

Appendix A: Science Supporting the Lake Trout Suppression Program

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A.1 Abstract

Suppression of lake trout populations and their impacts on both native and non-native fish species is an increasingly important issue to fisheries managers in the western United States. In Yellowstone Lake, suppression of the non-native lake trout population is considered vital to the restoration of a healthy Yellowstone cutthroat trout population and central to the park's Native Fish Conservation Plan. This appendix reviews pertinent lake trout biology, research concerning lake trout suppression efforts, and recent suppression actions in Yellowstone Lake and other western lakes. Based on past experience and recent population modeling, the annual effort needed to attain mortality rates of 0.30, 0.45, and 0.56 is anticipated to be 3,900, 5,600, and 7,000 km of fishing effort. (Fishing effort is defined as the total amount of net that is used to capture fish during one night.) If a fishing mortality rate of 0.30 could be maintained indefinitely, it is predicted that lake trout abundance within Yellowstone Lake would be held constant. If a mortality rate of 0.45 could be maintained for at least 10 years, lake trout abundance is predicted to be reduced to approximately 25% of the current level. Similarly, with a mortality rate of 0.56 maintained for at least 10 years, lake trout abundance is predicted to be reduced to approximately 5% of the current level.

A.2 Introduction

Control of non-native species has become a serious concern for fisheries managers across the country. Although many non-native species have been introduced to new habitat to promote more diverse fishing opportunities, the long-range consequences were often not recognized or given adequate attention. The unintended spread of many non-native species by immigration or illegal activity has also led to the homogenization of species, hybridization between closely related species, and significant decreases in or even extirpation of native species (Fredenberg 2002; Rahel 2002; Jelks et al. 2008). One such instance was the illegal introduction of lake trout (LKT) in Yellowstone Lake, which was thought to be one of the most secure habitats for Yellowstone cutthroat trout (YCT) (Behnke 1992; Behnke 2002). Predation by and possibly competition with LKT, along with other stressors, including prolonged drought and the presence of whirling disease, has led to record-level decreases in the lake's YCT population (Koel et al. 2005). Beginning almost immediately after the presence of LKT was verified in the lake in 1994, the National Park Service undertook a course of action to reduce LKT impacts on the YCT population (Bigelow et al. 2003). However, the LKT population has continued to increase (Gresswell 2009; Syslo 2010). (For a more detailed description of the history of the LKT suppression program in Yellowstone Lake, see chapter 1).

The purpose of this appendix is to review the science related to species suppression, particularly LKT, including:

1. LKT biology which may be relevant to suppression efforts
2. research and theory relevant to LKT suppression efforts
3. LKT suppression in other western lakes
4. recent LKT suppression efforts in Yellowstone Lake by the NPS and a private contractor
5. plans for future LKT suppression in Yellowstone Lake

A.3 Lake Trout Characteristics Pertinent to Suppression Efforts

Traditionally regarded as an economically important and highly-desired sport fish species throughout much of North America, the LKT has been widely introduced into lakes outside of its native range (Martin and Olver 1980; Crossman 1995; Behnke 2002). Martin and Olver (1980) described this species as one of the most important commercial and sports fishes of Canada and the northeastern United States, and historically the second most important food fish after lake whitefish (*Coregonus clupeaformis*). According to Behnke (2002), this fish has developed an “almost fanatical following among anglers across North America.” However, many of the attributes that have made it an important commercial and desirable sport fish (their food habits, longevity, ability to attain large sizes, and reproductive characteristics) also make it a formidable dilemma where they have become established outside their native range and are impacting native species or other desired non-native sport fisheries (Martinez et al. 2009).

A.4 Food Habits

Lake trout will consume a large variety of foods, including plant material, plankton, insects, worms, leeches, amphipods, and mammals (Martin and Olver 1980). They are considered a voracious piscivore (subsisting primarily on fish) when fish are available as prey, and they likely require these energy-rich sources of protein to attain the large sizes for which they are

renowned (Martin and Olver 1980; Luecke et al. 1994; Behnke 2002). Cannibalism reportedly occurs within LKT populations, but it is apparently important only when other prey species of fish do not occur or are not readily available (Martin and Olver 1980).

As LKT grow in size, they typically switch from a prey base dominated by invertebrates and other small items (omnivory) to one dominated by fish (piscivory). As LKT grow, their energy demand increases and they tend to eat larger fish rather than a greater number of fish (Martin and Olver 1980). The size of the prey an LKT can ingest is limited by how wide it can open its mouth. Several reports document LKT consuming fish larger than 50% of their own body length (Martin and Olver 1980; Ruzycki et al. 2003; Beauchamp et al. 2007). In Yellowstone Lake, LKT have been reported to consume YCT up to 55% of their body length, although 30% is more typical (Ruzycki and Beauchamp 1997; Ruzycki et al. 2003).

Lake trout are also very efficient predators, able to maintain high predation rates, perhaps because of their ability to search large volumes of water, even when prey species are at low densities (Eby et al. 1995; Martinez et al. 2009). In Priest and Flathead lakes, kokanee (*Oncorhynchus nerka*) remained an important component in the LKT diet well after kokanee were no longer caught in routine sampling or by sport anglers (Spencer et al. 1991; Stafford et al. 2002; Martinez et al. 2009).

The combination of these predatory capabilities could be deadly to native prey species such as YCT. Predation by an abundant LKT population could lead to a population crash of the native species on which it preys (Beauchamp et al. 2007; Martinez et al. 2009). As LKT abundance increases, competition for food sources common to both young LKT and their prey species could accelerate negative effects on the prey population.

A.4.1 Longevity

LKT are long-lived and have been reported to live up to 62 years, but 20 to 25 years is more typical (Behnke 2002). LKT switch from being primarily omnivorous to primarily piscivorous in Yellowstone Lake somewhere between five and eight years of age (Ruzycki et al. 2003). Assuming YCT persist, an LKT in Yellowstone Lake could be consuming primarily YCT for over 20 years during its lifetime.

Unlike the classic mammalian predator-prey relationship, in which predator numbers cycle with prey abundance, LKT predation that suppresses or eliminates its primary prey does not necessarily result in an LKT decline. LKT are cold-blooded species and do not require a constant food source to survive. In fact, although they require a high-energy food source for growth, LKT can persist for years on a diminished prey base (Martinez et al. 2009). Kokanee, the primary prey of LKT in Granby Reservoir, Colorado, were virtually extinct by the late 1990s (Martinez 2005; Martinez 2006). However, large (>50 cm) LKT that were tagged and recaptured at a later date showed little or no individual growth even 10 years after the kokanee collapse (Martinez 2005; Martinez 2006).

The persistence of a predator population despite the availability of scarce or lower quality prey in consecutive years is referred to as “predatory inertia” (Stewart et al. 1981). This situation is particularly insidious because an abundant predator whose population is maintained because of the longevity of the species and/or its ability to survive on alternate prey sources, dooms the chances that the suppressed prey can rebound.. If the YCT in Yellowstone Lake were to decline

to the point of no longer being an important food item for LKT, the LKT could readily persist on alternate food resources, maintaining their abundance, although at slower growth rates. This could lead to increased competition for food resources with YCT, likely making it difficult to increase YCT survival, and any increase in YCT survival would be readily consumed by an abundant yet underfed LKT population.

A.4.2 Ability to Attain Large Sizes

The LKT's longevity, and its ample prey base in Yellowstone Lake allow it to attain large sizes, second only to chinook salmon (*Oncorhynchus tshawytscha*) in North America (Donald and Alger 1986). The potential for these fish to reach large sizes gives them the potential to consume significant amounts of native prey. Unlike mammals, fish can continue to grow as they age, which increases their mouth gape and therefore the size of prey consumed, their reproductive potential. Larger LKT produce greater numbers and a higher quality of eggs and sperm (Venturelli et al. 2010).

The largest reported LKT in North America, which weighed over 45 kg, was captured in a gillnet in Lake Athabasca, Saskatchewan (Scott and Crossman 1973). Weights over 18 kg are common in waters with favorable food resources (Donald and Alger 1986). A LKT over 19 kg was caught in Heart Lake, just south of Yellowstone Lake, in 1931 (Varley and Schullery 1998). A 22.7 kg fish, caught in Jackson Lake just south of Yellowstone, is tied for the Wyoming state LKT record (Martinez et al. 2009). These fish, caught in smaller lakes than Yellowstone Lake suggest that Yellowstone Lake could eventually produce a new record LKT if suppression efforts were not in place.

A.4.3 Reproductive Characteristics

The LKT's tendency to spawn in the fall, often during cold and stormy weather, could affect suppression efforts. They are group spawners, with many males and females congregating together over the spawning area, and apparently they are often near the spawning areas for extended periods of time prior to spawning. Specific spawning time has been correlated with latitude, weather, and the size and topography of the lake (Scott and Crossman 1973). However, a decline in water temperature to approximately 10°C (Martin and Olver 1980; MacLean et al. 1990), shortening photoperiods and accumulated sunlight (Royce 1951; McCrimmon 1958), and the intensity and duration of wind activity (Martin 1957), all appear to be important in triggering LKT spawning activities, including migration to spawning areas. Strong, prolonged winds can trigger spawning and hasten its completion, while prolonged bright, calm days have been associated with more prolonged spawning activity (Martin and Olver 1980). These responses to weather conditions could affect suppression efforts negatively, resulting in the need to work in inclement weather or positively (if fair weather prolonged the spawning period).

Some LKT exhibit homing activities (Martin and Olver 1980; Ihssen et al. 1988; Hansen et al. 1995; Marsden et al. 1995). Males are thought to remain in the vicinity of spawning areas for up to several weeks, likely spawning multiple times. Females are believed to move in and out of spawning areas repeatedly during the spawning season. However, it is not known if the females leave after spawning once or if they return to emit eggs on multiple occasions (Martin and Olver 1980). More efficient targeting of adults, especially adult males, should be possible when their primary spawning areas are located and these behaviors are understood.

Mature lake trout have been reported to congregate in staging areas before the actual onset of spawning. However, this behavior is not well documented (Martin and Olver 1980). Several characteristics of lake trout spawning, such as group and broadcast spawning, make it reasonable to expect that they would congregate in preparation for spawning. Traditional thought suggests that LKT gather in deeper water near spawning areas. After dark, the LKT move onto the spawning area and remain there for several hours (Martin and Olver 1980). Perhaps pheromones from mature fish attract others to the area (Johnson et al. 2005). Gillnet catches in Yellowstone Lake lend support to the theory that LKT use staging areas. Nets set in proximity to known spawning sites typically produce high numbers of ripe LKT prior to the onset of spawning, with increased movement of mature LKT in the vicinity as peak spawning approaches (Bigelow 2009).

Lake trout can be very effective at pioneering new waters. Research into the genetic composition of LKT in Swan Lake, Montana, indicates that an effective population of only two or three LKT comprised the founding members of what is now considered an established population which threatens native bull trout (*Salvelinus confluentus*) (Kalinowski et al. 2010)

Despite these many obstacles, fisheries managers and scientists remain optimistic that LKT populations can be suppressed sufficiently to allow recovery of prey or competing native fish species (see Dux 2005; Hansen et al. 2008; Gresswell 2009; Martinez et al. 2009; Rosenthal and Fredenberg 2010; Wahl et al. 2010).

