Can Zebra Mussels or Quagga Mussels Invade Your Lake?

Dr. Gerry Mackie, Professor Emeritus, University of Guelph

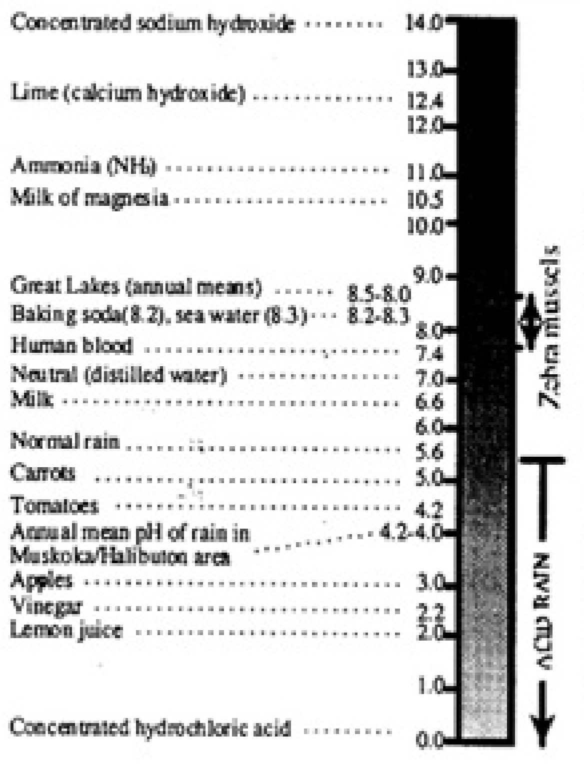
Zebra mussels and quagga mussels were introduced into the Great Lakes in the lake 80's and early 90s, probably through ship ballast water. They spread first to the canal lakes and now are spreading to other inland lakes. Both have reproduced very successfully, resulting in 'crusts' of zebra mussels covering the bottoms of invaded lakes. To understand whether your lake is likely to be invaded by zebra/quagga mussels, and how to prevent damage to your water systems in the event that they do invade, it is useful to understand a few things about their life cycle.

A Year in the Life of a Zebra Mussel

These two invasive mussels are pests because they possess two features: (1) They have a planktonic (floating) larval stage in their life cycle that allows them to enter any pipeline, including cottage pipelines. In addition, they are very prolific, each female capable of producing more than one million eggs per year, so there is potential for millions of larvae to enter cottage intakes. (2) The adults produce byssal threads which allow them to attach to solid substrates, including the walls of cottage intake structures. Eventually the pipe opening becomes plugged with the build-up of shells and water flow is reduced or even stopped. These two characteristics, free-floating young and attaching adults, are not found in native mussels. They have led to a variety of problems for private property owners, navigation, industries and utilities, fisheries and, finally, to the ecology of lakes.

Shell growth in zebra and quagga mussels starts in the spring when the water temperature reaches 8-10 °C. Eggs and sperm are released when the water temperature reaches 12-15 °C. The rate of larval development is highly variable and depends on temperature; the warmer the water, the faster the development. On average, development from the egg to the settled (attached) stage requires 21-30 days, as the water temperature rises from 12-20 °C. However, when the water temperature is maintained at 15-18 °C over a two- to three-week period, only 10-15 days may be required for development from egg to settlement stage. Hence, a good rule-of-thumb to use in deciding when to begin a zebra mussel biofouling control program is to *monitor the temperature and begin biofouling control before the water temperature reaches 15-18 °C (i.e., before larvae appear).*

The larvae pass through several developmental stages in the water column before settling to the bottom.



The pH acid scale, showing pH levels of common foods and substances.

The swimming larval stages are microscopic (40-300 µm). There are four of these planktonic stages; egg, veliger, veliconcha, and pediveliger, each stage lasting a few days. The mussel then sinks to the bottom, and these settled stages are named plantigrade, juvenile and adult. Adults are 0.8 to 2 cm long.

The two most important messages from the above are: *(1) filters with pore sizes larger than 40 µm will not keep zebra/quagga mussels out of cottage pipelines; (2) the biofouling stage begins with the settled plantigrade form, the planktonic larval stages do not cause biofouling problem because they do not attach to surfaces..*

What is the probability of zebra/quagga mussels reaching my lake?

