# Acoustic Fish Deterrents

**U.S. ARMY CORPS OF ENGINEERS** **Building Strong®**

**ANS Control Technology:**
Acoustic Fish Deterrents – Continuous Wave and Pulsed Pressure Wave.


**USGS researchers and their associates observe Asian carp.**

**Targeted Species:** This Control may be effective for fish of the ANS of Concern – CAWS [1], namely: alewife (*A. pseudoharengus*), bighead carp (*H. nobilis*), black carp (*Mylopharyngodon piceus*), blueback herring (*Alosa aestivalis*), inland silverside (*Menidia beryllina*), northern snakehead (*Channa argus*), ruffe (*Gymnocephalus cernuus*), sea lamprey (*Petromyzon marinus*), silver carp (*H. molitrix*), skipjack herring (*A. chrysochloris*), threespine stickleback (*Gasterosteus aculeatus*), and tubenose goby (*Proterorhinus marmoratus*).

**Selectivity:** This Control was developed to specifically target fish and is generally non-selective among fish species. There is no information on its effects on aquatic invertebrates.

**Developer/Manufacturer/Researcher:** The main manufacturers of seismic technology are Bolt Technology, Sercel, and Ion Geophysical Corp[2]; currently the only developer of water gun technology is Bolt Technology. The U.S. Geological Survey (USGS) Illinois Water Science Center is evaluating the effects of sound technology on physical structures in water, e.g. lock and dams, and to accurately map the pressure gradients generated from water gun operation. The USGS Great Lakes Science Center and USGS Upper Midwest Environmental Sciences Center are completing research to evaluate the use of water guns to alter fish behavior, including evaluations as potential barriers to the movement of Asian carp.

**Brief Description:** There are two general types of acoustic fish deterrents: continuous wave and pulsed wave. These deterrents use sound/pressure waves (noise) to influence the behavior of or injure aquatic organisms. The Controls presented in this fact sheet have the potential to be lethal if the organism is close to the source of the pressure wave, though most are not considered lethal for animals located at distance from the sound source. Acoustic fish deterrents can be stationary or semi-portable. The compressor required to operate the larger pulsed pressure wave water guns for any length of time weighs about 3,000 lbs, however smaller configurations have been used experimentally in the CAWS.

It has been shown that underwater ensonification at the resonant frequency of the lung can damage and even kill aquatic organisms. This is due to the resonance of the wave creating disturbances within air-filled cavities, which leads to tissue damage. For fish, the most vulnerable to underwater sound are

[1] For a complete list of the 39 specific ANS of Concern – CAWS, please see Table 1 of the main report.

[2] Manufacturers and products mentioned are examples only. Nothing contained herein constitutes an endorsement of a non-Federal entity, event, product, service, or enterprise by the U.S. Army Corps of Engineers or its employees.

those with swim bladders. Carp fit into this category and thus are expected to be sensitive to underwater sound at the resonant frequency of the swim bladder.

The use of underwater ensonification could be effective in controlling carp movement within restricted waterways, where the sound could not be avoided. If the swim bladder of the Asian carp is susceptible to specific frequencies, this approach may have the advantage of specifically targeting carp and not affecting other species.

*Continuous Wave* – Continuous wave sonar uses high intensity, low-frequency sonar waves generated from a Low Frequency Active (LFA) sonar source array. The LFA sonar source array is a set of acoustic transmitters that produce sound that is irritating to fish. Continuous wave sonar was originally developed by the United States Navy to identify submarines (Tyler 1992), but is now being tested to determine if it can be used as a deterrent or as part of a fish guidance system or barrier.

*Pulsed Pressure Wave* - Pulsed pressure waves are high intensity sound/pressure waves generated by a sound source (hydro gun, air gun, blast explosive) to irritate, harm, or kill aquatic organisms. A hydro gun produces sound waves using a pneumatically- or hydraulically-powered piston. In contrast, an air gun produces sound waves by the explosive release of high pressure air directly into the surrounding water. Blast explosives (e.g. primacord), on the other hand, send a concussive shock wave through the water. Hydro guns produce shorter, cleaner implosive pressure waves which produce higher frequencies than the air gun. Air guns are superior for oil exploration as they produce more low frequency waves and deep penetration of the water column (Hutchinson & Detrick 1984). Since output pressures are dependent on input air pressure, very low operating pressures at a sub-lethal level may motivate fish to move from the direction of the source. The pressure gradient surrounding a gun will be dependent on the input pressure to the gun – that is, a given gradient of constant pressure will be further from a gun fired at 2,000 PSI vs. the same gun fired at 1,000 PSI. Similarly, a given pressure gradient may be further from a large gun than a small gun even if operated at the same pressure. Air guns and hydro guns may be fired in repeated bursts. Blast explosives are less suited for continuous application due to the chronic need to reset charges and the possible release of toxic residues.

**Prior Applications:**

*Continuous Wave* – The effects of continuous wave sonar have been widely studied on marine mammals and fish; however, its use as a fish deterrent is a new approach in freshwater.

