZMR-1-14

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Environmental Effects of Zebra Mussel Infestations

Background

Zebra mussels (*Dreissena polymorpha*) exert a profound influence on their environment through two types of effects: food-related and habitat-related. A food-related effect is the ability of zebra mussels to filter particulate matter from water (Figure 1). Zebra mussels can filter particulate matter over a wide size range, from particles as small as 0.7 to 1.0 μm in diameter (Jorgensen and others 1984, Sprung and Rose 1988) to particles as large as 750 μm (Ten Winkel and Davids 1982). The immense standing crops of zebra mussels can result in an unrivaled ability to clarify water of particulate matter (Morton 1971; Piesik 1983; Reeders, Bij de Vaate, and Slim 1989; Mackie 1991). A consequence of this filtering activity is the removal of phytoplankton from the water column. Planktonic diatom densities near Bass Island in western Lake Erie in 1990-91 were less than 15 percent of their densities in the mid-1980s (Beeton 1992). This reduction in diatom densities clearly appears to be an effect of the zebra mussel invasion of Lake Erie in the late 1980s.

Purpose

The purpose of this technical note is to summarize information on the likely environmental effects of zebra mussels.

Additional information

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Environmental effects of zebra mussels

The removal of phytoplankton from the water column by zebra mussels has implications beyond the producer level. Many members of the zooplankton, including most cladocerans, the calanid copepods (one of the two principal types of copepods in the water column), and many rotifers, feed on phytoplankton. It seems clear that zebra mussels will have a detrimental effect on overall zooplankton numbers by decreasing the zooplankton's phytoplankton food base (Figure 1). In addition, researchers have shown that zebra mussels directly reduce zooplankton numbers by filtering out smaller animals such as protozoans, rotifers, immature copepods, and some cladocerans (Shevtsova and others 1986; MacIsaac, Sprules, and Leach 1991). Zebra mussels can therefore be viewed as predators of both phytoplankton and zooplankton (Figure 1).

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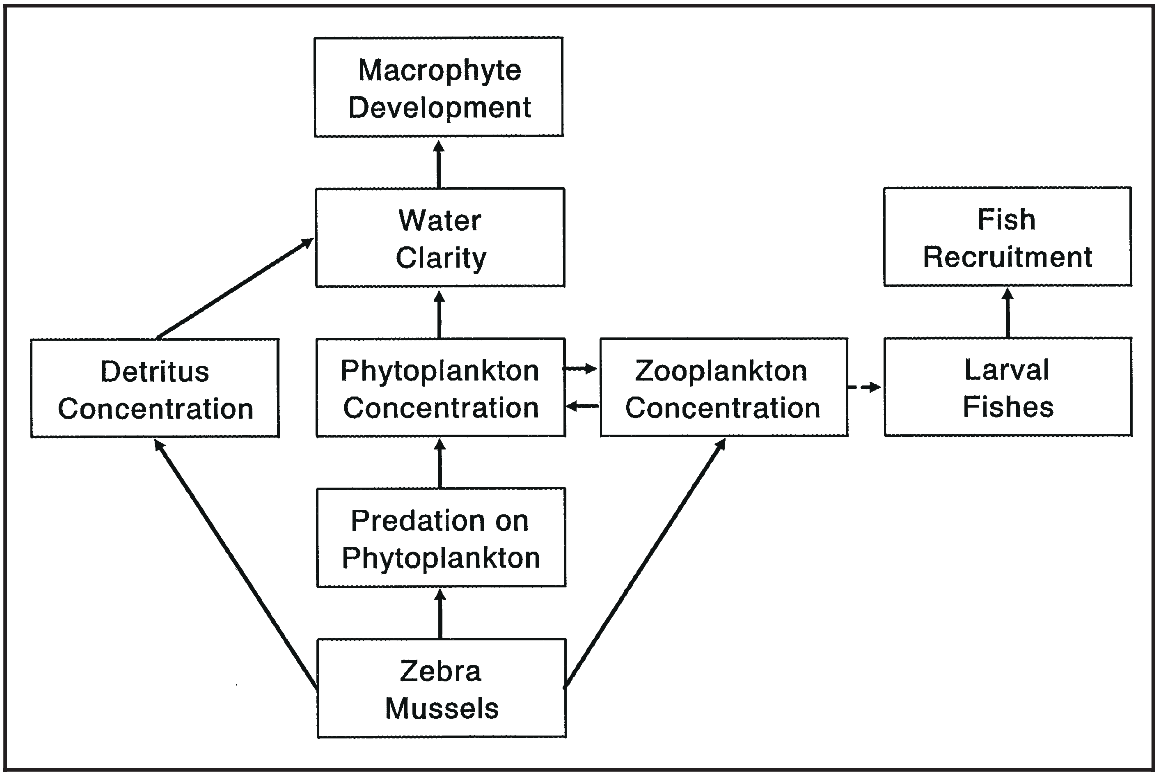

