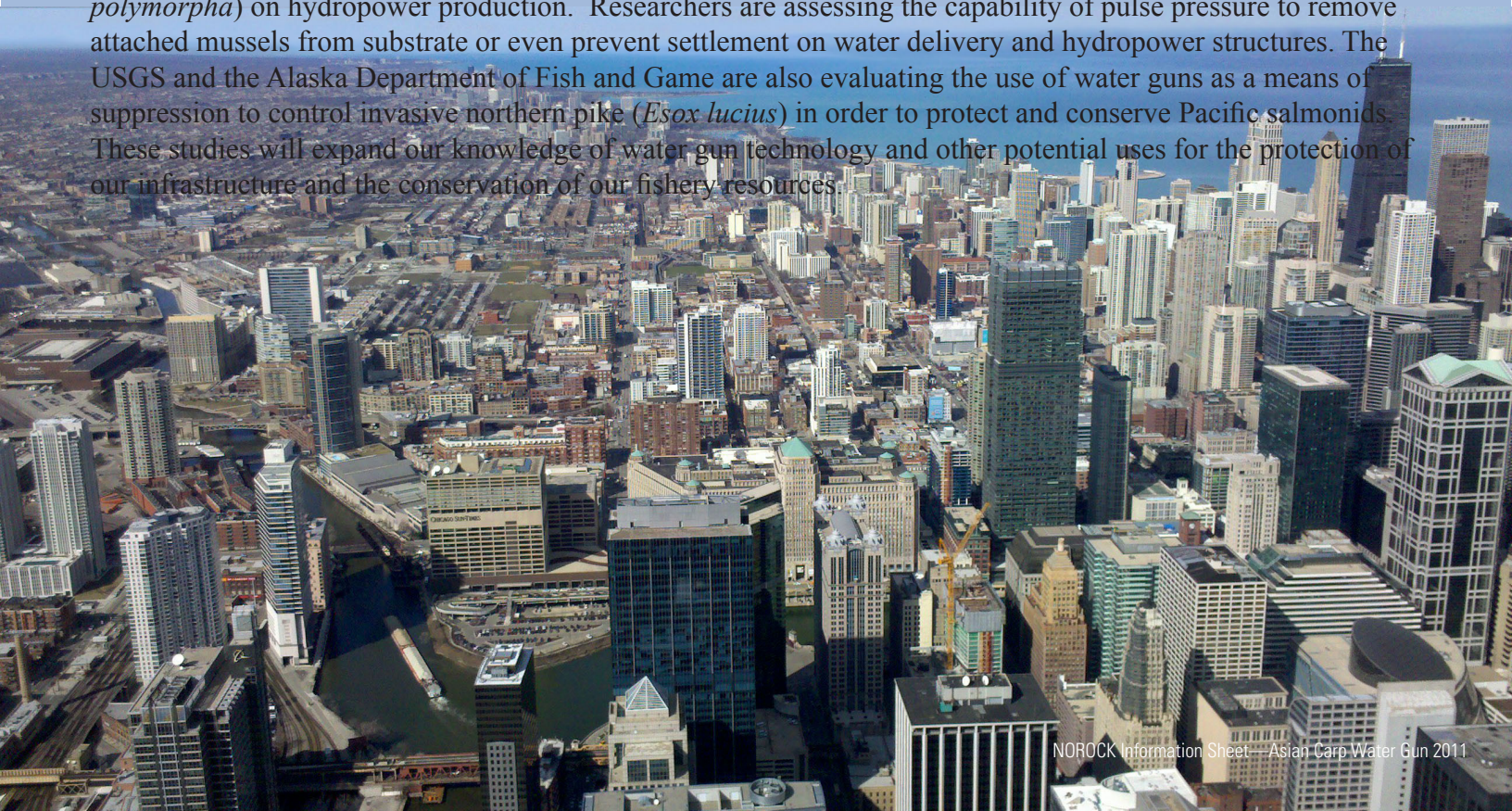
Northern Rocky Mountain Science Center
U.S. Department of the Interior
Geological Survey

Use of seismic technology to divert, herd or eradicate aquatic invasive species: A focus on Asian carp in the Great Lakes ecosystem

Research at the USGS Northern Rocky Mountain Science Center (NOROCK) is focused on developing sound energy barriers to prevent the expansion of two types of invasive Asian Carp in the Great Lakes ecosystem, bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*). Preliminary experiments have been conducted on Asian carp and non-target organisms to evaluate behavioral and physiological responses to the sound energy levels produced by water guns. Studies in 2011 are directed at the establishment of stationary and mobile barriers and the characterization of frequencies and energy levels that will divert Asian carp in the Chicago Sanitary and Shipping Canal. The study is funded by the Great Lakes Restoration Initiative.

In the 1960's oil exploration companies began towing seismic air gun technology behind large vessels to explore the composition of the ocean floor using pulse pressure technology. Later in the early 1980s the water gun was developed to generate a cleaner signal by eliminating the interference produced by the air gun. Although water guns were developed as an alternate means of seismic exploration, they were quickly discontinued because they were less efficient at producing low frequency energy, and there were concerns about their effect on aquatic life. Today, it is those same properties of water guns that may provide the means to establish an acoustic barrier deterrent for Asian carp.

