



Acoustic Fish Deterrents

U.S. ARMY CORPS OF ENGINEERS

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

Targeted Species: This Control may be effective for fish of the ANS of Concern – CAWS¹, 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 (*Hypophthalmichthys molitrix*), skipjack herring (*A. chrysochloris*), threespine stickleback (*Gasterosteus aculeatus*), and tubenose goby (*Proterorhinus marmoratus*).



USGS researchers and their associates observe Asian carp.

Source: Jackson Gross, USGS

Selectivity: This Control was developed to specifically target fish and is generally non-selective among fish species.

Developer/Manufacturer/Researcher: The main manufacturers of seismic technology are Bolt Technology, Sercel, and Ion Geophysical Corp²; currently the only developer of water gun technology is Bolt Technology; a researcher of sonic technology is Jackson Gross at the U.S. Geological Survey (USGS), Northern Rocky Mountain Science Center.

Brief Description: There are two general types of acoustic fish deterrents: continuous wave and pulsed wave. Both of these deterrents use sound/pressure waves (noise) to influence the behavior of or injure aquatic organisms and can be lethal if the organism is close to the source of the pressure wave. Acoustic fish deterrents are portable or can be mounted on stationary platforms.

Underwater ensonification affects fish using either a sudden burst or a continuous resonant sound wave, both of which create disturbances within air-filled cavities within the body that lead to tissue damage. Fish species that have a swim bladder are the most vulnerable to underwater sound. The swim bladder is an internal organ used to maintain a normal upright position in water. Carp species have a swim bladder and therefore, are expected to be sensitive to underwater ensonification at the appropriate resonant frequency.

The use of underwater ensonification could be effective in controlling carp movement within restricted waterways, where the sound could not be avoided. This approach also has the advantage of specifically targeting carp, as other fish would either not be susceptible, or would have a different resonant frequency (Sandra Morrison, USGS, E-mail communication, 2011).

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.

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 (i.e. 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. Increasing input pressure will subsequently decrease the distance of sound attenuation which may also be a function of the chamber size of air guns and hydro gun. 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 divert, herd, or kill invasive Asian carp as a means to inhibit movement and stop dispersal. 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, and may be useful for clearing fish from small reaches of the CAWS, 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 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.

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, monitoring of equipment and fish populations, and repeat explosions.

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.

Citations:

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