A Report on Invading Species HIGH LEVEL 3

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A Report for the Ministry of the Environment
Zebra Mussels: An Invading Species

Key Characteristics

The zebra mussel (*Dreissena polymorpha*) is named for its zebra stripe pattern on its shell. It has stripes that alternate yellow, brown, black, and/or white. It averages about one and a half inches in length and has a life span of up to three years in Lake Erie. The shell shape of the zebra mussel is a perfect adaptation for survival and invasion. The ventral surface is flat, allowing the mussel to pull tightly against a surface to start a colony. The shell has a triangular shape, making it very difficult for predators to grab a hold and pull the mussel off of the surface to which it is attached. Zebra mussels attach themselves to hard surfaces by means of byssus. Byssus comprises several threads that are secreted through a byssal gland at the base of the foot. A mussel can produce up to twelve threads, which are a liquid until they come in contact with the surrounding water, per day and up to six hundred in a lifetime. The mussel has two valves hinged by a "spring loaded" ligament on its topside, therefore causing the valve gap to be widest on the bottom edge. Adductor muscles at the front and back attach these valves together. To close the valves, the mussel contracts the adductor muscles. Since the adductor muscles can only be contracted when the mussel is alive, closed valves are indicators of a living mussel.

Scientific Analysis of the Problem

Zebra mussel possess several qualities that result in difficulties for both other aquatic species and humans living around them. The mussels and clams native to the Great Lakes have been suffocated and starved as a result of the zebra mussels'

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invasion. The zebra mussels eat zooplankton and phytoplankton, which are the staple diet of many of the native fish and other aquatic animals. Zebra mussels filter about one litre of water per day, removing almost all of the plankton, therefore leaving hardly any food for the other small fish and aquatic animals in the area. Native clams are suffocated when Zebra Mussels attach themselves to the clams' shells and begin a colony.

> In lakes St. Clair and Erie, zebra mussels have severely reduced populations of native mussels. Some mussel species in the St. Croix River are very rare and are officially listed as endangered. As zebra mussels spread, biologists are concerned that these species face imminent extinction (Bowen, 2003).

In addition to being harmful to aquatic life, zebra mussels are damaging to human recreational equipment and property, as well as businesses with factories and buildings on the waterfront. Zebra mussels commonly clog water intake pipes to cottages, power plants, water treatment facilities and factories. "In fact, since 1989, some facilities located on Lake Erie have reported big reductions in pumping capacity and occasional shutdowns caused by encrusted zebra mussels" (Bowen, 2003). As well as the "encrusting of navigation buoys to the point that the buoys sink deeper in the water than normal" (Mackie), zebra mussels also habitually attach themselves to boats, boat motors, and other recreational equipment.

"The mussel's reproductive cycle is one key to its rapid spread and high abundance" (Bowen, 2003), as one female mussel can produce anywhere from several hundred thousand to one million eggs in a single season. "In less than 10 years, zebra mussels spread to all five Great Lakes and into the Mississippi, Tennessee, Hudson, and Ohio River Basins … Only one lake was infested in 1992;

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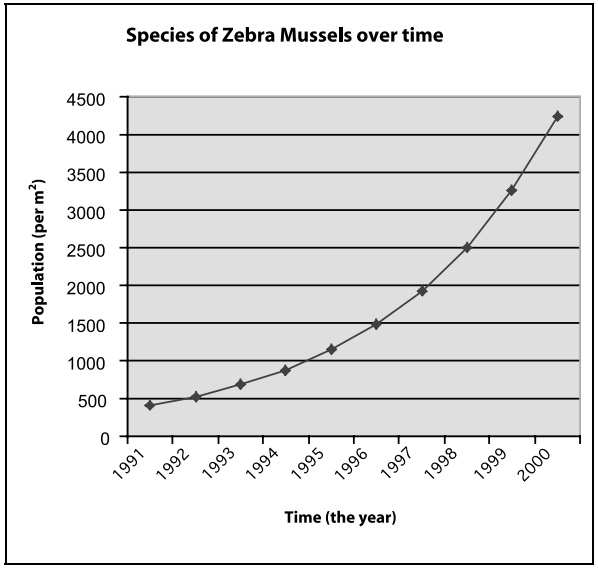
today there are over 100" (Zebra Mussels Cause). The results of these prolific breeding habits are illustrated in the following graph:

Zebra Mussel Population in a Small Water Body

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Population (per m^2)	400	520	676	876	1142	1485	1930	2509	3262	4241



Predictions for the Future

The population growth in the small body of water described in the graph is expected to level off eventually. However, Ontario has many bodies of water, and without control measures the total population could continue to rise quickly across the province for many years.

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It is easy to speculate that in the future zebra mussels will continue to be an annoyance and a hazard to waterfront plants, communities, and of course, recreational facilities. However, there are a number of solutions to each of the many problems zebra mussels cause to their surrounding environment. The following table indicates a few common problems caused by zebra mussels, and a possible solution or prevention method.

Problem	Potential Solution
Encrusting of boating and sailing vessels	Boats should be air dried for five days or cleaned with chlorine or boiling water before using in un-infested waters. If any mussels are scraped off of boat surfaces, they should be bagged and discarded in the garbage
Fouling of cottage plumbing and intake structures	There are many different products on the market to help keep mussels out of pipes, or to clean them out once they get there. For example: [redacted], all of which have been tested by [redacted].