*Pulsed Pressure Wave* - Air guns were developed in the 1960s and are used for a variety of purposes, including marine petroleum exploration and as a fish deterrent in both freshwater and marine environments. Hydro guns were developed in the 1980s for the same purposes and are presently being studied in the Chicago Sanitary and Ship Canal by USGS. The USGS is studying the effects of water guns to alter the behavior of invasive Asian carp as a means to inhibit movement (e.g. to herd fish toward commercial fishing nets) and stop dispersal (i.e. to create a barrier). Initial studies will determine the effects of different sound wave frequencies on various age classes of Asian carp, at a range of distances from the sound source. The magnitude of the sound wave will be measured in order to quantify fish response to sound impacts. Initial and delayed lethality will be assessed, as well as

sub-lethal evading behaviors (Asian Carp Regional Coordinating Committee 2011). Blast explosives are commonly used at construction areas to protect fish near work zones (Keevin & Hempen 1997).

**General Effectiveness:** The response of fish to loud noises ranges from no response, short term avoidance (moving away from the sound source), long term avoidance (altering behavior to avoid the sound), physiological damage (hearing loss), and even death (tissue disruption). A variety of factors including frequency of pressure waves, intensity, duration, and distance from acoustic source influences effectiveness (Popper 2003; Halvorsen et al. 2011).

*Continuous Wave* – The LFA sonar source array has been shown to have a non-lethal behavioral effect on rainbow trout. However, the results varied with different groups of trout, suggesting developmental and or genetic impacts on how sound exposure affects hearing (Popper et al. 2007).

*Pulsed Pressure Wave* – The effectiveness of pulsed pressure waves is mixed—incidental observations during blasting operations indicate that individual blast explosions are not very effective in "scaring" fish from the blast zone for long periods of time (Ferguson 1962; Nix & Chapman 1985; Falk & Lawrence 1973; Keevin & Hempen 1997), and the sound of the air gun had little effect on the day-to-day behavior of the resident fish and invertebrates in a marine environment (Wardle et al. 2001). However, the pulsed pressure waves are lethal to adults, eggs and larvae, although larval fish are less sensitive than those in which the swim bladder has developed (California Department of Fish and Game 2002). The lethality of pulsed pressure waves varies with fish size, species, orientation of the fish relative to the shock wave, amount and type of explosive, detonation depth, target depth, water depth, and bottom type (Wright 1982).

**Operating Constraints**The repeated use of these technologies may have a deleterious effect on canal walls and underwater structures, would impact navigation, and may present safety issues, possibly requiring public access restrictions. Considerations include the quantity of explosives that could be used safely in one session, water flow and turbidity in the vicinity of explosives placement, navigation blockage, and safety issues. The repeated use of explosives could result in an accumulation of explosive residue that may impact water quality downstream of the treatment area.

**Cost Considerations:** Both Controls may require the armoring and shoring of canal walls and underwater structures to withstand repeated shock waves.

*Continuous Wave* –

***Implementation:*** The LFA sonar source array is being tested experimentally. If successful, full implementation would involve the development of a land-based project site for mounting and operating this Control.

Planning and design activities in the implementation phase may include research and development of the technology, modeling, site selection, site-specific regulatory approval, plans and specifications, and real estate acquisition. Design will also include analysis of this Control's impact to existing waterway uses including, but not limited to, flood risk management,

natural resources, navigation, recreation, water users and dischargers, and required mitigation measures.

***Operations and Maintenance:*** This Control would require maintenance of mechanical devices, electricity, and monitoring of equipment and fish populations.

***Mitigation:*** Design and cost for mitigation measures required to address impacts as a result of implementation of this Control cannot be determined at this time. Mitigation factors will be based on site-specific and project-specific requirements that will be addressed in subsequent, more detailed, evaluations.

*Pulsed Pressure Wave* –

***Implementation:*** The water gun is being tested experimentally. If successful, full implementation would involve the development of a land-based project site for mounting and operating this technology. The USGS is exploring different methods to also deploy the gun from mobile locations. The implementation cost of this Control depends on the quantity and type of blast explosives used, as well as possible long-term effects of blast explosives in the body of water and surrounding areas. If hydro guns are used there wouldn't be any residues remaining.

Planning and design activities in the implementation phase may include research and development of the technology, modeling, site selection, site-specific regulatory approval, plans and specifications, and real estate acquisition. Design will also include analysis of this Control's impact to existing waterway uses including, but not limited to, flood risk management, natural resources, navigation, recreation, water users and dischargers, and required mitigation measures.

***Operations and Maintenance:*** This Control would require maintenance of mechanical devices and monitoring of equipment, surrounding infrastructure, and fish populations to gauge the effect of repeated pressure waves.

***Mitigation:*** Design and cost for mitigation measures required to address impacts as a result of implementation of this Control cannot be determined at this time. Mitigation factors will be based on site-specific and project-specific requirements that will be addressed in subsequent, more detailed, evaluations.

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