Scientists have shown by means of *transportation models* that the odds of zebra mussels being transported to a "*target lake*" from a "*source lake*" increase greatly, if: (1) the target lake is close to a source lake; (2) the target lake is a popular tourist lake; (3) trailer-boat traffic is high. A boater is five times more likely to visit a lake 30 km away than one that is 160 km away. *Implicit in this model, is that the more often a boater stops at other lakes NOT infested with zebra mussels, the greater the chance of cleansing the boat and trailer, or diluting the numbers of mussels remaining on the boat and trailer.* The studies also showed that boaters are more likely to move between lakes within the same county, with movement between nearby lakes being highly probable. In addition, the probability of survival of larvae and adults within crevices or attached to boats and trailers decreases with: (1) increasing distance travelled; (2) high air temperatures; and (3) low humidity.

How do I determine if zebra mussels are in my lake?

If there are full-grown adults, or at least the shells are large enough to see with the unaided eye, they will be easy to spot. Merely pick up any solid object, like a rock, cement block, *or anything sitting on the bottom that is not covered by sand*, and look for attached mussels. If you wish to examine a water sample for larval stages, you will need a microscope. You can also send a preserved sample (70% isopropyl alcohol will do)

(Continued on page 25)

(Continued from page 24)
to OFAH. See their web site for instructions. http://www.invadingspecies.com/ or call them at 1-800-563-7711.

Will zebra/quagga mussels grow in my lake?
All aquatic organisms have certain requirements in order to grow and reproduce. The following describes some tolerances and requirements of zebra and quagga mussels.

Temperature: Zebra mussels require at least 8-10 °C to begin growth and at least 12-15 °C to begin reproduction. Quagga mussels have lower thermal requirements, both growth and reproduction beginning to occur at about 7 °C. The duration of these temperatures is more important than the absolute temperature itself. Temperatures of at least 15 to 18 °C are required for the life cycle to be completed in 21 to 30 days for both species. *Hence, temperatures above 15-18 °C must be maintained for at least 21 to 30 days in order for settlement to occur.*

Calcium: All mussels need calcium for their shells. Studies have shown that a minimum of 7 mg/L is required for growth and 15 mg/L for reproduction to occur. *Infestation* **Infestation** *intensities* (a measure of biofouling potential) increase directly with increasing calcium levels between 10 and 25 mg/L. Infestation intensity is high and not affected by calcium levels above 25 mg/L. Hence, *little to no biofouling can be expected to occur between 7 and 15 mg Ca/L, moderate to intense biofouling between 15 and 25 mg Ca/L, and extensive biofouling, with possible taste and odour problems associated with high mussel mortality, above 25 mg Ca/L.* Calcium levels can be calculated by dividing the calcium hardness by 2.5. For example, if the calcium hardness is 50 mg $CaCO_3$/L, the calcium level is 20 mg/L.

Acidity: Acidity is usually expressed as pH. pH below 7 signifies acidic conditions; pH below 7 signifies basic conditions. Acidity in lake waters is closely correlated with calcium levels, since calcium bicarbonate and carbonate neutralize acid and therefore raise the pH. Optimal growth and reproduction for both zebra and quagga mussels occurs at pH pH levels greater than 8.0. *Little to no biofouling can be expected to occur below pH 7.5, moderate to intense biofouling between pH 7.5 and 8.0, and extensive biofouling above pH 8.0.*

> You can count on **high** zebra mussel densities if the water maintains the following three conditions:
> - **15—18 °C temperature** for 21 to 30 days
> - **at least 20 mg calcium/L**
> - **and a pH > 8.0**
>
> Lakes with the following conditions may accumulate moderate levels of mussels over time:
> - **pH levels near (± 0.5) 7.5**
> - **calcium levels near (± 5) 15 mg/L**
>
> Lakes with the following conditions will support few if any mussels:
> - **pH levels below 7.0**
> - **calcium levels below 10 mg/l**

Other conditions: Zebra and quagga mussels are tolerant of a wide range of conditions, including a certain degree of pollution and high silt loads (measured as turbidity).

Lethal conditions for zebra mussels
Temperature:For zebra mussels, the *acute* lethal temperature ***acute*** lethal temperature ranges from about 33 °C to 42.3 °C; 40 °C will kill them almost instantly. However, the amount of previous exposure to warm water greatly affects the acute lethal temperature.

> **Clues for killing zebra mussels:**
> - Dump them into boiling water for 5 min.
> - Dry them in dry (not humid) air for at least two weeks.
> - Let dissolved oxygen levels drop below 2 mg/L for at least one week in pipelines.

Chronic lethal temperatures: The tolerance times at different temperatures increase with increasing exposure times and decreasing shell size. Several thermal tolerance studies have been conducted to determine the feasibility of using high temperatures to control zebra mussels. In general, zebra mussels, like all other aquatic organisms, adjust their upper thermal tolerance limits by acclimatizing to increasing summer temperatures as the summer progresses. The time to death of zebra mussels is rapid at freezing temperatures, death occurring in less than 24 h at -3 °C (= 27 °F). However, the temperature rarely falls below 4 °C in deep water and is between 1 and 3 °C in shallow, unfrozen water.