A.4.4 Management Challenges of Lake Trout Introductions

A consequence of LKT introductions in the West in many cases has been the establishment of desirable sport fisheries (Martinez et al. 2009). However in other instances, such as Yellowstone Lake, LKT trout are an unwelcome addition to the ecosystem and considered an invasive species (McIntyre 1995; Koel et al. 2005). Invasive species have been defined as non-native species having demonstrable economic or ecological impacts on the receiving habitat (Lockwood et al. 2007). LKT in Yellowstone Lake meet these criteria, and disastrous impacts to the native fish and wildlife have been documented (Koel et al. 2005).

Invasions by non-native species such as LKT are a leading cause of species extinctions and pose a significant problem for native species conservation, including many native stocks of cutthroat trout (Mack et al. 2000; Mooney and Cleland 2001; Quist and Hubert 2004; Jelks et al. 2008). Impacts from these invasions have led to wide-ranging ecological and economic impacts (Schullery and Varley 1995; Simberloff et al. 2005). Throughout western North America, management agencies are in the difficult predicament of managing LKT while attempting to minimize its negative impact on native species (Deleray et al. 1999; Ruzycki et al. 2001; Fredenberg 2002; Maiolie et al. 2005; Rosenthal and Fredenberg 2010). In many cases, LKT have decimated native or desired prey fish, compete with native counterparts, and are changing the ecological balance of the systems (Yule and Luecke 1993; Johnson and Martinez 2000; Ruzycki et al. 2001; Tronstad 2008).

Ecosystem disruptions are not limited to negative interactions with native species. In Flathead Lake, Montana, LKT increases became a driving factor in the collapse of kokanee in four to five years (Spencer et al. 1991; Martinez et al. 2009). Although competition with the invasive opossum shrimp (*Mysis relicta*) for zooplankton had previously been implicated as the major cause, the availability of opossum shrimp increased the food and survival for juvenile lake trout,

which resulted in increased predation on the already stressed kokanee population and accelerated its collapse (Spencer et al. 1991; Stafford et al. 2002; Martinez et al. 2009). That also led to a severe reduction in the wintering bald eagles that relied on autumn spawning congregations of kokanee (Spencer et al. 1991).

Cutthroat trout populations have often declined, exhibited reduced growth, or disappeared entirely in the presence of non-native LKT. Establishment of LKT is believed to have led to declines of native cutthroat trout populations in several western North American lakes, including Bear Lake, Idaho-Utah (Ruzycki et al. 2001); Lake Tahoe, California-Nevada (Cordone and Frantz 1966); Jackson Lake, Grand Teton National Park, Wyoming (Behnke 1992); Priest Lake and Lake Pend Oreille, Idaho; and Heart and Yellowstone lakes, Yellowstone National Park, Wyoming (Dean and Varley 1974; Koel et al. 2005). In Yellowstone Lake, predation appears to be the primary mechanism by which LKT are currently exerting pressure on YCT. However, if the LKT population continues to expand, it could reach a point where competition for food resources would also become a serious impact.

If feasible, the preferred option for managing invasive species, would be complete eradication. Examples exist of successful invasive species eradication of many taxa in many habitat types, including many species of insects and other invertebrates, plants, as well as fish, rabbits, and goats (Myers et al. 2000; Zavaleta et al. 2001). The use of antimycin eliminated the non-native brook trout (*Salvelinus fontinalis*) from Arnica Creek, a tributary to Yellowstone Lake, within two years in the mid-1980s (Gresswell 1991). However, eradication is not always realistic or feasible, and management agencies must implement control strategies and undertake long-term suppression of the invader to reduce its numbers and spread within the ecosystem. These options may require indefinite investments of time and money to keep the invader and its impacts at bay (Zavaleta et al. 2001).

A.5 Research and Theory Relevant to Lake Trout Suppression

Avoiding depletion of desirable fishery stocks has been a primary concern of fishery managers for generations. Over-exploitation of fishery populations has been demonstrated repeatedly in many types of waters and for many different species of fish. Examples range from the once prolific cod fishery of the Grand Banks in the Atlantic Ocean to small populations of a desired sport fish in a local stream or small lake that have collapsed despite efforts to prevent over-harvest (Selgeby 1982; Hutchings and Reynolds 2004; Pilkey and Pilkey-Jarvis 2007). There is growing evidence that many global fisheries are driving natural populations of fish well below sustainable harvest levels (Myers et al. 1997; Pauly et al. 1998; Myers and Worm 2003; Froese 2004; Worm et al. 2009). Even in Yellowstone Lake, over-exploitation contributed to greatly depressed stocks of YCT because of angler harvest and egg-taking operations in which adult fish were intercepted and stripped of their eggs and sperm (Gresswell and Varley 1988). Fortunately, ceasing the hatchery operation and restricting harvest allowed the YCT population to recover (Gresswell and Varley 1988).

The persistence of a population is a function of mortality, growth, and reproduction. A fundamental concept in fisheries management is that if harvest exceeds the ability of the population to replace itself, the population will collapse (Van den Avyle and Hayward 1999). Fisheries management often focuses on regulating harvest by limitations on either gear or the number of fish that can be removed. These same concepts can be used to predict the levels of harvest required to intentionally collapse a fish population. A basic assumption behind LKT

suppression is that if fish populations in more vast and complex ecosystems can inadvertently be collapsed by over-exploitation, the same could be deliberately accomplished in simpler and smaller systems such as Yellowstone Lake.

In order for any population to persist, each individual must produce, on average, one viable offspring before it dies. This would result in a population growth rate of 1.0 (replacement value). If individuals produce more than one viable offspring on average prior to their death, the population growth rate will be greater than 1.0. The goal of suppression is to average fewer than one offspring produced per individual, resulting in a population growth rate less than 1.0 and a declining population. When individuals are removed from the population prior to reproducing replacements, unsustainably high levels of harvest occur and the population collapses. Fishery managers frequently refer to this as “recruit overfishing.” A mortality rate of 0.5 (50%) or a yield of 0.5 kg/ha have been considered unsustainable in native LKT fisheries (Healey 1978). Population modeling demonstrates that more intensive fishing pressure would hasten the collapse of a LKT population (Eby and Syslo 2007; Syslo 2010).

Lake trout populations in relatively unproductive lakes exhibit slow growth rates and reach sexual maturity as late as 12 or 15 years (Martin and Olver 1980; Dux 2005). Population modeling suggests such populations would be highly vulnerable to recruit overfishing that led to relatively rapid a population collapse (Dux 2005). However, recruit overfishing has often occurred on more productive and larger bodies of water with species that mature at younger ages. For example, Selgeby (1982) described the collapse of the lake herring (*Coregonus artedii*) population in the Wisconsin waters of Lake Superior as a result of recruit overfishing of spawning adults.

Hansen (1999) attributed the collapse of several stocks of LKT in Lake Michigan, Lake Superior, and Lake Huron to commercial overharvest. As fishing effort increased in each of these lakes, a collapse of the lake’s LKT population followed. Despite the large size of these lakes and the complexity of their fish communities, LKT were eventually eliminated from all of the Laurentian Great Lakes except Lake Superior, where LKT numbers were greatly reduced (Hansen 1999).

By targeting the older, more reproductive individuals in a population, it may be feasible to both reduce population abundance and significantly alter the population’s reproductive potential. Recent studies of maternal influence on population dynamics concluded that populations with higher proportions of older females have higher growth rates than do populations with more, younger females (Birkeland and Dayton 2005; Venturelli et al. 2010). Venturelli et al. (2010) modeled population dynamics in which harvest targeted juvenile, adult, or both juvenile and adult walleye in Lake Erie. Juvenile survival increased with increased egg size, egg quality, and other factors related to the increasing age of the females. However, if harvest reduced the females’ mean age, the population’s reproductive potential was also be reduced. Birkeland and Dayton (2005) reported similar results in black rockfish (*Sebastes melanops*s). Both examples recommended protecting older fish in order to preserve the resiliency and reproductive potential of the population. Suppression of a non-native species should therefore focus removal on the oldest individuals in the population in order to reduce the mean age of mature females, the population’s intrinsic growth rate, and ultimately the size of the population.

Recent research also suggests that decreasing egg and larvae survival would be a valuable addition to efforts to reduce LKT abundance. Eby and Syslo (2007) demonstrated that, although

reducing adult numbers would produce a relatively large reduction in a LKT population, the combination of both egg and adult removals would substantially increase the rate of population decline.

A.6 Lake Trout Suppression in Other Western Lakes

Martinez et al. (2009) summarized fishery management issues involving LKT in 15 lakes and 3 reservoirs throughout the western United States, including lakes in California, Idaho, Montana, Utah, Washington, and Wyoming, and reservoirs in Colorado and Wyoming/Utah. The vulnerability of native species to predation from or competition with LKT has caused several management agencies to investigate or implement methods to control LKT populations. Even in lakes and reservoirs where they are not considered an invasive species and are managed as a trophy sport fish, LKT can become over-abundant, warranting some level of suppression to keep them from depleting their prey (Deleray et al. 1999; Johnson and Martinez 2000; Martinez et al. 2009).

The invasive impacts of LKT can be divided into three main categories: declines in native bull trout (*Salvelinus confluentus*) because of competition with LKT (Donald and Alger 1993; Fredenberg 2002); declines in native cutthroat trout subspecies primarily because of LKT predation; and declines in other desirable non-native species, primarily because of LKT predation (Martinez et al. 2009). Active LKT suppression is currently being carried out in Idaho on Lake Pend Oreille and Upper Priest Lake, in Montana on Swan and Quartz lakes, in Wyoming on Yellowstone Lake, and in Colorado at Blue Mesa Reservoir (Martinez et al. 2009). At present, LKT suppression in Lake Pend Oreille appears to be the most successful (Wahl et al. 2010), although the results in Swan Lake and preliminary information from Quartz Lake are encouraging (Rosenthal and Fredenberg 2010; Muhfield and Fredenberg 2009).

LKT have been in Lake Pend Oreille since the 1920s (Vidergar 2000), but only recently showed population growth that caused concern (Hansen 2007; Hansen et al. 2010). The establishment of opossum shrimp, a prey item believed to have increased the survival of juvenile LKT, apparently gave that population the added boost to expand (Stafford et al. 2002; Hansen et al. 2010; Martinez et al. 2009). To restore the lake's valued kokanee sport fishery, as well as reduce competition with native bull trout (protected under the Endangered Species Act) and introduced Gerrard rainbow trout (i.e., Kamloops), Idaho Fish and Game has undertaken an aggressive LKT suppression program. Using a combination of commercial-scale gillnetting and trapnetting along with angler incentive programs, recent data suggest that LKT size and numbers are both declining. The kokanee population has shown signs of recovery, with the percentage of juvenile fish surviving from age 1 to age 2 increasing from 10% in 2007 to 75% in 2009, and adult numbers showing a 10-fold increase from 2008 to 2009 (Idaho Department of Fish and Game 2010).

