

Preventing Zebra Mussel Infestation of Lake Powell

Mark Anderson, Glen Canyon National Recreation Area, P.O. Box 1507, Page, Arizona 86040; mark_anderson@nps.gov

John Ritenour, Glen Canyon National Recreation Area, P.O. Box 1507, Page, Arizona 86040; john_ritenour@nps.gov

Zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. bugensis*) constitute one of the greatest threats to water resources in the western United States. These small invasive mussels with varying stripes have already spread throughout much of the eastern United States. The genus *Dreissena* is unique among freshwater mussels in that they can attach to surfaces using byssal threads. The use of byssal threads allows zebra mussels to build up mats that can reach over 30 cm thick. Zebra mussel mats can form within pipes, reducing or clogging their flow. These mussels will encrust docks, launch ramps, rocks, and any hard surfaces in the water. Industries in infested areas spend billions of dollars every year to remove zebra mussels from raw water-related structures (O'Neill 1996).

Zebra mussels have a great impact on recreation. Boats left in infested waters will develop a layer of zebra mussels on their hulls and engines. Microscopic life stages can enter, attach, and clog the cooling systems of engines. Beaches can become covered with piles of shells washed up by wave action. The shells have sharp edges that can cut bare feet. The shells also carry bits of zebra mussel flesh that fill the air with a stench as they decompose.

In addition to the costs to industry and recreation, zebra mussels cause ecological damage. Any strategy to kill zebra mussels in the environment will also destroy other forms of aquatic life. Zebra mussels will encrust crayfish, turtles, and native clams. They show a preference for attaching to other mussel shells, inhibiting their shells from opening or closing, and thus killing them. Zebra mussels filter an enormous amount of water, removing large quantities of algae, thus disrupting the food chain. Undigested food is packed into a ball of mucous and ejected as a pseudo-fecal pellet. These pellets can form thick layers beneath infestations, creating a large oxygen demand that can cause fish kills. There are no predators of consequence in the United States. Within their home range, zebra mussel populations are probably kept in check by parasites, such as trematodes. The parasites in the native range of zebra mussels do not promise much utility for control in the United

States because they are rather non-specific. It has been suggested that since zebra mussels are so prolific, humans could use them as a food source, but zebra mussels are very efficient at accumulating toxins because of the large amount of water that they filter. Even other animals that eat zebra mussels can be unfit for human consumption due to the bio-magnification of the toxins in zebra mussels.

The zebra mussel life cycle progresses from a tiny egg stage to a veliger and post-veliger stage, which are all planktonic. After the post-veliger stage, they enter a settling stage when the production of a shell makes them too dense to float. The forming mussels begin to sink and seek a substrate upon which to attach. The passage from the egg to settling stage requires two to three weeks. After settling, zebra mussels can detach, move around, and reattach as they grow up to 3 cm long and live four or five years. Some zebra mussels have been reported to live up to nine years in Europe (Marsden 1992). They become sexually mature after the first year and each female can reportedly produce up to a million eggs annually.

Native to the Caspian and Black seas of Eastern Europe, zebra mussels had spread throughout Europe by 1920 with the creation of canals and increased capacity of humans to spread the mussel. It was recognized at that point that their havoc could be spread to the United States in the ballast water of commer-

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cial ships. They were first discovered in America in 1988, amongst the Great Lakes in Lake Saint Clair. Since then, they have spread throughout the Great Lakes and into eight major river systems.

Zebra mussels are of great concern to resource managers at Glen Canyon National Recreation Area. Lake Powell is considered the most likely point of introduction of zebra mussels to the Colorado River system. Nearly three million people visit Lake Powell each year. People spread zebra mussels attached to the surfaces of boats, and in their microscopic forms even a drop of water may transport them in the bilge, engine, live well, or trailer of a boat. The conditions in Lake Powell are good for zebra mussel colonization. Table 1 presents the life requirements of zebra mussels and the how those parameters compare with ranges found in Lake Powell.

Glen Canyon Zebra Mussel Prevention Program

To stop the spread of zebra mussels to Lake Powell and the Colorado River system,

the national recreation area operates a Zebra Mussel Infestation Prevention Program (ZMIPP). ZMIPP works in cooperation with the Utah aquatic nuisance species action team and the 100th Meridian Initiative. The Utah Division of Wildlife Resources started the Utah aquatic nuisance species action team. It has produced pamphlets and signs to aid in the education of boaters and promoted the inspection of boats at 23 Utah state parks. The National Invasive Species Act of 1996 founded the 100th Meridian Initiative, which is a forum for multi-agency cooperation with the goal of stopping the spread of invasive aquatic nuisance species across the 100th meridian from east to west. This goal is achieved by promoting information and education, voluntary boat inspections and boater surveys, monitoring, rapid response, and identification and risk assessment of pathways (Mangin 2001).

ZMIPP consists of monitoring Lake Powell for infestation, screening visitors to identify boats that may carry zebra mussels, and providing for potentially infested boats to

Table 1. Zebra mussel colonization potential based on limnological parameters (O'Neill 1996). Typical values for Lake Powell are in bold.