Oxygen: Zebra mussels cannot tolerate even short periods of no oxygen but can survive low oxygen levels (~ 2 mg/L) for about 2 weeks.

Drying out: Quagga and zebra mussels can survive 5 to 13 days in low humidity (that is, out of the water). Without renewed oxygen supplies, the mussels eventually succumb to accumulations of toxic end-products during dry periods, but are known to survive out of water for up to at least 7 days under damp conditions (e.g. rain).

Will all parts of a lake have the same zebra mussel problems?
The infestation levels of zebra mussels around a lake may differ, depending upon the size and type of lake, numbers of inflows, water chemistry of inflows, and water currents. For example, inflows that have a lower pH and calcium level than the overall means for the lake will tend to "dilute" waters in the mixing areas. Also, larger lakes tend to have a greater variety of current patterns, determined by wind and inflows. If water currents tend to be offshore at a cottage, zebra mussel infestations would be lighter, and the arrival of mussels would be later, than at cottages with onshore currents. Lake St. Clair is a good example. The major inflow is the St. Clair River, which then flows mostly along the U. S. shores of the lake, pushing veliger-laden water toward the Ontario side. The

(Continued on page 26)

(Continued from page 25)
impact of the zebra mussel on populations of freshwater mussels occurred three years earlier on the Ontario shores of Lake St. Clair than on the U. S. shores.

Do I need to protect my intakes from zebra mussels?

There are two strategies that can be used to control biofouling zebra mussels. A *proactive strategy* is used to prevent the mussels from settling in the first place, usually by filtering your water. Killing of mussels is not necessarily needed to prevent settlement. A *reactive strategy* allows the mussels to settle and grow to the end of the summer, and then they are killed. In other words, you can either keep the veligers out or let the mussels grow during the summer and clear them out in the fall.

For cottages, a proactive strategy is recommended because it eliminates any potential problems created by using a reactive strategy in which large doses (typically of chlorine) are used. Also, taste and odour problems may develop from putrefaction of large masses of mussels after they are killed. Further, since reactive strategies are usually used at the end of the year, someone must be present for one to two weeks while control is being applied. This is not an issue for permanent dwellings but could be an issue for seasonal dwellings. While a proactive strategy eliminates most of these problems, it is usually more expensive to use because the devices are designed to operate continuously, or at least every time the pump is used.

Here is a quick way on how to decide whether you need to establish a control program and what you can do:

1. You will need a thermometer, a pH sampler (such as an indicator solution for measuring pH of water in swimming pools), and a calcium hardness kit, which is available from companies that sell water softeners; many stores who sell swimming pool products will test water samples for pH and calcium hardness for free. Otherwise, call the district Ministry of Natural Resources or Ministry of Environment and Energy for data on your lake.
2. Using the pH and calcium data above, decide if the lake has potential for zebra mussel infestations. Select one of the following options, either 1a or 1b:

1a. Infestations not possible
Do nothing

1b. Infestations possible (light to heavy) *Go to 2a or 2b*

2a You have a temporary foot valve
Go to 3a or 3b

2b You have a permanent foot valve
Go to 5.

3a Infestation potential is light
Go to 4

3b Infestation potential is heavy
Go to 5

4 ***Clean or boil removable components and drain pipeline in the fall (drying or freezing will kill all mussels during the fall and winter period).*** *Field experiments have shown that mussel attachment intensity on materials tends to be least on copper (90% Cu) and greatest on plastics (e.g. ABS), with other materials exhibiting the following order of mussel attachment efficacy: copper has < brass has < galvanized iron has < aluminum has < acrylic has < black steel has < polyethylene has < PVC has < ABS. However, the experiments were done in standing waters, and flow rate affects the amount of settlement in pipelines.* ***Consider modifying the intake structure, such as using a brass screen around the foot valve.***

5 ***Install a biofouling control program.***

One final word of caution. Adult mussels are known to ***translocate***, that is, detach from a substrate and be carried by water currents, waves, etc. to another location and re-attach. Generally, translocation is not sufficient in itself to plug intakes. Also, much of the translocation seems to occur during winter months, when most pumps and intake systems are shut down. However, ***if the dwelling is a permanent residence and intakes are not shut down (e.g. winterized), it would be prudent to examine exposed intakes for translocated adults in the spring, or at least before the next settlement event.***