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Problem	Potential Solution
Fouling of cooling water inlets in boat motors	Before being used in un-infested waters, boat motors should be flushed and cleaned thoroughly to eliminate any hitchhikers.
Fouling of scuba or snorkelling gear	If gear feels gritty, there may be veligers (young mussels) attached. Gear should be air dried for five days or placed in boiling water to kill any mussels.

As for the future impact on organic matter, it appears to be more serious for some species than others. For example, when zebra mussels filter the water to eat, they deprive other species of food, but they also clear the water and allow for algae and plants to collect enough sunlight to grow healthier and stronger. Zebra mussels also provide food for some fish and waterfowl, and it has been suggested that they become a food source to humans as well.

Recommendations for a Course of Action

There are two basic strategies used to control biofouling [making something unfit for its intended use by fouling it with organic growth(s)]. A proactive strategy employs methods that prevent the initiation of biofouling. A reactive strategy allows some biofouling to occur, but control methods are applied just before nuisance growths and problems occur (Mackie).

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There are advantages and disadvantages to each of these strategies, but the right combination of both would be ideal. In areas where zebra mussels are already a problem, a proactive strategy, such as applying small amounts of chlorine to industrial systems to prevent veligers from settling, followed by a reactive strategy, such as, applying more potent levels of chlorine to kill off all existing adult mussels. In non-industrial areas, introducing fish and waterfowl that prey on zebra mussels is an alternative solution. Although in some situations reactive strategies seem best, in most cases, proactive strategies prove more efficient and effective. For example, in the aforementioned situation, there will be much clean up to be done after employing a reactive strategy. The shells of the dead mussels will have to be disposed of and the water will have to be detoxified because of high chemical content. An effective proactive strategy would be to educate the public and inform them of the dangers and prevention methods of zebra mussels invasion. If bylaws can be passed to prevent boaters from entering their boats into un-infested waters at marinas without first having them inspected, the spread of Zebra Mussels will be greatly reduced, and attention can be focused on lowering the population in already affected areas.

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Bibliography

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Teacher's Notes

Knowledge/Understanding

– The student demonstrates considerable understanding of how the invading species has adapted. He or she links adaptations to the zebra mussel's success within the environment (e.g., "The ventral surface is flat, allowing the mussel to pull tightly against a surface to start a colony"). However, some of the characteristics presented are not relevant to the problem (e.g., "the adductor muscles can only be contracted when the mussel is alive").

Inquiry

– The student analyses the actual or potential problem with a high degree of effectiveness. He or she identifies some positive and negative aspects of zebra mussel presence (e.g., "when zebra mussels filter the water to eat, they deprive other species of food, but they also clear the water and allow for algae and plants to collect enough sunlight to grow healthier and stronger. Zebra mussels also provide food for some fish and waterfowl").
– The student predicts the future impact of the invading species with considerable effectiveness. He or she predicts that "zebra mussels will continue to be an annoyance and a hazard to waterfront plants, communities, and of course recreational facilities." The student also predicts the possibility of positive effects (e.g., "it has been suggested that they become a food source for humans"). However, the student makes only a vague projection of the future population of the invading species in Ontario (i.e., "without control measures the total population could continue to rise quickly across the province for many years").

Communication

– The student communicates information in graph/chart/table format with considerable clarity. The data table and graph show the exponential growth in the population of zebra mussels "in a Small Water Body" over a ten-year period. The table presents numerical data very clearly. The graph is clearly labelled and accurately plotted. However, the title "Species of Zebra Mussels over time" is misleading.

– The student communicates ideas and information with considerable clarity. The report has logical sections, but the organization of material within them is questionable in places (e.g., the section on Predictions for the Future is largely devoted to solutions to existing problems). Scientific terminology is appropriately used and explained (e.g., byssus, biofouling). However, the report includes a non-metric measure (i.e., "about one and a half inches in length").

Making Connections

– The student recommends and justifies a highly effective course of action. He or she addresses the advantages and disadvantages of both proactive and reactive strategies "In areas where zebra mussels are already a problem", and recommends that "the right combination of both" types of strategies "would be ideal". The student gives alternative reactive strategies for different areas (e.g., "applying small amounts of chlorine to industrial systems to prevent veligers from settling"; "In non-industrial areas, introducing fish and waterfowl that prey on zebra mussels"). He or she recommends proactive strategies to prevent the further spread of zebra mussels (e.g., "educate the public and inform them of the dangers and prevention methods").

Comments

This work is representative of a high level-3 performance. The student demonstrates a considerable degree of achievement of the expectations in the Knowledge/Understanding and Communication categories of knowledge and skills. The student also demonstrates a considerable degree of achievement with respect to one criterion in the Inquiry category. However, with respect to the Making Connections category and one criterion in the Inquiry category, the student demonstrates a high degree of achievement – i.e., achievement that is more characteristic of level 4.

Next Steps

In order to improve his or her performance, the student needs to:

- edit and proofread the report to ensure that all information is relevant and well organized;
- use scientific data to project the future population of the invading species across the province;
- correct the title of the graph;
- use SI units throughout the report.