Swan Lake has only recently been invaded by LKT (detected in 1998), but population expansion is considered a threat to native bull trout in that lake and lakes upstream in the watershed (Cox 2010; Rosenthal and Fredenberg 2010). The first two years of a three-year experimental LKT suppression program initiated at Swan Lake in 2009 are encouraging (Rosenthal and Fredenberg 2010). An estimated 4,850 LKT had to be removed in 2009 in order to achieve a 50% mortality rate; 5,213 LKT were actually removed via contracted netting (Healey 1978; Rosenthal and Fredenberg 2010). In 2010, over 10,000 additional LKT, primarily juveniles, were removed (Frendenberg, US Fish and Wildlife Service, personal communication).

A.7 Lake Trout Suppression in Yellowstone Lake

A.7.1 Suppression Effort Required

A total mortality rate of 0.5 is widely accepted as sufficient to collapse a LKT population (Healey 1978). Netting to suppress LKT in Yellowstone Lake in 2007 caused an estimated fishing mortality rate of 0.22 (Syslo 2010). Fishing mortality is not entirely intuitive because natural mortality and juvenile recruitment also influence population abundance. Population growth rate (with replacement value, or stability = 1.0) provides an additional, perhaps simpler metric to help understand fishing mortality. Despite the 2007 fishing mortality rate of 0.22, the LKT population was projected to increase at an estimated rate of 1.08, which would result in a doubling of abundance every nine years (Syslo 2010). To reduce the population by 50% within 10 years, the suppression effort would need to be increased 2.7-fold over that exerted in 2007 (Syslo 2010).

Using the 2007 LKT catch data and population metrics, Syslo (2010) compared the current suppression effort and expected population growth rates with fishing mortality rates ranging from 0.0 to 0.7 in 0.05 increments. When juvenile survival was assumed to be equal to values reported for LKT across its native range and the fishing mortality rate was sustained for 10 years, Syslo (2010) predicted decreases in the LKT population using the following equation:

$$y = -0.9884m + 1.3004,$$

where y = population growth rate and m = fishing mortality for LKT in Yellowstone Lake.

Using the 2007 estimates for fishing mortality and estimated population growth, Syslo (2010) estimated the fishing mortality required to achieve reductions in the Yellowstone Lake LKT population (fig. A-1).

Projected lake trout abundance in Yellowstone Lake with varying levels of suppression effort based on levels of conditional interval fishing mortality obtained from recent Yellowstone Lake lake trout population modeling, assuming suppression lasts for 10 years and juvenile lake trout survival is equal to published values (Syslo 2010)

Based on NPS 2007 lake trout suppression data, Syslo's (2010) work, and an assumption that suppression would continue for 20 years, changes in LKT abundance with given changes in suppression effort were projected (table A-1, fig. A-2). Preliminary results from a pilot study initiated in 2009 suggested that contract netters would have success with suppression similar to that of the NPS crew. Contract netters and the NPS crew had essentially the same LKT

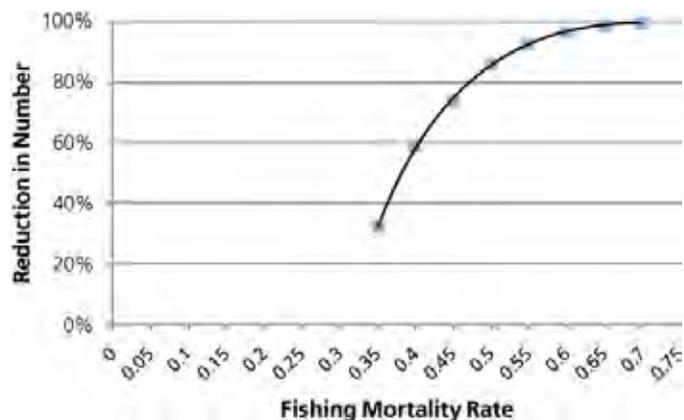


Figure A-1. Predicted reduction in numbers, using a population matrix model based on lake trout data from Yellowstone Lake, Wyoming, 2007 (Syslo 2010). Estimates assumed suppression effort would be sustained for a 10-year period and juvenile survival was equal to values in the published literature (Syslo 2010).

catch rate during a three-week period in June 2009. It was therefore assumed that a contracted crew would be able to achieve a fishing mortality rate of 0.11 for 10 weeks and 0.225 for 20 weeks. Assumed that the NPS fishing mortality rate stayed at 0.225 for the season (the calculated rate for NPS effort in 2007; Syslo 2010), the combined fishing mortality would be 0.33 with 10 weeks of contract netting, and increase to 0.45 with an additional 10 weeks of contract netting.

Table A-1. Projected amount of Suppression Effort

	Total Gillnet Effort for Season	Predicted Fishing Mortality Rate	Predicted Resultant Population Growth Rate
NPS crew only	2,800 km effort	0.225	1.08
NPS crew and contract crew for 10 weeks	3,900 km effort	0.300	1.00
NPS crew and full-season contract crew	5,600 km effort	0.450	0.86
NPS crew and 2 full-season contract crews	7,000 km effort	0.560	0.75

Fishing mortality of LKT has increased linearly with increased effort over the past several years (Syslo 2010), but at some point additional effort will begin to yield diminishing returns as LKT numbers are thinned. Although that point cannot be determined from these projections, it is assumed that it would be somewhere between a doubling and tripling of the suppression effort. Syslo (2010) suggested that, with a population growth rate of 1.0, a LKT mortality rate of 0.30 was required to hold the population at its current level. Based on previous experience, this level of mortality could be achieved by adding 10 weeks of contract netting to the 2007 NPS level of

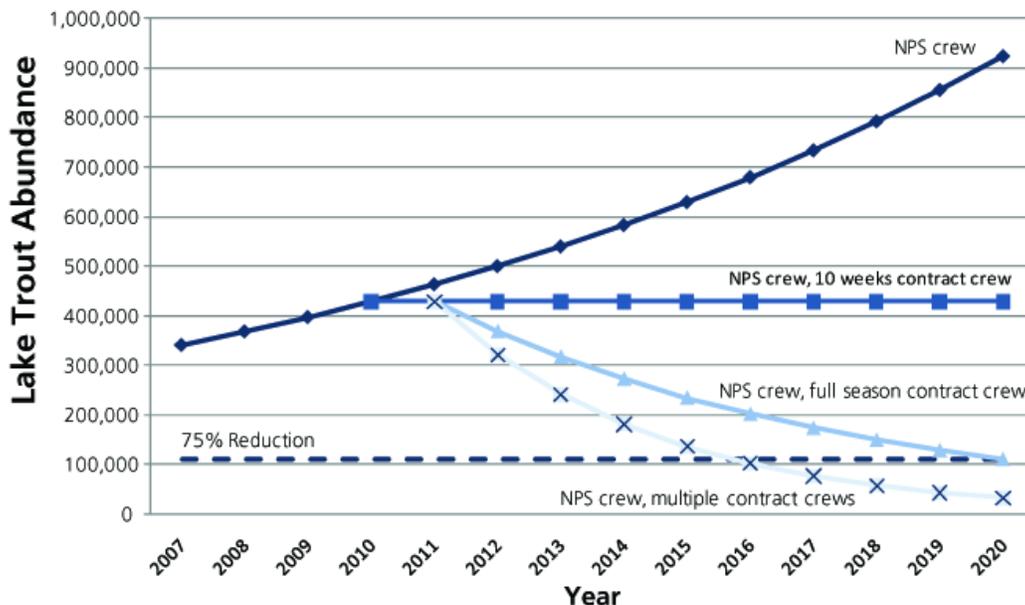


Figure A-2. Projected lake trout abundance in Yellowstone Lake with varying levels of suppression effort using gillnetting. Projections are based on levels of m (where m =conditional interval fishing mortality) obtained from recent Yellowstone Lake lake trout population modeling, assuming suppression lasts for 10 years and juvenile lake trout survival is equal to published values (Syslo 2010). Values for population growth rate are estimates of levels achievable with NPS crew (estimated total of 2,800 km of gillnet fished for the season). NPS crew augmented by 10 weeks of contracted suppression (estimated total of 3,900 km of gillnet fished for the season). NPS crew augmented by a full season of contracted suppression (NPS, contract crew full season; estimated total of 5,600 km of gillnet fished for the season), and NPS crew augmented by two contract crews working the full season (NPS, multiple contract crews; estimated total of 7,000 km gillnet fished for the season). The dashed line represents estimated target of 75% reduction in abundance level.

effort. Similarly, it was assumed that doubling the contract netting effort to 20 weeks would double the mortality rate to 0.45 with a predicted population growth rate of 0.86; tripling the effort would increase the mortality rate by 0.56 with a predicted population growth rate of 0.75 (fig. A-2). This modeling illustrates that increasing the mortality rate reduces the population size in a shorter timeframe.

A.7.2 Most Recent NPS Removal Efforts

Recent removal efforts have relied on the use of gillnets and intensified through 2007 (Koel et al. 2005; Koel et al. 2010), when more than 74,000 LKT were removed from Yellowstone Lake. However, removal efforts have decreased along with available resources in recent years (fig. A-3) as LKT numbers have continued to increase. As LKT catch rates in gillnets increase, the time to process the nets increases, necessitating an overall reduction in effort. Nonetheless, 10-20 km of gillnet were in place fishing for LKT on a typical day from June to September during removal operations on Yellowstone Lake from June to September, 2002–2009. Catch has improved as NPS staff gain knowledge about seasonal LKT distribution patterns, enhancing the ability to target LKT while avoiding by-catch of native YCT (Koel et al. 2010). Unfortunately, not all of the increased catch can be attributed to increased efficiency. Population modeling suggests that the LKT population had a growth rate of 1.08 in 2007 (Syslo 2010) despite NPS increased efficiency.

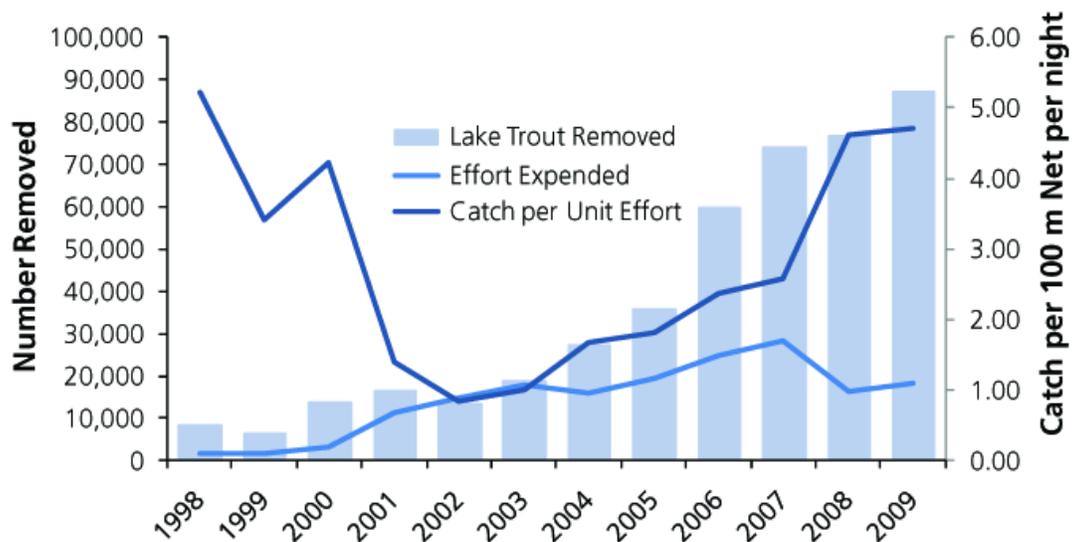


Figure A-3. NPS Lake Trout Suppression Efforts. Yellowstone National Park lake trout suppression numbers for lake trout removed, effort expended, and catch per unit of effort, where effort is equal to 100 m of gillnet fishing for one night, 1998 through 2009.