Pulse pressure technology is currently being evaluated as a means to control other aquatic invasive species throughout the US. The USGS along with the US Bureau of Reclamation is conducting studies with water guns and air guns. This research is exploring the feasibility of using these technologies to mitigate the effects of biofouling organisms such as quagga mussels (*Dreissena rostriformis bugensis*) and zebra mussels (*Dreissena polymorpha*) on hydropower production. Researchers are assessing the capability of pulse pressure to remove attached mussels from substrate or even prevent settlement on water delivery and hydropower structures. The USGS and the Alaska Department of Fish and Game are also evaluating the use of water guns as a means of suppression to control invasive northern pike (*Esox lucius*) in order to protect and conserve Pacific salmonids. These studies will expand our knowledge of water gun technology and other potential uses for the protection of our infrastructure and the conservation of our fishery resources.



Why Water Guns?

Water guns provide three mechanisms to deter carp: 1) the use of sound at frequencies Asian carp hear, 2) a pressure wave, and 3) two high velocity water jets.

The water gun signature is short and clean compared to that of the air gun (Figure 1). The water gun has a low amplitude precursor pulse that is followed by the main implosion which produces a large positive spike. This is followed by a similarly shaped negative peak as the pulse is reflected off of the water's surface. After this the pressure quickly stabilizes.

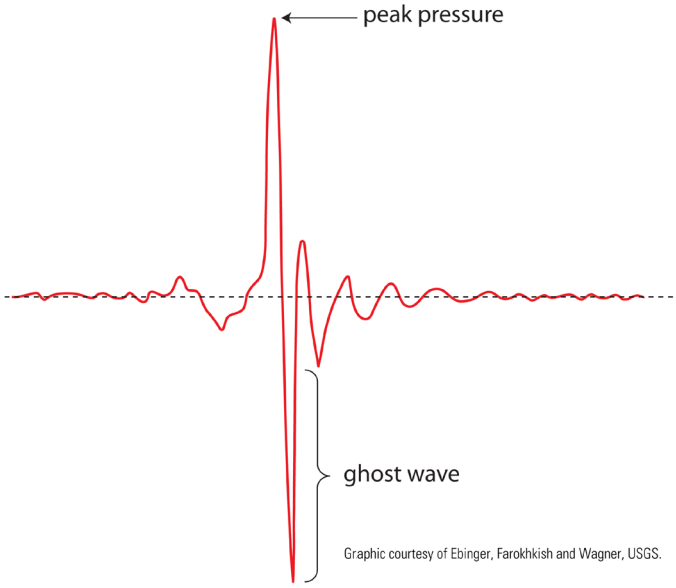


Figure 1. Graphic illustrating the various components of a water gun pulse. Graphic courtesy of Ebinger, Farokhkish and Wagner, USGS.

The water gun operates as a low energy, implosive source that produces a short, bubble-free pulse (Figure 2). The implosion of the cavity is created by the jet of high-pressure water expelled from the gun. These guns have dual chamber/piston assembly. Upon firing the gun high-pressure air in the upper chamber propels the firing piston into the lower chamber, which then ejects the water through the ports at the base of the gun. When the piston decelerates, a cavity is formed behind the expelled water. The main acoustic pulse is created when this cavity implodes due to the surrounding hydrostatic pressure.

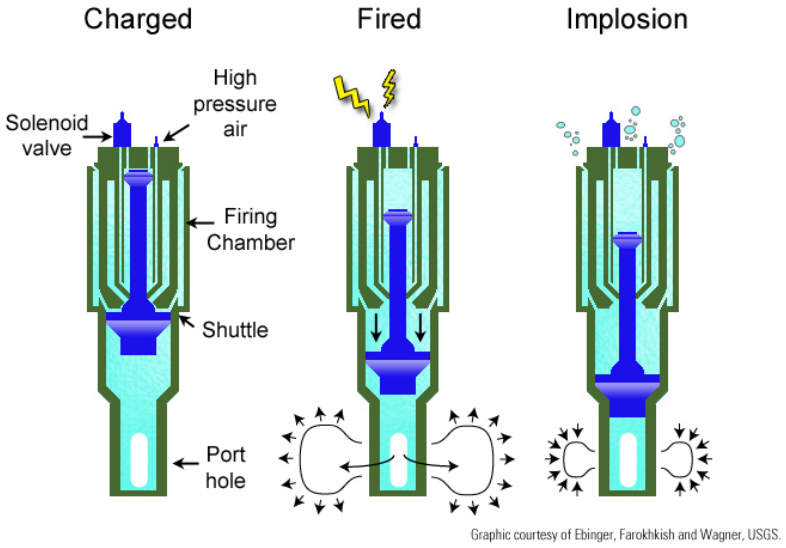


Figure 2. Graphic illustrating a water gun in the charged, fired, and implosion phases. Graphic courtesy of Ebinger, Farokhkish and Wagner, USGS.

The Northern Rocky Mountain Science Center is located in Bozeman, Montana and includes two field stations in Montana and one duty station in Wyoming. For more information on NOROCK's research, please visit http://nrmsc.usgs.gov or contact the Center Director: Jeff Kershner 406-994-5304 or jkershner@usgs.gov