



Powerful Control. Less Risk.

Tiny invaders are a costly hassle for the hydropower industry.

Zebra and quagga mussels* may be small in stature, but there's power in numbers and these tiny creatures are having a big ecological and economic impact throughout North America. They make themselves at home in freshwater lakes and rivers, where mussel populations spread rapidly and form thick, heavy colonies.

As these invasive mussels spread they are proving to be a destructive force with significant economic cost. Hydroelectric power plants that draw from bodies of water with large mussel populations present are susceptible to infestation. Colonies of zebra and quagga mussels can damage equipment and infrastructure; they can also clog pipes, filters and screens, obstructing or stopping the flow of critical cooling water. This can result in ongoing maintenance costs, expected and unexpected outages and a reduction in power generation. United States Congressional researchers estimated that zebra mussels alone cost the power industry \$3.1 billion during 1993-1999.

As the hydropower industry searches for a method of control, one solution offers the greatest benefits with less risk to equipment, workers, non-target species and the environment. Zequanox® is a naturally derived molluscicide that offers a highly effective and environmentally compatible control method for these invasive mussels.



** For more in-depth information on zebra and quagga mussels, visit the U.S. Geological Survey at www.usgs.gov.*

IMPACT ON HYDROELECTRIC POWER PLANTS

Zebra and quagga mussel infestations are an increasing area of concern for hydroelectric power facilities. As mussel populations grow, colonies of the invasive mussels can infest critical infrastructure resulting in significant maintenance and mitigation costs, and in some cases outages or a reduction in energy generation.

While the impact of invasive mussel infestations will vary from plant to plant depending on the construction and method of operation, most plants face a number of similar challenges.

Reduced flow.

Buildup of mussels within pipes, on penstocks, trashracks and screens restrict water flow and reduce hydraulic capacity, which leads to a loss of electricity production.

Restricted water intake to heat exchangers and transformers.

Mussel fouling on water intakes for the heat exchangers that cool the generators can cause generators to overheat and precipitate an immediate shutdown. Water-cooled transformers, if starved for cooling water due to mussel obstruction, may also overheat and catch on fire, creating a health and safety issue for the plant.



Increased corrosion.

Prolonged attachment to steel and cast iron pipes and screens can increase corrosion and reduce the structural integrity of these components, resulting in ongoing repair and replacement costs.

Damage to mechanical parts.

Once zebra and quagga mussels are established within a hydroelectric plant, shell debris from dead mussels can damage moving parts, resulting in a degradation of power production over time, more frequent planned outages for maintenance or even a complete shutdown for repairs if damage to parts goes unnoticed for too long.



CONTROLLING ZEBRA AND QUAGGA MUSSELS IN HYDROPOWER

Hydropower plants require regular, ongoing maintenance and preventive measures to minimize the impact of invasive zebra and quagga mussels. While a variety of chemical and manual control strategies are available, these methods have a number of shortcomings.

Chemical control.

Chlorine and other oxidizing chemicals commonly used to control invasive zebra and quagga mussels come with a number of major drawbacks. Chemical treatments of adult mussels take days to complete and the efficacy of such methods may be impacted by water temperature and/or water quality. Non-oxidizing chemicals, while achieving adult mussel mortality more quickly, usually must be detoxified prior to discharge. This operation increases cost and regulatory burden.

These chemicals can pose significant risk to humans, non-target species and the environment. These toxic chemicals are subject to extensive regulatory restrictions and require special precautions for storage and handling. At a minimum, treatments may disrupt normal operations and workers are required to wear personal protective equipment when working with these chemicals.

In hydropower plants these chemicals are discharged within the tailrace into open water where they may negatively impact the environment if released in greater amounts than planned or prescribed by the regulator.

Mechanical control.

While mechanical control methods may be less hazardous to employees and the environment compared to chemical treatments, they can be expensive and/or labor intensive and come with significant limitations.

Antifouling coatings are effective only where they can be applied. Physical removal is only effective in parts of the plant that can be reached by pressure washers, specialized scraping machines or divers.

Ultra-violet (UV) light treatment targets the larval (i.e., free floating) stages of the mussels and provides protection only to locations downstream of the equipment. This is also true of microfiltration. Moreover, any temporary equipment failure—including a nonfunctioning UV lamp or micro tear in a filter—may let veligers move through the system and settle. In addition, both UV light and microfiltration require significant capital investment, disruption and changes to existing piping systems and continuous vigilance to ensure consistent control.