Most of the effort has been directed at LKT that are 200-450 mm total length. These fish reside in deeper water than do most YCT, making them an easy target for gillnets while minimizing the YCT by-catch. Larger LKT tend to be less vulnerable to gillnets and are often found in shallower depths where the YCT by-catch is unacceptably high. However, mature LKT become more vulnerable to gillnetting from late August until early October, when they exhibit increased movements and congregate in preparation for spawning. This time of year is a prime time to target mature LKT without netting unacceptable numbers of YCT.

Approximate locations of five areas suspected as spawning sites or travel corridors to spawning sites in Yellowstone Lake have been identified (fig. A-4):

1. adjacent to Carrington Island
2. northeast of West Thumb geyser basin
3. south-central portion of Breeze Channel
4. west of the mouth of Solution Creek
5. mouth of Flat Mountain Arm.

These areas have been targeted during spawning seasons to exploit the increased movement and aggregations of LKT preparing to spawn. In 2009, approximately 15% of the total number of LKT removed was captured by focusing on these areas during the spawning season (Yellowstone National Park, unpublished data). Despite control efforts, however, large numbers of LKT remain in Yellowstone Lake, and the population continues to expand (Gresswell 2009), as indicated by the increasing catch and catch per unit effort of LKT (fig. A-3) and by recent modeling of this population (Syslo 2010).

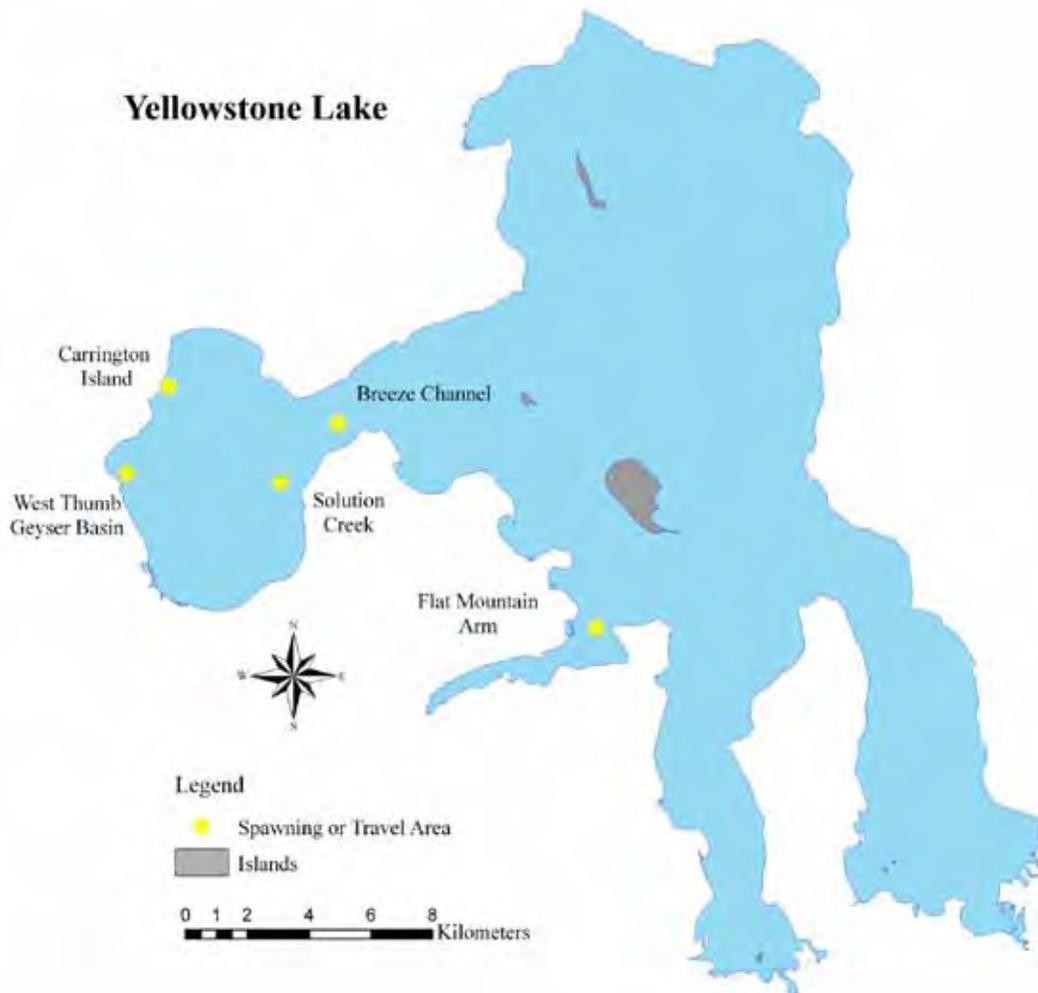


Figure A-4. Yellowstone Lake with prime areas targeted during spawner netting, mid August through early October: Carrington Island, West Thumb geyser basin, Solution Creek, Breeze Channel, and Flat Mountain Arm.

A.7.3 Contracted Lake Trout Suppression

Preliminary results from the 2009 contract netting suggested contractors could accomplish at least as much as NPS netters. In the three-week 2009 netting period, they netted 14,429 LKT from the population. They fished a combination of small (25, 32, and 38 mm bar) and large (44, 51, 57, and 64 mm bar) mesh gillnets. The largest catches were of the smaller fish entangled in the small mesh (11,469 LKT; fig. A-5); however, catches were also high for the large mesh (2,960 LKT). productive

Although catch rates are consistently higher in the smaller mesh sizes, it is the larger fish that actively prey on YCT and reproduce, necessitating their removal. It appears possible to lower overall population reproductive potential and predation by targeting the older, faster growing fish (Birkeland and Dayton 2005; Walsh et al. 2005; Venturelli et al. 2010). Based on the 2009 results, it appears that the commercial techniques used were more efficient at capturing the larger fish than were NPS methods. The contractors' boat configuration and operator experience allowed the gillnets to be placed in a much more intricate and advantageous pattern than is feasible in NPS operations. This did not appear to be important when targeting the smaller fish, but preliminary results suggest it was more effective at entangling the larger LKT.

Large, deep-water trapnets have proven successful at targeting LKT in commercial fisheries in the Laurentian Great Lakes (Hansen et al. 2007). It is live-entrapment gear, meaning that nearly

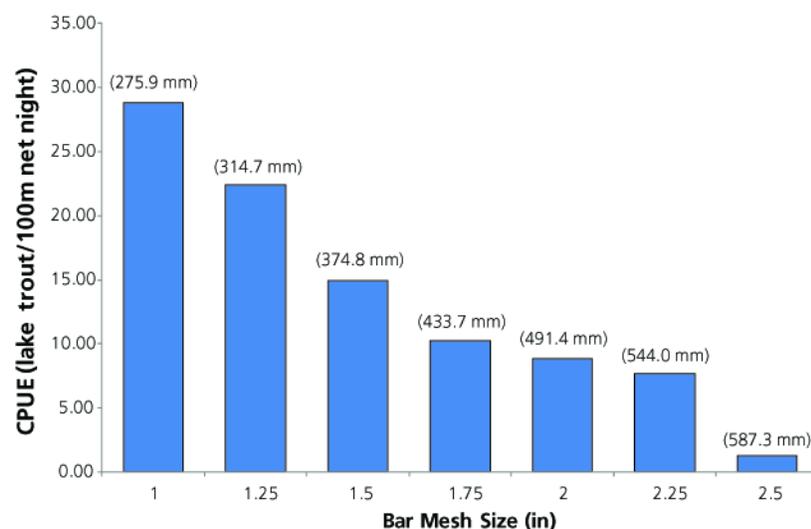


Figure A-5. Catch per unit effort (CPUE) of lake trout in contract netters gillnets, spring 2009. Mean length for each mesh size is reported in parentheses above the related bar.

all fish captured are captured alive and non-target species can be released unharmed (Copes and McComb 1992). The Idaho Department of Fish and Game has had success targeting larger LKT (>520 mm total length) on Lake Pend Oreille in northern Idaho with this type of gear (Peterson and Maiolie 2005; Hansen et al. 2007). Although trapnetting alone is not likely to significantly suppress a LKT population, it could substantially contribute to the success of removal efforts in combination with gillnetting and angler harvest (Hansen et al. 2007).

A.7.4 New and Experimental Techniques

New suppression methods are being researched and, if proven effective and feasible, could be incorporated into Yellowstone's suppression program. A detailed literature review examining methods to suppress fish populations in lake systems (Gross 2009) led to investigations into the use of carbon dioxide, electricity, seismic technology, light radiation, and suction to destroy eggs

and embryos at spawning sites (<http://www.nrmssc.usgs.gov/staff/jgross/research>) that may be used in future LKT suppression efforts.

Other potential technologies to combat invasive LKT include the use of piscicides to destroy eggs and embryos at the spawning sites (see Appendix B), trapping and removing young-of-the-year LKT as they leave the spawning sites, use of attractants to concentrate LKT for more efficient removal, and use of remote sensing equipment, such as telemetry (Dux 2005; Wahl et al. 2010), hydroacoustics (Warner et al. 2009), or LiDAR (Shaw et al. 2008), to monitor LKT distribution and more efficiently target adults.

A boat-mounted electrofisher has been used on a limited scale to remove congregations of adults at spawning areas. This has proven highly effective at the Carrington Island spawning site in the West Thumb basin of Yellowstone Lake because of its shallow depth (fig. A-4). However, this technique as presently applied is not effective in spawning areas deeper than 2 m. Another drawback of this technique is that LKT come into the shallow areas after dark to spawn, increasing the safety risks to staff operating the boat and electrofishing gear. Future research and adequate safety precautions could overcome both of these difficulties.

A.8 Conclusions

LKT eradication or at least significant suppression is key to native species restoration in Yellowstone Lake. Without the suppression program, the native YCT are likely to be reduced to even lower abundance levels than the record lows currently being documented. However, Yellowstone Lake is a relatively simple ecosystem, with only three fish species larger than minnows: LKT, YCT, and longnose suckers (*Catostomus catostomus*). Suppression efforts are not complicated by incidental catch of abundant prey species or species listed under the Endangered Species Act, both of which would require special handling and increased work load. Given the demonstrated human ability to over-fish stocks and unintentionally cause them to collapse, a panel of 15 fishery biologists and scientists convened to examine LKT suppression on Yellowstone Lake concluded that with the appropriate amount of effort, it should be feasible to collapse the LKT population in Yellowstone Lake. (See chapter 1 for more details on the panel's conclusions and recommendations; Gresswell 2009). Similar work at Lake Pend Oreille in Idaho has shown progress in suppressing the LKT population, and a concurrent rebound in the kokanee population has been verified (Wahl et al. 2010). Early results from an experimental LKT removal program in Swan Lake are also encouraging (Rosenthal and Fredenberg 2010).

