Piscicides

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

ANS Control: Piscicides – antimycin A, rotenone, niclosimide and 3-Trifluoromethyl-4-nitropheno (TFM)

Targeted Species: Piscicides have an effect on all fish including those specific ANS of Concern – CAWS[1]. This control may be effective on blueback herring *(Alosa aestivalis)*, skipjack herring (*A. chrysochloris)*, alewife (*A. psuedoharengus)*, northern snakehead (*Channa argus)*, threespine stickleback (*Gasterosteus aculeatus)*, ruffe (*Gymnochephalus cernnus)*, silver carp (*Hypophthalmichthys molitrix)*, bighead carp (*H. nobilis)*, inland silverside (*Menidia beryllina)*, black carp (*Mylopharyngodon piceus)*, sea lamprey (*Petromyzon marinus)*, and tubenose goby (*Proterorhinus marmoratus).*

Selectivity: Piscicides were designed to manage or control fish; however, they are non selective and are known to affect macro-invertebrates. Depending on the type, concentration, method and timing of application, and length of exposure to the piscicide used, it may be toxic to other aquatic species.

Developer/ Manufacturer/ Researcher: Piscicides are manufactured by a variety of chemical companies. Researchers include the United States Geological Survey (USGS) Great Lakes Science Center (Ann Arbor, MI); the USGS Upper Midwest Environmental Science Center (La Crosse, WI); and Duane Chapman of the USGS Columbia Environmental Research Center (Columbia, MO).

Pesticide Registration/Application: Pesticides, including piscicides, must be applied in accordance with the United States Environmental Protection Agency (USEPA)-approved product label guidelines. Users must read and follow the pesticide product label prior to each application. The registration status, trade name, and availability of pesticides are subject to change. The listing of a pesticide in this fact sheet or Appendix B does not represent an endorsement by the USACE or USEPA regarding its use for a particular purpose.

Brief Description: Piscicides are chemicals used to kill fish. They can be used in a variety of aquatic environments

Pump, piping, and rotenone staged for use in the CAWS

Workers placing piping to administer rotenone

Buoys mark the location of submerged pipes across the CAWS for the rotenone

December 2009 Application of Rotenone in the CAWS

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

including lakes and rivers. There are four chemical piscicides registered for use in the United States: antimycin A, rotenone, niclosamide and TFM. The lampricides, niclosamide and TFM, are registered to control sea lamprey; however, niclosamide is also registered to control mollusks.

Antimycin A and rotenone –Antimycin A and rotenone are general piscicides, which kill all types of fish. Antimycin A is abacterial fermentation product and rotenone is a naturally occurring plant flavonoid. Both affect gill-breathing animals by inhibiting their use of oxygen at the cellular (mitochondrial) level (Bettoli & Maceina 1996).

Antimycin A is more toxic to fish than rotenone (Bettoli & Maceina 1996), yet less toxic to aquatic invertebrates in terms of long-term effects on aquatic community diversity and abundance (Lennon et al. 1971). Fish do not sense (i.e. avoid) antimycin A as they do rotenone (or the petroleum carriers used to solubilize rotenone), making it the preferable piscicide for stream treatments. It also requires less contact time than rotenone to cause death and kills all life stages of fish, including eggs (Berger et al. 1969). However, one study suggests that silver and bighead carp are relatively insensitive to antimycin A (Chapman et al. 2003). Additionally, antimycin A degrades faster than rotenone especially when exposed to air, warm temperatures, and high pH. Potassium permanganate readily detoxifies both antimycin A and rotenone (Bettoli & Maceina 1996).

Rotenone actually inhibits complex 1 of the electron transport system and affects all animals that use this complex in the electron transport system. It primarily has an effect on fish and invertebrates and has been used for insect control in gardens (Isman 2006).

Oral Delivery Systems: Researchers are exploring ways to selectively kill only invasive fish species while protecting native fish species. One technique, treating fish food pellets with rotenone, has been effective at controlling common carp in marshes (Gilligan et al. 2005; Bonneau & Scarnecchia 2001). Food pellets require far less rotenone to deliver a lethal dose than direct water application of rotenone, and can be removed from the water if not consumed; however, fish must typically be trained to consume the food pellets. Development of oral delivery techniques requires a full understanding of native and invasive species gill and gut enzyme activity and physiology, because a targeted delivery system will likely use an oral or gill adhesion delivery route. Designing the pellets to float and correctly sizing the pellets can reduce the chance of poisoning non-target fish (Gehrke 2003).

Niclosamide and TFM – Niclosamide and TFM are used for controlling sea lamprey ammocetes in the Great Lakes tributaries. Niclosamide is the active ingredient in USEPA-registered molluscicides as well. Application of these piscicides is generally limited to headwaters where the diversity and abundance of fish is not high, limiting impacts. Lamprey do not have the enzymes needed to eliminate these chemicals as efficiently as other fish species, thus lamprey are more susceptible at lower concentrations. However, the toxicity of these compounds is highly pH/alkalinity dependent and minor shifts in environmental conditions can result in marked shifts in the toxicity of the compounds to non-target aquatic animals. Amphibians have regularly been found dead in creeks immediately after TFM treatment in Lake Erie watersheds and elsewhere in the Great Lakes. TFM is chemically and biologically stable and remains in solution in the lake system and persist for long periods of time. Niclosamide is often used in small amounts in small streams to reduce the amount of TFM needed to kill sea lamprey larvae (Bettoli & Maceina 1996), and in lake areas where the volume of chemical would otherwise be prohibitively large (Brege et al. 2003).

