Accelerated Water Velocity

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

ANS Control: Accelerated Water Velocity

Targeted Species: Accelerated Water Velocity may be effective in preventing the upstream transfer of all ANS of Concern – CAWS[1] via aquatic pathways. For more information, see *General Effectiveness* and *Operating Constraints* sections of this fact sheet.

Selectivity: Accelerated water velocity is a unidirectional barrier, meaning that it prevents only upstream movement of organisms and is non-selective.

Developer/Manufacturer/Researcher: Velocity barriers have been used by a variety of Federal and state natural resource agencies. New applications for this technology are being researched by Theodore Castro-Santos of the Conte Anadromous Fish Lab.

Accelerated water velocity channels must be smooth to prevent the formation of low velocity flow zones near the walls.

Brief Description: Accelerated water velocity works by generating a zone of water that flows faster downstream than an organism can swim upstream, thus creating a barrier. For this to work, the water velocity must correlate with the swimming performance of the ANS. Swimming performance of fish is defined as the capability plus the behavioral motivation to swim at a maximum rate of speed (McPhee & Watts 1976). This can be broken down into three activity levels: burst, prolonged, and sustained. Burst speeds are variably defined as swim speeds that can be maintained for only "a few seconds," less than 20 seconds, less than 30 seconds, and less than 60 seconds, depending on the research and fish species considered. Burst speeds, however, are typically two to four times greater than maximum sustained and prolonged swim speeds. Prolonged swimming, with periods of cruising and occasional bursts, can be maintained for 15 seconds to 200 minutes. Sustained swimming activity can be maintained for longer than 200 minutes (Blaxter 1969; Farlinger & Beamish 1977). The wall material of the accelerated water velocity channel should be smooth and solid to minimize drag along the edges that could slow flow and allow organisms to pass.

Many factors such as species, body length, form, physiological condition, conditioning to currents, motivation and behavior, water temperature, concentration of dissolved gases, turbidity, and light influence the swimming performance of fishes (Bainbridge 1960; Dahlberg et al. 1968; Farlinger & Beamish 1977; Gray 1957; Hocutt 1973; McPhee & Watts 1976). Substrate size and roughness also facilitate station holding and influence swimming performance by creating boundary layers and areas of turbulence, which fish use to navigate through fast-flowing waters. Younger life stages of migratory species have slower swimming speeds, given their shorter length, and schooling fish have a hydromechanical advantage and may be able to make progress against faster currents as a school rather than when swimming individually.

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

Prior Applications: Accelerated water velocity barriers have been constructed in the Great Lakes Region to block spawning runs of sea lampreys, while still allowing desirable fish to pass and reach their spawning grounds (Great Lakes Fishery Commission 2000). Accelerated velocity barriers have been widely studied at road culverts and dams, which prevent upstream movement of fish to habitats critical for species survival. Though most of this research was conducted to better enable migratory species to pass obstacles, it could be applied to prevent the upstream movement of ANS.

General Effectiveness: When properly designed, high-velocity barriers work well to control the movement of upstream movement of organisms but cannot prevent their downstream movement.

Operating Constraints: For an accelerated water velocity barrier to be effective, a constant velocity must be maintained throughout the water column under a wide range of channel discharges. This technology is best suited for use at dams, road culverts, and small canals. The effectiveness of accelerated water velocity channels is reduced in frequently flooded areas because ANS can swim past if floodwaters submerge the barrier and spill onto the floodplain. Under certain circumstances, a desired velocity may be achieved by installing riffles, relatively shallow and coarsely-bedded lengths of a river or stream, over which flows are at higher velocity and higher turbulence than the average stream flow velocity.

Velocity barriers must have a length and flow velocity greater than the fish's leaping ability and swimming endurance. Generally, a minimum flow of 7 feet per second over a distance of 180 feet would prevent upstream fish movement in the CAWS. Structures needed to maintain the required minimum velocity could interfere with navigation. Accelerated water velocity channels prevent upstream movement of non-target aquatic organisms.

Cost Considerations:

Implementation: The implementation of this Control would include planning, design, and construction of high-velocity channels. Planning and design activities in this phase may include research and development of this Control, 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: Velocity barriers would require periodic monitoring, debris removal and replacement of worn sections.

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:

Bainbridge, R. 1960. Speed and stamina in three fish. *The Journal of Experimental Biology*, vol. 37, pp. 129-153

Blaxter, J.H.S. 1969. Swimming speeds of fish. *FAO Fisheries Report*, vol. 62(2), pp. 69-100

Castro-Santos, T. 2005. Optimal swim speeds for traversing velocity barriers: an analysis of volitional high-speed swimming behavior of migratory fishes. *The Journal of Experimental Biology,* vol 208, pp. 421-432

Dahlberg, M.L., D.L. Shumway, & P. Doudoroff. 1968. Influence of dissolved oxygen and carbon dioxide on swimming performance of largemouth bass and coho salmon. *Journal of the Fisheries Research Board of Canada,* vol. 25, pp. 49-70

Farlinger, S. & F.W.H. Beamish. 1977. Effects of time and velocity increments on the critical swimming speed of largemouth bass (*Micropterus salmoides*). *Transactions of the American Fisheries Society,* vol. 106, pp. 436-439

Gray, J. 1957. How fishes swim. *Scientific American,* vol. 197(2), pp. 48-65

Great Lakes Fishery Commission. 2000. Sea lamprey barriers new technologies help solve an old problem. Great Lakes Fisheries Commission Fact Sheet 5. Ann Arbor, MI. Accessed December 18, 2011. http://www.glfc.org/pubs/FACT_5.pdf

Hocutt, C.H. 1973. Swimming performance of three warmwater fishes exposed to rapid temperature change. *Chesapeake Science,* vol. 14(1), pp. 11-16

McPhee C. & F.J. Watts. 1976. Swimming performance of Arctic grayling in highway culverts. University of Idaho College of Forestry, Wildlife and Range Sciences Bulletin 13, Moscow, ID