Future plans for LKT suppression in Yellowstone Lake will be based on the outcome of this environmental assessment. Chapter 2 presents four alternatives for a suppression program. Monitoring and evaluation are a part of each alternative so that future decisions will be informed and based on information gained from previous actions and from investigations conducted by colleagues in other ecosystems where LKT suppression is a management objective.

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Appendix B: Methods for Removal of Non-native Fish

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B.1 Abstract

Creating secure habitats for the conservation of native inland salmonids has become a common fisheries management practice in recent years. Most commonly, the goals of these efforts are to restore and preserve native fish biodiversity through the exclusion and removal of non-native fish and reintroduction of genetically unaltered native species. The need for projects of this nature is largely driven by competition, predation, and/or hybridization by non-native fish; however, other factors including habitat alteration, disease, and global climate change may also contribute to the need for action. A common project model that has evolved and become widely used follows three basic steps: (1) ensure isolation of the project area, (2) completely remove all non-native species, and (3) re-introduce genetically unaltered native species. The body of scientific information that has accrued around this model, conventional wisdom, and on-the-ground experience are used to carry out the project. The purpose of this document is to review the history and science of non-native fish removal for native inland salmonid restoration as it pertains to Yellowstone’s Native Fish Conservation Plan/Environmental Assessment.

B.2 Introduction

The National Park Service proposes to implement a Native Fish Conservation Plan that uses conventional approaches to remove non-native fish in order to restore genetically unaltered native inland salmonid populations and increase their likelihood of long-term persistence in the face of non-native species invasions, global climate change, and new pathogens. As part of the process for implementing this plan, the NPS has prepared an Environmental Assessment (EA) in compliance with the National Environmental Policy Act. The EA is designed to gather public input, incorporate it into the decision-making process, and define the proposed actions and their environmental consequences. This appendix is designed to provide a thorough review of the scientific literature on non-native fish removal for actions proposed in rivers, streams, and lakes other than Yellowstone Lake. However, some of this information is pertinent to proposed actions on Yellowstone Lake as well. Peer-reviewed scientific literature, state and federal government technical reports, and ecological and human health risk analyses were among the many sources used in compiling this document; the references cited and other sources of pertinent information are listed in the EA section on “Literature Cited.”

B.3 Non-native Fish Removal

Eliminating the competition, predation, and hybridization pressure of non-native fish on native populations is often the most difficult and controversial aspect of native inland salmonid conservation. It usually requires the complete eradication of all existing fish fauna from the project area prior to reintroduction of the native species. Complete removal is necessary to ensure that viable populations of non-native fish or individual fish harboring non-native genetic material do not persist. However, in instances where complete removal is not technically feasible, such as in Yellowstone Lake, or where a low level of non-native fish or genetic material is acceptable, near-complete removal may suffice. Three types of removal techniques are most commonly used (Wydoski and Wiley 1999):

1. Mechanical removal uses physical techniques such as electrofishing, gill or trap netting, weirs, or angling
2. Chemical removal uses piscicides (fish pesticides/toxicants) approved by the Environmental Protection Agency
3. Biological control introduces other organisms that are predatory, pathogenic, or otherwise detrimental to the non-native fish

Of the above methods, only mechanical and chemical removal are being considered in Yellowstone’s Native Fish Conservation Plan EA. The NPS has used both methods to conduct removals for salmonid management in the past, and both can be effective given the right conditions. As described below, each method has significant advantages and drawbacks.

B.3.1. Mechanical Removal of Non-native Fish

Wydoski and Wiley (1999) include barrier placement, manipulation of water level, netting and trapping, electrofishing, and installation of weirs as mechanical methods of controlling undesirable fish species. For our purposes, undesirable fish are non-native species that impede or pose a risk of impeding the ecosystem function of native fish or other aquatic organisms in a proposed conservation area. This portion of the document will discuss the use of weirs and

electrofishing as a means of mechanical fish removal; netting and trapping as a means of non-native fish removal is discussed extensively in Appendix A. (While Appendix A focuses on the removal of lake trout in Yellowstone Lake, comparable methods may be used to remove other fish species from smaller lakes.) Other methods of mechanical removal are not being considered by the EA unless discussed elsewhere.

The greatest advantage of mechanical removal over chemical removal is the ***ability to be selective in the fish being removed***. Mechanical methods, be they gillnets or trap nets, electrofishing, or fish weirs can take advantage of behavioral differences (spatial and temporal) among fish species to target non-native fish. Also, fish are often alive after capture with mechanical gears and can be sorted so that native fish are returned to the system and non-natives are removed. Another significant advantage of mechanical removal is the reduced impacts on non-target species such as the native fish, amphibians, or macroinvertebrates. While impacts to non-target species do occur from mechanical removal, they are generally more localized and less severe than with chemical removal techniques.

Mechanical removal is generally ***not useful for complete eradication*** of non-native fish from a large or complex system (lakes >10 acres, streams >2 miles). For example, Moore et al. (2005) reported that electrofishing is ineffective in streams greater than 6 m mean width and with more than four pools per km that are over 1 m in depth. Mechanical techniques, therefore, would not be useful for restoration of a cutthroat trout stream invaded by hybridizing RBT, because a single RBT missed and remaining in the system could be highly detrimental to the restored cutthroat trout population. Mechanical techniques can, however, be used to manage (suppress, control) non-hybridizing non-native species by limiting their abundance, distribution, and ability to reproduce. They have been successfully used for this purpose several times in small systems (Moore et al. 2005; Peterson et al. 2008; Shepard 2010) and have been used on Yellowstone Lake and other lakes in the Intermountain West to suppress LKT (Koel et al. 2005; Martinez et al. 2009). Overall, mechanical removal holds great value for limiting the influence and expansion of non-native fish (Peterson et al. 2008), especially in water bodies (such as Yellowstone Lake -see Appendix A) where the objective is to suppress/control a non-hybridizing non-native fish species (e.g. lake trout).

B.3.1.1. Electrofishing

The EPA defines electrofishing as the use of electric currents and electric fields to control fish movement and/or immobilize fish, allowing capture (EPA 2009). Electrofishing uses a gasoline generator or battery to produce electrical current that is applied to water in a metered fashion using an electrical control box. Fish caught within the electrical field are stunned and can then be netted. Electrofishing gear varies by habitat type, with back-pack units used on small streams, tow-barges on large streams and small rivers, rafts or boats on large rivers, and boats on lakes. Electrofishing is most effective in shallow waters and confined areas, and ineffective in open, large, or deep waters (Wydoski and Wiley 1999; Kulp and Moore 2000; Moore et al. 2005). In almost all cases the goal of electrofishing is the same: apply enough electricity to temporarily stun and capture as many fish as possible without causing injury or death to the fish. The captured fish are allowed to revive in a holding tank, after which they can be sorted by species and data collected from them.

Although injury to fish may occur, most fish survive properly conducted electrofishing (Hollender and Carline 1994; Kocovsky et al. 1997; Dwyer et al. 2001; Peterson et al. 2008). This method can be used to selectively remove non-native fish and return native fish to the wild. This

is often done when a native fish population and non-native and non-hybridizing fish coexist in the same stream. At Great Smoky Mountains National Park, the method has been used to remove rainbow trout (*Oncorhynchus mykiss*) from native brook trout (*Salvelinus fontinalis*) habitat (Kulp and Moore 2000; Moore et al. 2005), and various agencies have used it to remove brook trout from native cutthroat trout habitat in the West (Thompson and Rahel 1996; Koel et al. 2008; Shepard 2010). While complete eradication of the non-native species is often the goal, success has only been achieved a few times and at a great cost. Failures in these efforts are often attributed to project areas being too large or complex (Kulp and Moore 2000; Moore et al. 2005; Shepard 2010). The method is often used with substantial success to suppress the abundance and distribution of non-native fish (Peterson et al. 2008). In Yellowstone, brook trout have been successfully suppressed in Upper Soda Butte Creek since 2003 using electrofishing (Koel et al. 2008).

Electrofishing for non-native fish removal has several disadvantages. Multiple electrofishing treatments over several years have been required in cases where electrofishing has been successful at complete removal of non-native fish (Thompson and Rahel 1996; Shepard 2010). These electrofishing events are very labor intensive and come at considerable fiscal cost (Larson et al. 1986; Peterson et al. 2008; Shepard 2010). A 1997 review of removal techniques at Great Smoky Mountain National Park found that electrofishing was less cost-effective than other removal techniques (Kulp and Moore 2000). Electrofishing also causes some direct and indirect mortality to non-target fish; injuries to fish from electrofishing are not uncommon. In the repeated application of electrofishing for non-native fish removal, spinal injuries have been found to accumulate in non-target fish at significant levels (Kulp and Moore 2000; Peterson et al. 2008). There is evidence that longnose sucker population abundance has declined significantly as a result of repeated electrofishing (Kocovsky et al. 1997), but salmonid population level effects have not been demonstrated (Hollender and Carline 1994; Dwyer et al. 2001). Mortality and injuries can be reduced by lowering the electrical dosage applied during capture, but doing so reduces the efficiency of capture of non-native fish, potentially necessitating additional electrofishing treatments.

Electrofishing is also a size-biased sampling technique; larger fish are captured more efficiently and more likely to be injured severely (Kulp and Moore 2000; Peterson et al. 2008). Wydoski and Wiley (1999) noted that “a voltage gradient sufficient to control small fishes would narcotize, injure, or even kill larger fishes.” This implies that using sufficient power to capture small non-native fish may jeopardize larger native species. Amphibians are also susceptible to electrofishing and presumably electrofishing injury, although no literature could be found detailing the degree of impact. Similarly, aquatic invertebrates are susceptible to electrofishing but the impacts are not well known. Much as with fish, it is suspected that while individual amphibians and invertebrates may be injured or killed by electrofishing, population level effects, even from repeated exposure, are unlikely.

B.3.1.2. Weirs

For the purposes of this discussion, a fish weir is a fence-like structure that transects a stream channel at or near a perpendicular angle to flow. The purpose of a fish weir is to block the movement of fish up and/or down a stream while allowing the water to flow through the structure without significantly altering the character of the stream. The weir can be used to stop migration or to funnel fish into a trap where they can be collected. Weirs are temporary structures designed to operate at specific times of the year, usually during the spawning period. They can be designed so that they are impediments to upstream fish movement but not

downstream movement. For the purpose of this EA, the primary use for weirs would be to inhibit the access of non-native fish to spawning habitats and to collect fish so that non-natives could be sorted and removed. In this manner, weirs are a selective technique for managing non-native fish.

Weirs are most effective where fish inhabit a large river or lake and migrate to tributaries to spawn. The weirs are placed near the mouth of the spawning tributary and are thus encountered by fish making their way to spawning locations. In situations where non-native fish spawn at different times than do the native species of concern, weirs can be placed between foraging and spawning habitat to impede the access of non-native fish to places where they can reproduce. In situations where native and non-native fish have similar spawning timing, a weir can be placed that directs fish into a trap where fish can be collected and then sorted by species. Native species can then be manually passed over the weir to spawn and non-native fish can be removed. Either situation results in “selective passage” of native fish and exclusion of non-native fish.