Figure 1. Diagram of zebra mussel effects on aquatic ecosystems. "Compartments" directly linked are connected by arrows with the causal compartment at the arrow's origin and the affected compartment at the arrow's point. The dashed arrow shows a probable effect. (See text for explanation of the effects. The figure is a modification of diagrams presented in Yount 1991)

The impact of zebra mussels can extend beyond the producer and primary consumer trophic levels; the dominant food source for most larval fishes is zooplankton. Sufficient zooplankton concentrations are necessary for the development of larval fishes and their recruitment into adult populations. However, at present, evidence from the field has not demonstrated a negative effect on fish recruitment. Walleye have successfully spawned on their historic spawning shoals in Lake Erie despite the presence of high densities of zebra mussels on the shoals. Also, the viability of the walleye eggs appears to be unaffected by zebra mussels (Fitzsimons and others 1992). Recruitment of young walleye in Lake Erie in 1990 and 1991 (post-zebra mussel invasion) was average to good, and recent growth of young-of-the-year walleyes did not appear to differ from that of years before the introduction of zebra mussels (Nepszy 1992). However, optimism regarding fish recruitment in spite of the presence of zebra mussels should be tempered since the Lake Erie evidence is for one species only. Lack of a zooplankton food base due to zebra mussel filtering activities could still prove to be a very serious problem for larval fishes (Figure 1).

One of the positive results of zebra mussel invasions is the resulting increase in water clarity. Increased water clarity should result in increased aquatic macrophyte development in affected habitats. Although macrophytes sometimes present problems from a management perspective (occasionally interfering with swimming, fishing, or boating), macrophytes are generally desirable from an ecological perspective. Macrophytes present an additional dimension to lakes and streams besides that afforded by the bottom (McDermid and Naiman 1983); macrophytes are used as hiding places by small fishes and are densely colonized by invertebrates (Muttkowski 1918; Krecker 1939; Andrews and Hasler 1943; Dvorak and Best 1982; Schramm, Jirka, and Hoyer 1987; Cyr and Downing 1988; Beckett, Aartila, and Miller 1992; among others). These invertebrate colonizers are, in turn, an important food source for fishes (Schramm and Jirka 1989) and waterfowl (Krull 1970). Unfortunately, in areas infested by *Dreissena*, the macrophytes themselves may become colonized by zebra mussels.

Since their introduction to Lake St. Clair in 1986 or 1987, zebra mussels have spread rapidly throughout the Great Lakes system, and are now present in large numbers in Lake Erie and Lake Ontario, with isolated populations in Lakes Superior, Michigan, and Huron (Griffiths and others 1991). In addition to invading the Great Lakes, zebra mussels have also moved into some of North America's major rivers, including the Mississippi, Ohio, Illinois, St. Lawrence, and Hudson Rivers. The environmental effects of zebra mussels on these large rivers is unknown. It is clear, however, that zebra mussels will compete with some of the native invertebrates for food and/or habitat (space).