Prior Applications: Piscicides have been used by fishery biologists to sample fish communities and remove undesirable fish species since the 1930s (Bettoli & Maceina 1996), and they have been a principal means for assessing fish populations in Ohio River locks for many years (Margraf & Knight 2002). Standard operating procedures have been developed for the application of antimycin A, rotenone and lampricides (Finlayson et al. 2010; Moore et al. 2008; Adair & Sullivan 2011).

The National Park Service has successfully used antimycin A to restore native fish populations (Gresswell 1991). Extracts from rotenone containing plants have been used to catch fish prior to their application for fisheries science (Krumholz 1948). Rotenone was used in the CAWS in 2009 during the maintenance of the Chicago Sanitary and Ship Canal's Electric Fish Barrier IIA and in 2010 to determine whether Asian carp were present in areas where eDNA[2] tests had indicated that bighead and silver carp may have been present (USACE 2010). In Australia, rotenone was used to eliminate carp from Tasmania in the 1970s and to eradicate non-native trout from streams (West et al. 2007). Rotenone pellets have been used experimentally in controlling common and grass carp in lakes (Fajt 1996; Gehrke 2003).

The lampricides TFM and niclosamide have been used successfully for sea lamprey control in tributaries of the Great Lakes since 1958. (Smith & Tribbles 1980)

General Effectiveness: There are a variety of factors that impact the effectiveness of piscicides, including suspended solids, temperature, pH, dissolved oxygen, and dissolved iron. Rotenone was found to be fatal to bighead and silver carp after a 4-hour exposure period (Chapman et al 2003). Rotenone was effective at killing common carp and 10 other fish species during the 2009 CAWS application and over 40 fish species during the 2010 CAWS application (USACE 2010).

The period of time it takes antimycin A to kill fish may be influenced by the surfactant used during application. One study indicated that it took 32 hours to kill Asian carp while using the most concentrated antimycin A dose permitted (Chapman et al. 2003), but antimycin A used with a different surfactant killed various cyprinid fishes after an exposure period of 12 hours (Rach et al. 2009). At the typical treatment rates used for antimycin A, all fish species would be vulnerable, though some are more sensitive. Antimycin A is relatively selective for fish with scales. It has been used to selectively remove scaled fish from catfish aquaculture facilities (Finlayson et al. 2011). Antimycin A is more active in warm water than in cold, is slightly more active in soft water than hard, and is more active and persists far longer in water at pH 5 to 8 than at pH 9 or 10 (Berger et al. 1969).

Oral Delivery Systems: An oral delivery formulation for Asian carp is still in the developmental stages. The USGS is developing oral delivery systems to selectively deliver piscicides to silver

[2] eDNA (Environmental DNA) is the genetic material of an organism that is found in the environment. Organisms, like Asian carp, release DNA into the environment in the form of secretions (slime), feces, and urine. These substances and the DNA within them slowly degrade in the environment, but can be collected in water samples if caught soon enough. These water samples are filtered and the genetic material is collected and processed to identify the presence or absence of Asian carp DNA.

and bighead carp in a microparticle. Their research has identified enzyme triggers to release the piscicide from the microparticle - enzymes present in bighead and silver carp that are less active or not present in native planktivores like gizzard shad and bigmouth buffalo. They are presently testing the effectiveness of the oral delivery system microparticle to deliver rotenone to bighead and silver carp but not affect bigmouth buffalo or paddlefish. The effectiveness of oral delivery systems on invasive fish species such as Asian carp has yet to be determined. Baiting fish with rotenone-treated product has had limited success in past attempts (Gehrke 2003; Boogaard 2003).

Operating Constraints: Standard operating procedures are required for piscicides, including extensive preparatory work, stringent application procedures, and follow-up (monitoring), all of which are intended to reduce effects on non-target organisms. Piscicides require application of the treatment, and collection and disposal of dead fish. Fish kills with piscicides generate large quantities of dead fish that must be collected and properly disposed. The required amount of time to apply piscicides varies greatly, depending on the selected piscicide, size of the treatment area, water temperature, target fish species, flow, mixing rate, and the detoxification protocol. Lampricides are labeled for use only by the US Department of the Interior, the US Fish and Wildlife Service, state fish and game agencies, and Fisheries and Oceans Canada and Provincial Certified Applicators trained in sea lamprey control.

Cost Considerations:

Implementation: Implementation costs would include application method planning, purchase of the piscicide, and application of the piscicide. 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: Operations and maintenance costs would include routine application of the piscicide, collection and disposal of dead fish, and effectiveness monitoring. Another consideration is the deactivation of the compound to limit effects on non-target organisms.

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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