While the goal of a weir is to impede fish passage to the greatest extent possible, a weir is usually not a complete barrier to fish movement. While small fish are often able to pass unimpeded, large fish may also sometimes pass the weir. This unintentional passage is usually due to constraints in weir construction and operation. For example, a weir may be designed to operate at normal water flows for a given stream, but not at flood water flows because construction of a structure large enough to function under flood conditions would significantly impact other resources. A weir may also be designed to “fail” if it becomes clogged with debris. This programmed failure is meant to prevent catastrophic damage to the weir and the stream banks. Regardless of the reason for failure, it is important that the use of weirs not be confused with the use of fish barriers. Weirs may be useful for reducing the abundance and limiting the expansion of non-native fish, but they are not reliable for complete exclusion of non-native fish.

The use of weirs does have some disadvantages. Weirs require a high degree of maintenance, i.e., removing obstructions, cleaning pickets of sediment and debris, and repairing minor damage. They also require installation of infrastructure and disassembly. They can cause alteration to the stream bank, either through the installation of the weir itself or by alteration of stream flow patterns. The degree to which a weir requires installation of infrastructure and maintenance is usually based on its intended longevity and efficiency (i.e., the degree to which the weir impedes fish migration). Generally, weirs that will be in place for many years, operate for long periods during the year, and aim for near total efficiency require considerable resources for installation, maintenance, and eventual disassembly. Shorter-term and/or less efficient weirs may be installed and maintained more easily.

Weirs that direct fish into a fish trap for later sorting and selective passage pose the same problem as other selective removal techniques: fish identification. Although identification of fish between separate species can be reliably performed by staff with a small amount of training, the identification of hybridized fish (rainbow trout × cutthroat trout hybrids) is much more difficult. Several studies have demonstrated that while accurate visual identification of hybridization at the population level is possible (Baumsteiger et al. 2005), identification of individual hybrid fish is much less reliable (Weigel et al. 2002; Kennedy et al. 2009; Seiler et al. 2009). Even modern genetic analysis, which is extremely reliable for detecting population level hybridization, is not a completely reliable means for detecting low levels of hybridization in individual fish (Campbell et al. 2002). Highly hybridized fish, those with many non-native

alleles, are easier to distinguish from genetically unaltered fish than are those with low levels of hybridization.

The species of fish may also affect the difficulty identifying hybridization. For example, westslope cutthroat trout (*Oncorhynchus clarki lewisi*) that are hybridized with rainbow trout may be easier to identify than westslope cutthroat trout that are hybridized with Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*). In any case, selective removal of fish, particularly hybrids, comes with the risk of both releasing some non-native or hybridized fish and removing some native fish. For this reason, selective removal is not considered a viable tool for complete restoration of genetically unaltered native fish populations where hybridization is present. It may, however, be a powerful tool in mitigating recent invasions where hybridized fish contain a high number of non-native genes.

B.3.2. Chemical Removal of Non-native Fish

Piscicides are chemical fish toxins that are applied to water with the intent of killing fish. As many as 30 chemicals have been used as piscicides in fisheries management since the 1930s (Finlayson et al. 2000). At present, only four chemicals are registered for use as piscicides by the EPA (table B-1), two of which are lampricides, designed specifically to control sea lampreys; the other two are general fish toxins (Wydoski and Wiley 1999), rotenone and antimycin A (hereafter antimycin), which are discussed below.

Table B-1. Chemicals Registered by the U.S. Environmental Protection Agency for Use as Piscicides

	Trade Name	Cas No.	EPA Reg. No.	Active Ingredient	Formulation Type	Manufacturer
General Piscicides	Antimycin A	1397-94-0		Antimycin A		
	Fintrol (Concentrate)		39096-2	Antimycin A	Liquid	Aquabiotics Corp.
	Rotenone	83-79-4		Rotenone		
	CFT Legumine		75338-2	Rotenone	Liquid	Prentiss Inc.
	Synpren-Fish		655-421	Rotenone	Liquid	Prentiss Inc.
	Prentiss Fish Toxicant Powder		655-691	Rotenone	Powder	Prentiss Inc.
Lampricides	Niclosamide	1420-04-8		Niclosamide		
	Clonitralid		774-01	Niclosamide		
	Bayer 73		217800	Niclosamide	Powder	
	Bay 70% wettable powder--mup		6704-89	Niclosamide	Powder	USFWS
	Bay 73 technical		6704-88	Niclosamide	Chemical Concentrate	USFWS
	Bayluscide 20%		6704-92	Niclosamide	Powder	USFWS
	Bayluscide 3.2%		6704-91	Niclosamide	Solid	USFWS
	Bayluscide 70%		75394-1	Niclosamide	Powder	B.I. Mitchell, Inc.
	Bayluscide 70%-- sea lamprey larvicide		6704-87	Niclosamide	Powder	USFWS
	3-trifluoromethyl-4-nitrophenol (TFM)	88-30-2		TFM		
	TFM bar		6704-86	TFM	Solid	USFWS
TFM-hp sea lamprey larvicide (lamprecid)		6704-45	TFM	Liquid Concentrate	USFWS	

Denotes chemical (not product)

B.3.2.1. Piscicide Action

The two EPA-approved piscicides proposed for use in this EA both function in the same manner. The piscicide enters the fish's body through the gills where it is transferred directly into the blood stream (Wydoski and Wiley 1999; Ling 2003). This mode of exposure contributes

greatly to the toxicity of the chemicals. Antimycin and rotenone interfere with cellular respiration during the electron transport chain, inhibiting the cells' ability to make energy (Fukami et al. 1969; Quintanilha and Packer 1977; Finlayson et al. 2000; Durkin 2008). After prolonged exposure, this interruption of cellular respiration kills fish in treated waters. While the specific action of each chemical is slightly different, the result is the same. Rotenone, also known as Tubotoxine or Derris Powder ($C_{23}H_{22}O_6$; NIOSH 2000; Rayner and Creese 2006), uncouples oxidative phosphorylation at complex I of the electron transport chain. Antimycin ($C_{28}H_{40}N_2O_9$), a much more recently discovered piscicide, interferes at complex III, as shown in Figure B-1 (Quintanilha and Packer 1977; EPA 2007a; EPA 2007b; Vinson et al. 2010). Because of its greater availability, rotenone is now the most widely used piscicide (Finlayson et al. 2000; Rowe 2003).

All fish species are susceptible to the proposed piscicides (EPA 2007b). However, the resistance of fish to piscicide does vary widely by species (table B-2), and in some situations the degree of resistance can be exploited to produce species-selective removals (Leonard 1939). This is most commonly done in catfish culture where antimycin doses that are sub-lethal to catfish are applied to culture ponds to remove more susceptible "rough fish" species (Moore et al. 2008). Given the current fish assemblage in Yellowstone, and the fact that trout are among the most sensitive fish species to EPA-approved piscicides (Grisak et al. 2007), selective removal using piscicide would not be practical. That means that if piscicide were applied in accordance with this EA the result would be complete eradication of all fish present in the project area.

Electron Transport Chain

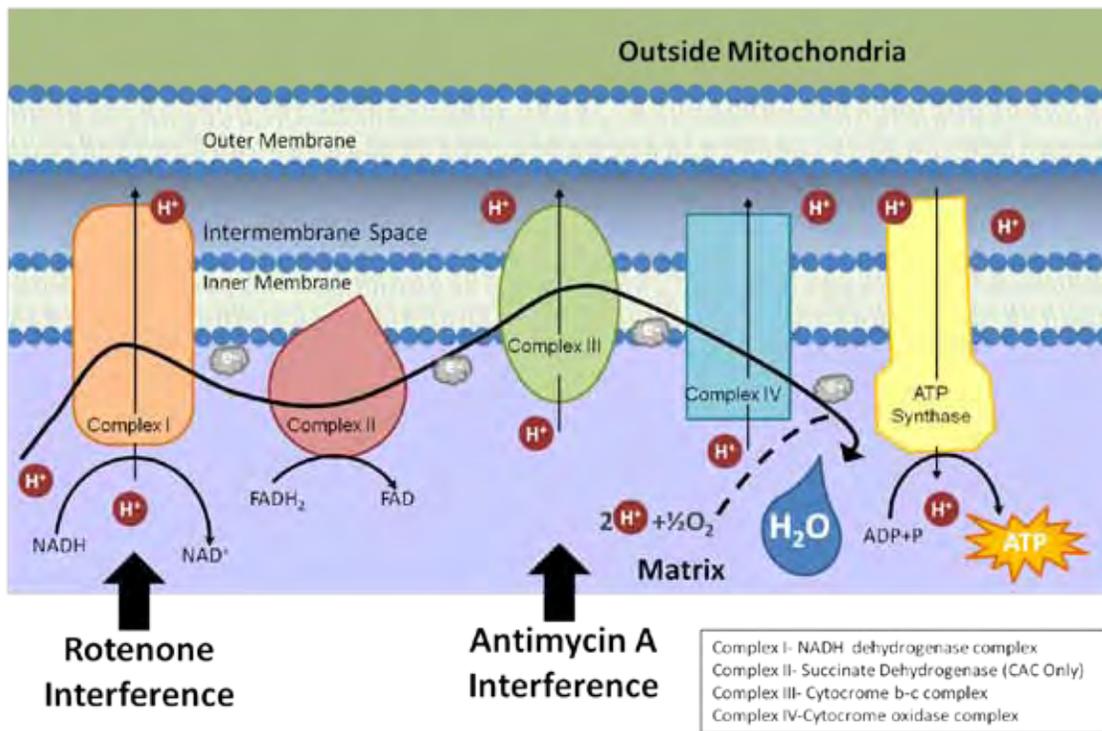


Figure B-1. Locations of piscicidal interference in cellular respiration in the electron transport chain; Complex I for rotenone and II for antimycin. (Adapted from Quintanilha, A.T. and L. Packer, 1977, Surface localization of sites of reduction of nitrox.)

Table B-2. Fish Response to Piscicide

Species (common name)	LC ₅₀ at 96h		
	Rotenone	Antimycin	KMnO4
Lake trout	1.345	0.05	
Rainbow trout	2.3	0.012	1,220–1,800
Longnose sucker	2.85	0.03	—
Coho salmon	3.1	0.01	—
Yellow perch	3.5	0.04	—
Fathead minnow	7.1	0.025	—
Bluegill	7.05	0.03	2,300–3,600
Green sunfish	7.05	0.22	—
Largemouth bass	7.1	0.24	—
Channel catfish	8.2	1.36	750
Black bullhead	19.45	4.8	—
Goldfish	341.0	0.18	—
Striped bass	—	—	960–4920
Common carp	—	—	3,050–3,450

Table B-2. LC₅₀ of rotenone, antimycin, and potassium permanganate (ppb) at 96h as tested in a variety of fishes. (Adapted from Finlayson et al. 2000, Turner et al. 2007a, and Phillips et al. 2005.).

Origin of Piscicide

Antimycin and rotenone are both naturally occurring chemicals. Antimycin is a product of *Streptomyces* bacteria with fungicidal properties (Lennon 1970; Vinson et al. 2010), while rotenone is derived from the roots of numerous tropical plants from the bean (*Leguminosae*) family, (NIOSH 2000; Rayner and Creese 2006). Both are used in fisheries management to eradicate undesirable fish species, but have different origins.