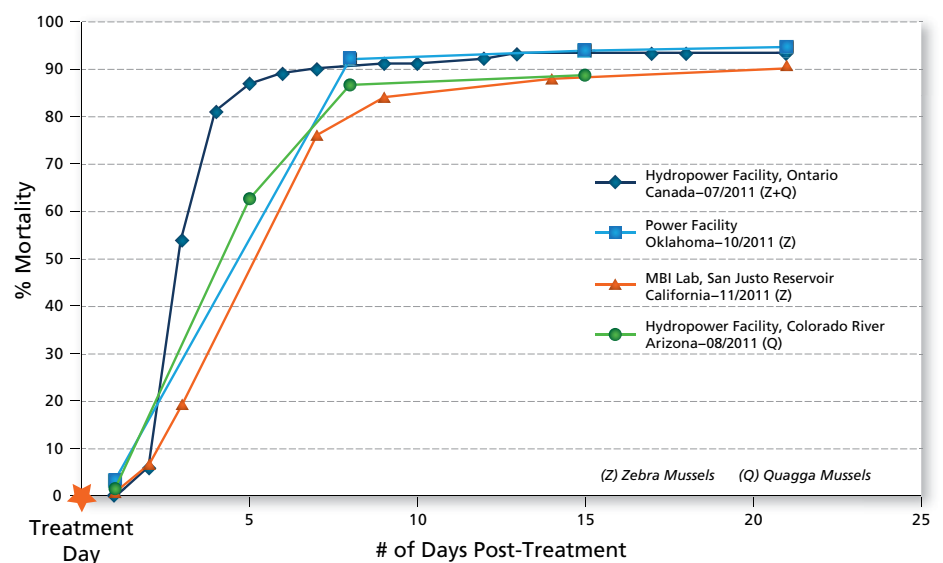
ZEQUANOX IS SIMPLE, EFFECTIVE AND REDUCED RISK

Zequanox® is the first biological solution for controlling invasive zebra and quagga mussels that offers efficacy comparable to chemical solutions, but does not endanger employees or result in harmful impacts to other aquatic organisms when used as directed.



Zequanox is composed of dead cells of a naturally occurring microbe (*Pseudomonas fluorescens*), which,

when consumed by zebra and quagga mussels at any stage in their lifecycle, destroys the mussel's digestive system.



In 2011, the Environmental Protection Agency (EPA) approved Zequanox as a reduced-risk pesticide. As a result, Zequanox is not subject to regulatory restrictions on product usage (time of year, frequency of treatments, etc.) and has minimal monitoring and reporting requirements when compared to chemical control methods.

Zequanox can be applied using standard equipment with virtually no interruption to normal operations, and applicators need only minimal personal protective equipment. Furthermore, operators can continue working throughout the plant during Zequanox treatments.

"In extreme cases, mussel infestation may cause unexpected outages, which are very costly. But for most plants they represent a chronic loss of production, which can be avoided with the appropriate control strategy."

– Renata Claudi, environmental scientist and leading expert on invasive mussel control

WHY ZEQUANOX?

- Proven effective
- Controls mussels at all life stages— from veliger to adult
- Works in a range of water conditions and temperatures
- Easy to administer
- Treatments do not disrupt normal operations
- No need for detoxification prior to discharge
- No capital equipment to purchase, install or maintain
- Requires minimal personal protective equipment during application
- Minimal risk to humans, animals and aquatic life

CONTROL INVASIVE MUSSELS BIOLOGICALLY WITH ZEQUANOX

Zequanox is simply the right choice for controlling invasive zebra and quagga mussels while reducing risk to humans, infrastructure, non-target species or the environment.

Let us help you avoid employee injury, equipment damage and costly downtime. Contact us at zequanox@marronebio.com or 530.750.2800 today to develop a treatment management plan for your hydroelectric power facility.

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Marrone Bio Innovations, Inc. is a leading global provider of natural products for the agricultural and water treatment markets. MBI's effective and environmentally friendly natural agricultural products provide higher yields and quality while managing pesticide resistance and residues. Through its proprietary discovery and development platform and strategically in-licensed technologies, MBI has developed a pipeline of advanced and early-stage products for the significant agricultural and water treatment markets. MBI's products for the agricultural market include the biofungicide Regalia®, and the broad-spectrum bioinsecticide Grandevo™. MBI is addressing the water market with Zequanox® for controlling invasive aquatic mussels in fresh waterways. MBI has three dozen patents pending in the United States and globally.



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