Variable	Colonization Potential			
	High	Moderate	Low	Very Low
Salinity (ppt)	0-1	1-4	4-10	10-35
Calcium (mg/l)	25->125	20-25	9-20	<9
Hardness(mg CaCO3/l)	90->125	45-90	25-46	<26
PH	7.5-8.7	7.2-7.5 8.7-9.0	6.5-7.2 9	<6.5 >9
Water Temperature (C)	18-25	16-18 25-28	9-15 28-30	<8 >30
Turbidity (cm Secchi)	40-200	20-40	10-20 200-250	<10 >250
Dissolved Oxygen (ppm)	8-10	6-8	4-6	<4
Water Velocity (m/sec)	0.1-1.0	0.09-0.1 1.0-1.25	0.075-0.09 1.25-1.5	<0.075 >1.5
Conductivity (uS)	83->109	37-81	22-35	<21

be washed. The monitoring portion of ZMIPP uses artificial substrate samplers to detect the settling-stage zebra mussels. Buoys and docks are also informally checked for the presence of adult zebra mussels. No zebra mussels have been found in Lake Powell.

Visitor screening is conducted at entrance stations. Lake Powell has relatively few access points. Many of the access points have staffed entrance stations where visitors are contacted directly. At each of these entrance stations, including Wahweap, Antelope Point, Bullfrog, and Hall's Crossing, visitors entering the national recreation area with boats are asked questions that assess the risk their boats pose to Lake Powell. The questions are kept to a minimum to avoid lines. Each visitor with a boat is asked, "Has your vessel been used east of the Rocky Mountains in the past 30 days?" If the visitor answers "No," the questioning is over. If the visitor answers "Yes," they are asked, "In which states or provinces east of the Rocky Mountains was your vessel used?" If the answer includes states or Canadian provinces where zebra mussels are known to have infested, the visitor is given a "prevention packet."

The prevention packet includes a pamphlet, a coupon for a free boat washing, and a map with directions to the washing facilities. The pamphlet, produced by the Utah aquatic nuisance species action team, gives information on zebra mussels and other aquatic nuisance species. The maps give some information specific to Lake Powell and directions from the entrance station that the visitors have entered to the washing facilities. The concessionaire conducts boat washings at no cost to the National Park Service (NPS) or the visitors.

Resource management staff at Glen Canyon National Recreation Area work with the concessionaire to ensure that washings are conducted in a manner to minimize the potential of zebra mussels being spread to Lake Powell. Boat washers must assume that the boat is infested. Infestations can be hard to detect, and boats sent for washing have been identified as a high risk. Because the microscopic veligers can exist in very small amounts

of water, all standing water must be drained from areas such as the bilge, live wells, bait buckets, and engine cooling systems. The drained areas are then flushed with water at over 60°C to kill zebra mussels. Any organic matter visible on the boat or trailer must be removed, and the entire boat is washed with a high-pressure, hot-water spray. Special attention must be paid to all areas that will contact the water, including the hull, lines, fenders, motor, trim tabs, anchor, trailer, and especially any confined or tight spaces that can create moist microhabitats. Adult zebra mussel survival when exposed to air is limited by desiccation. Care should be taken not to spread zebra mussels with removed organic matter, water drained from the boat, and any rinse water not hot enough to kill the mussels.

The threat to western states from zebra mussel infestation is very real. Agricultural check stations in California, Oregon, and Washington inspect boats for zebra mussels; at least four boats have been found carrying zebra mussels. In the spring of 2002, the national recreation area's aquatic ecologist was at the Bullfrog Marina on Lake Powell to educate concessionaire employees about zebra mussels and the proper procedures to follow when washing boats. The concessionaire employees stated that a boat from Wisconsin had been launched several weeks earlier. Upon inspection, zebra mussels were found on the trim tabs. It took several tense hours to contact the owner of the boat for permission to pull the boat out of the lake.

The owner said that the boat had been out of the water for nine months prior to being launched and had experienced freezing temperatures during that time; the zebra mussels were assuredly dead. The owner had moved from Wisconsin to Grand Junction, Colorado. He wanted to moor his boat on Lake Powell. He knew that his boat had become infested with zebra mussels. Specifically to remove the zebra mussels, he had the boat sandblasted and painted before bringing it to Lake Powell. Despite the owner's warning about zebra mussels, the trim tabs were not cleaned. The most frightening part of the story is that this visitor had tried to do everything right, but still Lake

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Powell was not safe. The only reason the boat had been out of the water for so long is because weather conditions had not been good for painting.

During the 2001 season, 13 potentially infested vessels entered the national recreation area. Nine of the 13 went to the concessionaire for the free washing. In 2002, 31 boats were identified as “high risk” and 22 were washed. Washings in 2001 and 2002 were entirely voluntary. The dramatic increase in the number of boats identified as a risk probably does not indicate a rise in risk level, but instead, better participation from the fee collectors. During 2001, fee collectors were not consistently asking the questions described earlier. By 2002, many of them had been better educated and understood the risk involved. Consensus-building among park staff and concessionaires is a very important step in preventing zebra mussels and other aquatic nuisance species. Another benefit of a greater consensus in the park is that for the 2003 season, regulations have been put in place that make washings mandatory for any boat identified as a risk by the program.

Zebra mussel infestation is one of the most significant and potentially devastating threats to western water resources. ZMIPP is a proactive and unique effort to stop zebra mussels

from infesting Lake Powell and the Colorado River System. Zebra mussel awareness in western states is slowly increasing. Other NPS units that are taking action to prevent zebra mussels, primarily through education efforts, include Lake Mead National Recreation Area and Curecanti National Recreation Area. In the spirit of the NPS mission, Glen Canyon National Recreation Area is protecting resources and providing for recreation by taking action to stop the spread of zebra mussels and promoting education that could save all waters of the West.

References

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