Literary reference to the use of plant-derived piscicides dates back to Aristotle's *Historia Animalium*, in which he explains that the mullein plant placed in water will kill fish and noted that it was used as a fishing technique (Thompson 1910). By the early part of the 13th century, the use of many plant-derived chemicals on fish was outlawed in Europe (Wilhelm 1974). The earliest record of traditional fishing with rotenone were from Brazil in 1649 and North America in 1775 (Krumholz 1948). In both cases aboriginal peoples used rotenone-bearing plant materials to capture fish for consumption. Aboriginal societies have used rotenone for centuries, harvesting the chemical from the roots of legumes and applying it to localized areas as a form of subsistence fishing (Ball 1948; Ling 2003; Pellerin 2008). Rotenone was an effective way for traditional peoples to harvest fish as it poses little threat to human health through consumption (Betarbet et al. 2000; Robertson and Smith-Vaniz 2008).

Rotenone was first isolated as a chemical compound in 1929. Its name comes from the plant that it was originally identified in, the Peruvian plant rotenone (*Lonchocarpus sp.*), locally known as barbascos or cube (St. Onge 2002). In addition to its piscicidal use, rotenone has been used world-wide as a pesticide on crops and livestock for over 150 years. It was first registered by the EPA in 1947 (Ling 2003). Rotenone-based products have been available as a general use pesticide for residential pest control throughout the United States for decades; however, re-registration for this use is not being pursued (EPA 2007b). Fisheries managers began to value rotenone as a tool for eradication of undesirable fish species in the 1930s. In 1934, Michigan

became the first state where rotenone was applied to treat lakes and ponds (Lennon 1970). It wasn't until the 1960s that fisheries managers began to use it for reclamation projects on rivers and streams, but every state except Hawaii had used rotenone by 1974 (Finlayson et al. 2000; McClay 2000). Beyond today's modern fisheries management uses, herbal fish toxins, including rotenone, are still used as a traditional fishing method by aboriginal peoples (Van Anandel 2000; Kamalkishor and Kulkarni 2009).

Antimycin was discovered in 1945 (EPA 2007a). Produced by many species of *Streptomyces* bacteria, antimycin forms naturally and also has fungicidal properties. It was registered as a Restricted Use Pesticide by the EPA (2007a) in 1960 and since then has been used solely as a piscicide. Of the three products with antimycin as the active ingredient that were originally registered by the EPA, only one, Fintrol, is currently on the market (Aquabiotics Inc., Vancouver, Washington) (Lennon 1970; EPA 2007a; Vinson et al. 2010).

Piscicide Use

In almost all cases, the application of piscicide is designed to kill fish. However, the specific objectives of piscicide applications vary widely and have changed over time. As mentioned above, aboriginal peoples have applied rotenone for hundreds of years to collect fish for consumption (Ball 1948, Krumholz 1948). The first application of rotenone in the U.S. fisheries management occurred in 1934 (McClay 2000), and the NPS used it for the first time in 1938, to remove yellow perch from Goose Lake in Yellowstone. In 1946, the NPS used rotenone to remove non-native suckers from Bear Lake in Rocky Mountain National Park (Barrows 1939; Field 1946). Since then, piscicides have been used extensively in national parks to meet inland salmonid management goals (table B-3). In conventional fisheries management, piscicides are commonly used for reduction or elimination of undesirable fish and for quantifying fish populations (table B-4; McClay 2000; Robertson and Smith-Vaniz 2008; Vinson et al. 2010). While improvement of sportfish populations is sometimes the goal of piscicide use, it is not the proposed use in Yellowstone under this EA, which proposes to use piscicide only to restore imperiled native fish species through the eradication of non-native fish.

This EA proposes to use piscicide to completely remove non-native fish from isolated habitats and potentially reduce juvenile lake trout shortly after emergence from their spawning locations. Other than complete dewatering, piscicide application is the only way to completely eradicate fish populations, particularly in large or complex habitats (AFS 1985; Finlayson et al. 2000; Peterson et al. 2008). Several efforts to completely remove non-native fish populations from small streams via electrofishing have been effective (Moore et al. 2005; Peterson et al. 2008), as have gillnetting efforts in high mountain lakes (Vredenburg 2004), but the use of mechanical means to completely eradicate non-native fish from large or complex streams and lakes has not been successful (Moore and Larson 1989; Kulp and Moore 2000; Meyer et al. 2006). Piscicide applications, while not without their failures, have repeatedly been demonstrated to successfully remove entire non-native fish (see table B-3). One objective of this EA is to restore native fish populations to habitats large enough to resist extinction from stochastic events like wildfire and the long-term effects of global climate change, necessitating the use of piscicides as management tools. In situations where habitats are small and simple enough to make complete removal via mechanical means possible or where complete removal of all non-native fish is not required to meet the project objective, methods other than piscicides are being considered (table 8).

Table B-3. Piscicide Applications for Inland Salmonid Management in National Parks.

Year	National Park	Location	Piscicide (A=Antimycin R=Rotenone)	Species Removed	Goal	Barrier*	Success**
1938	Yellowstone	Goose Lake	R	Yellow perch	Enhance sportfishing (RBT)	N	Y
1946	Rocky Mountain	Bear Lake	R	Suckers	Restore native species	Y	?
1957	Great Smoky Mountains	Abrams Creek	R	Native fish	Enhance sportfishing	Y	N
1957	Great Smoky Mountains	Indian Creek	R	Native fish	Enhance sportfishing	Y	N
1958	Rocky Mountain	Caddis Lake	R	Non-native cutthroat	Restore native species (GBC)	N	Y
1965	Mt. Rainer	Tipsoo Lake	R	Non-native cutthroat	Restore native species	N	N
1965	Yosemite	Delaney Creek	R	BKT	Non-native introduction (PCT)	N	N
1966	Yosemite	Upper and Lower Skeleton Lakes	R	BKT	Non- native introduction (PCT)	N	N
1966	Glacier	Two Medicine Creek	R	Suckers	Enhance sportfishing (RBT)	N	Y
1973	Rocky Mountain	Hidden Valley Creek	A	BKT	Restore native species (GBC)	N	N
1975	Rocky Mountain	Bear Lake	A	BKT	Restore native species (GBC)	N	Y
1975	Yellowstone	Canyon Creek	A	BRN	Restore native species (GRY)	Y	N
1977	Yellowstone	Pocket Lake	A	BKT	Restore native species (YCT)	N	N
1978	Rocky Mountain	West Creek	A	BKT	Restore native species (GBC)	N	Y
1979	Rocky Mountain	Timber Lake and Creek	A	Non-native cutthroat	Restore native species (CRC)	N	Y
1979	Sequoia & Kings Canyon	Hidden Lake and Soda Springs Creek	A	BKT	Restore native species (GLT)	N	Y
1980	Rocky Mountain	Ouzel Lake and Creek	A	BKT	Restore native species (GBC)	N	N
1982	Rocky Mountain	Fern Lake and Creek	A	BKT	Restore native species (GBC)	N	Y
1983	Rocky Mountain	Lawn Lake and Roaring River	A	BKT	Restore native species (GBC)	N	Y
1985	Yellowstone	Arnica Creek	A	BKT	Restore native species (YCT)	N	Y
1985	Rocky Mountain	Bench Lake and Ptarmigan Creek	A	Non-native cutthroat	Restore native species (CRC)	N	Y
1986	Rocky Mountain	North Fork Big Thompson River, Lake Husted and Lost Lake	A	BKT	Restore native species (GBC)	N	O
1986	Mt. Rainer	Tipsoo Lake	A	RBT	Restore native species	N	N
1987	Pictured Rocks	Spray Creek	R	BKT	Restore native species (GRY)	N	Y
1987	Pictured Rocks	Section 34 Creek	R	BKT	Restore native species (GRY)	N	Y
1987	Rocky Mountain	Lower Hutcheson Lake and	A	CTX	Restore native species (GBC)	N	Y

*Y indicates a barrier was constructed as part of the restoration project, *O indicates restoration work is ongoing.

Year	National Park	Location	Piscicide (A=Antimycin R=Rotenone)	Species Removed	Goal	Barrier*	Success**
		Cony Creek					
1988	Rocky Mountain	Pear Lake and Cony Creek	A	CTX	Restore native species (GBC)	N	Y
1988	Rocky Mountain	Sandbeach Lake	A	RBT	Restore native species (GBC)	N	Y
1990	Rocky Mountain	Spruce and Loomis Lake	A	RBT	Restore native species (GBC)	N	Y
1996	Rocky Mountain	Dream Lake	A	CTX	Restore native species (GBC)	N	Y
2000	Great Basin	Strawberry Creek	R	RBT, BKT	Restore native species (BCT)	N	Y
2000	Crater Lake	Sun Creek	A	BKT	Restore native species (BLT)	Y	Y
2000	Great Smoky Mountains	Sams Creek	A	RBT	Restore native species (BKT)	Y	Y
2002	Great Basin	Snake Creek	A	BKT	Restore native species (BCT)	N	Y
2003	Great Smoky Mountains	Bear Creek	A	RBT	Restore native species (BKT)	Y	Y
2004	Great Basin	Johnson Lake	A	BKT	Restore native species (BCT)	N	Y
2005	Great Smoky Mountains	Indian Flats Prong	A	Hatchery BKT	Restore native species (BKT)	Y	Y
2006	Yellowstone	High Lake	R	CTX	Restore native species (WCT)	N	Y
2008	Great Smoky Mountains	Lynn Camp Prong	A	RBT	Restore native species (BKT)	Y	O
2008	Yellowstone	Specimen Creek	R	CTX	Restore native species (WCT)	Y	Y
2009	North Cascades	Middle and Lower Blum Lake	A	BKT	Restore native species (BLT)	N	O

Table B-3. Piscicide applications for inland salmonid management in national parks. Sources of information: Barrows 1939, BSWF 1966, USFWS 1977, Gresswell 1991, Buktenica 2000, Vredenburg 2004, Moore et al. 2005, Koel et al. 2007, Baker et al. 2008, Glesne and Rawnhouser 2009, Koel et al. 2010, M. Kulp pers. comm. 2010, D. Boiano pers. comm. 2010, C. Downs pers. comm. 2010. Arctic grayling (GRY), Bonneville cutthroat trout (BCT), Brook trout (BKT), Brown trout (BRN) Colorado River cutthroat trout (CRC), Cutthroat hybrids (CTX), Golden trout (GLT), Greenback cutthroat trout (GBC), Piute cutthroat trout (PCT), Rainbow trout (RBT), Westslope cutthroat trout (WCT), Yellowstone cutthroat trout (YCT).

Table B-4. Common Uses of Piscicide in Conventional Fisheries Management

Piscicide Use	Proposed use in Yellowstone
Control of undesirable fish (improve sport fishing)	No
Eradication of fish in rearing facilities	No
Quantification of fish population (sampling)	No
Treatment of drainages prior to impoundment	No
Eradication of fish to control disease	No
Restoration of threatened or endangered species	Yes
Eradication of harmful exotic fish	Yes

Table B-4. Common uses of piscicide in conventional fisheries management (modified from McClay 2000) and proposed uses of piscicides under the Native Fish Conservation Plan.