Invertebrates such as the mayfly *Hexagenia* are found in very dissimilar habitats from zebra mussels. *Hexagenia* is found in silty locations where it constructs (and lives) in U-shaped burrows in the bottom. In contrast, *D. polymorpha* is found on hard, clean surfaces to which it attaches using its byssal threads. Despite their use of different habitats, both organisms are filter-feeders, and *Hexagenia* will have to compete with zebra mussels for food. Large-river, filter-feeding invertebrates such as the chironomid *Rheotanytarsus* and the hydropsychid caddisflies *Hydropsyche orris*, *Potamyia flava*, and *Cheumatopsyche* sp. are found on clean, hard surfaces (Fremling 1960, Beckett 1982, Beckett and Miller 1982) and will have to compete with zebra mussels for both food and space. Such organisms may be displaced by zebra mussels.

All invertebrates will not be negatively affected by *D. polymorpha*. Zebra mussels deposit organically rich feces and pseudofeces around themselves. As a consequence of rapidly and thoroughly filtering items in the water column, zebra mussels transfer the energy processes that formerly occurred in the open water into benthic processes, that is, biotic energy transfers will move to the bottom in the proximity of *D. polymorpha* (Mackie 1991).

Invertebrate deposit-feeders such as the chironomid genus *Chironomus* are found abundantly in organically rich areas; in fact, organically enriched areas in streams below sewage treatment plants are sometimes called the "*Chironomus* zone." Izvekova and Lvova-Katchanova (1972) showed that suspended matter agglutinated by zebra mussels was a very good food source for *Chironomus* larvae. While invertebrates such as hydropsychid caddisflies will have to compete with zebra mussels for food and space, deposit-feeders such as *Chironomus* should benefit from the presence of zebra mussels.

Rivers such as the Mississippi are quite turbid, because of their large suspended solids load. It had been hoped that the high suspended solids concentrations of rivers such as the Mississippi would interfere with zebra mussel colonization, since high turbidity rates decrease the filtration rate of zebra mussels (Morton 1971). In addition, strong water movements and high suspended solids loads of large particles have been implicated in causing high mortality rates of zebra mussel postveligers (Stanczykowska 1978). However, evidence from the field indicates that zebra mussels have been able to cope well with the turbid conditions of the Mississippi and other large rivers. Confirmed sightings of zebra mussels in the Mississippi River have been made from La Crosse, WI, downstream to St. Louis, MO; zebra mussels have also been found over the length of the Illinois River and in the lower Ohio River. It appears that the high suspended solids concentrations of large rivers in the United States will not prevent colonization by zebra mussels.

One of the most unfortunate consequences of the introduction of zebra mussels is their effect on unionid bivalves. Evidence from Lake St. Clair, the site of the introduction of zebra mussels, is gloomy. In zebra-mussel infested areas of Lake St. Clair,

- By 1990, 100 percent of the unionids were encrusted with zebra mussels; no individuals or species had been spared (Gillis and Mackie 1992).
- The mean number of zebra mussels attached to living unionids in 1990 equaled 638 zebra mussels per unionid. Many unionids had between 1,000 and 2,000 zebra mussels living on them (Gillis and Mackie 1992).
- The density of living unionids in 1991 was only one eightieth of what it was in 1990 (Gillis and Mackie 1992).
- From 1990 to 1991, the number of living unionid species had decreased from 11 to 4 (Gillis and Mackie 1992).

Zebra mussels in Lake St. Clair have grown very heavily over the siphon areas of unionids and strip the food out of the water column before it can reach the unionid (Mackie 1991). In some cases the zebra mussels have grown over the opening between the valves of the unionid, which prevents the native bivalves from opening completely. In other cases, the zebra mussels have grown between the valves such that the unionids can no longer close, making the bivalves vulnerable to predation and parasitism (Mackie 1991). It is clear that *Dreissena polymorpha* presents a very serious threat to the unionid communities of North American lakes and rivers. It is likely that the biotic communities of large rivers that have been colonized by zebra mussels will be very different in composition, density, and function than they are at the present.

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