Piscicide Application

Piscicides are applied through a wide variety of methods depending on the type of water body, piscicide formulation, location, and applicator discretion. Because the spectrum of application methods is extremely broad and methods have changed as technologies have improved, the discussion here is limited to those methods relevant to this EA. Methods not discussed here, such as application from aircraft (Bonneville Power Administration 2005), are not being considered. All proposed methods would be carried out in a manner that strictly adheres to practices permitted by the product labeling, including use of personal protective equipment (PPE) for applicators, controlling public access, determining the maximum necessary application concentrations, and all other applicable guidelines (Appendix D). Both antimycin and rotenone have undergone re-registration by the EPA and when new labels are published following completion of that process, the NPS will immediately adopt all new standards and procedures set forth by the EPA.

Application to lakes is most often accomplished via motorized boat, from which the piscicide is applied as a diluted liquid formulation or a powdered piscicide (rotenone only) is mixed with water to form a slurry and pumped into the lake. The product labels provide guidance on the degree to which piscicides must be diluted prior to application (Appendix D). When applied via motor boat, piscicides are applied below the surface of the water using a pump system. Specially designed Venturri pumps are often placed behind the propeller on the boat motor and generate sufficient vacuum to apply diluted piscicide from a holding tank. This system, which requires no moving parts or power system beyond the boat's motor, was used successfully to apply liquid rotenone to High Lake in Yellowstone in 2006 (Koel et al. 2007) and is the system most likely to be used if piscicides were applied to other small, shallow lakes in the park as proposed in this EA. In deeper lakes or lakes where the possibility of incomplete mixing due to a strong thermocline is a concern, diluted piscicide may be actively pumped to depth using electric pumps. In any case, the goal of piscicide application in lakes is to achieve even distribution of the chemical throughout the entire water column and littoral zone. Applying the piscicide sub-surface eliminates the possibility that the chemical may drift to adjacent terrestrial environments and greatly reduces the potential for unanticipated human or environmental exposure to the chemical. Concentrations of piscicides applied to lakes in the park would follow the products' "Normal Pond Use" guidelines.

Application to streams is most often accomplished through a series of metered dispensing stations placed at specified intervals along the stream's course. While designs for dispensation stations vary widely (USFWS 2005), they all work by either gravity or the use of a small electric pump, and they are all designed to discharge a constant, specified volume of piscicide into the stream. Most dispensation stations use an 18.9-l (5-gallon) reservoir to hold diluted piscicide and discharge at a rate of 40 ml/min for an 8-hour treatment or 80 ml/min for a 4-hour treatment. The dispensation rate can be altered to adjust treatment time. The amount of piscicide placed in the dispensation stations is determined by the desired application concentration and the volume of flow in the stream. So, while the volume of liquid in the reservoir usually does not vary, the concentration of piscicide in the reservoir is adjusted for each station. Stations are placed in secure and stable locations either on the stream bank or on a stand in the stream channel, and are actively monitored by project staff for the duration of the treatment. The drip nozzles of the stations are placed very close to the water's surface to reduce the potential for piscicide drift to terrestrial environments.

Because piscicide breaks down and loses its toxicity quickly in flowing water (Robertson and Smith-Vaniz 2008), drip stations must be placed at intervals along the stream to maintain concentrations lethal to target fish. Among the most significant of the many factors that degrade piscicide are sunlight (photolysis), water (hydrolysis), and physical disturbance (EPA 2007b, Robertson and Smith-Vaniz 2008, Brown 2010). The maximum possible interval between dispensation stations depends on the combined effect of these factors. Bioassays in which live fish in sentinel cages are observed during piscicide application would be used to determine the stream length that could be treated by one drip station. The NPS used this method, which is commonly employed for this purpose, for the piscicide treatment of East Fork Specimen Creek (EFSC). Water samples collected during that treatment demonstrated the rapid breakdown of rotenone in the natural environment (fig. B-2). The distance a drip station treats is measured in travel time, the distance water travels down a stream in a given amount of time. Application of non-toxic dye is used to determine travel time prior to treatment.

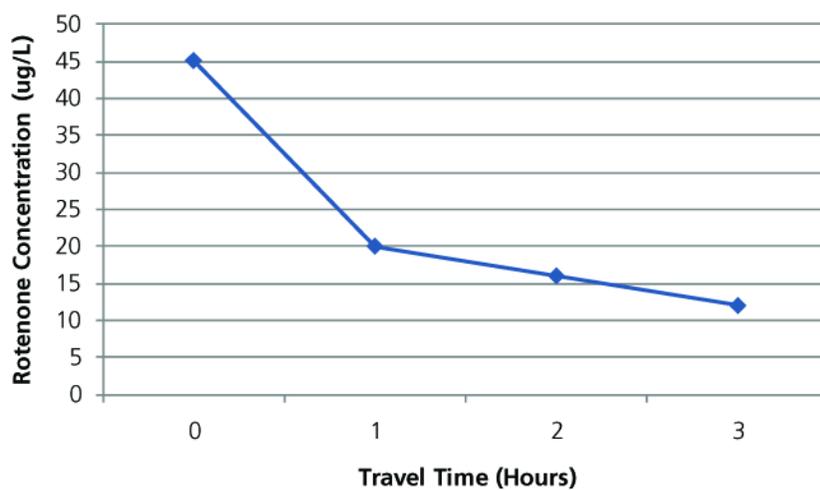


Figure B-2. Water samples collected during rotenone treatment on Specimen Creek demonstrated the rapid breakdown of rotenone in the natural environment. (Data collected by D. Skaar, Montana Fish, Wildlife and Parks.)

Most lake and stream systems contain springs and seeps that are constant sources of fresh ground water and can provide fish refuge from piscicide application, resulting in project failure if not treated properly. Application of liquid or powdered piscicide to the surface of springs has been demonstrated to be largely ineffective because only the surface of the spring is treated and not the source of the water. In 1990 the Utah Division of Wildlife Resources developed a mixture of rotenone, sand,

and gelatin that carries piscicide to the bottom of springs and effectively treats them for approximately 12 hours at concentrations lethal to fish (Spateholts and Lentsch 2001). This method was used in the treatment of High Lake and EFSC (Koel et al. 2007; Koel et al. 2008; Koel et al. 2010) and would be used in proposed piscicide projects to effectively treat springs and seeps.

Backpack sprayers with hand-held wands can also be used to apply highly diluted liquid piscicide. This method is used in backwater areas along streams and the littoral zones of lakes where mixing may be incomplete due to minimal water movement. It helps ensure that untreated refuges do not occur and minimizes the likelihood of project failure due to incomplete eradication. When applied from backpack sprayers, small amounts of piscicide are applied directly to the water surface by trained staff in a manner that minimizes drift onto terrestrial environments.

Piscicide Regulation

The EPA is the primary agency responsible for regulation of pesticides in the United States. Under the Federal Insecticide, Fungicide, and Rodenticide Act, the EPA is responsible for

ensuring that application of a pesticide does not present an unreasonable risk to human health or the environment (EPA 2010). It registers pesticides for specific uses and produces a label that specifies the requirements for application. These labels are legal documents and failure to follow the requirements constitutes a violation of federal law. While the states bear the primary authority for enforcement of pesticide use laws, the EPA shares the ability to prosecute violations (EPA 2010). The EPA also designates chemicals as general (for use by the general public without license) or restricted use (for use only by certified applicators).

Each state is responsible for registering pesticides for use within its boundaries, certifying applicators for application of restricted-use pesticides, and enforcing pesticide application laws. In Montana, Idaho, and Wyoming, this responsibility falls to the states' departments of agriculture, which have specific application certification exams for aquatic pest control and require continuing education courses to maintain aquatic pest control licenses. That means that an aquatic pesticide applicator must be specifically certified by the state in which the activity is to occur. The department of environmental quality in each of the three states requires that every piscicide application be specifically permitted prior to application. Additionally, all proposed applications of pesticides in national parks are reviewed through the NPS Pesticide Use Proposal process to ensure that they adhere to the NPS Integrated Pest Management policy.

The EPA also regulates the application of piscicide under the Clean Water Act (CWA), which requires a National Pollution Discharge Elimination System (NPDES) permit for the intentional point source discharge of a pollutant in water. In *Fairhurst v. Hagner*, the Ninth Federal Circuit Court held that pesticides applied directly to a lake in order to eliminate non-native fish, where there are no residues or unintended effects, are not "pollutants" under the CWA because they are not chemical wastes and therefore do not require an NPDES permit (9th Cir. 2005). However, more recent rulings have led the EPA to reconsider the intentional application of pesticides to water and a final rule released in 2010 will require these activities to be NPDES permitted beginning in April 2011. As such, all actions proposed in this EA would be NPDES permitted in addition to any other state or federally mandated permitting.

The NPS has multiple staff at Yellowstone who are certified by the state of Montana to apply piscicides and act as project coordinators. In addition to meeting the minimum requirements for piscicide application, they have attended the U.S. Fish and Wildlife Service's "Rotenone and Antimycin Use in Fisheries Management" training course. All piscicide applications in the park are also reviewed by the park's Integrated Pest Management coordinator prior to initiation. All staff involved in piscicide projects are given thorough training about piscicide use and safety and are provided with label and material safety data sheet (MSDS) information as well as all required PPE.

Limiting Human Exposure to Piscicides

The means of exposure is a significant factor in the risk posed by any chemical to humans or other organisms. In general, the more direct the route into the bloodstream, the greater the risk. Thus, intravenous, respiratory, and subcutaneous pathways of exposure are very dangerous. Ingestion can also be dangerous but may be mitigated by the body's ability to degrade the toxin in the digestive tract. Dermal exposure can result in toxic effects but is a much less direct pathway into the body and therefore generally presents a lower risk. Other pathways of exposure are possible, but those listed above represent the pathways of piscicide exposure most significant to humans and other organisms.

A second important factor in assessing the risk of a chemical to humans or the environment is the concentration at which the chemical is used. In the piscicides proposed for use in this EA, concentrations are 5–7.5% active ingredient for rotenone and 20% for antimycin in the undiluted products; application rates would range from 8 to 50 parts per billion (ppb). For example, CFT Legumine, the product used to treat High Lake and EFSC in Yellowstone is 5% rotenone. The target concentration for CFT Legumine when used for trout eradication is normally a 1-ppm formulation or 50-ppb active ingredient (see Label). That means that 1 gallon of CFT Legumine effectively treats more than 300,000 gallons of water. This extremely low concentration can be used because fish are very sensitive to rotenone and they are exposed to the chemical through a respiratory pathway.

Duration of exposure is also important in assessing the risk a chemical poses to humans and the environment. Exposure that lasts no more than 96 hours (Newman and Unger 2003) generally requires higher chemical concentrations to cause toxic effects than does chronic exposures (WHO 2001). The application of piscicides as proposed in this EA is very unlikely to result in chronic exposure to humans or the environment because flowing water treatment duration is short (8 hours maximum) and treatment of small lakes takes only hours. In streams, the piscicide is present during the application and for the short time it takes to be flushed out of the system, neutralized, or naturally broken down. Piscicide can persist for longer periods in lakes, usually a few days to a few weeks, depending on the temperature of the lake, with longer persistence in colder water. The longest reported persistence of rotenone in a lake was 160 days (EPA 2007b), but that was a cold-water lake treated to 250-ppb rotenone, five times higher concentrations than proposed in this EA.

For the purposes of this discussion, the two groups of people for whom piscicide exposure is a concern are the piscicide applicators and the general public, who would most often encounter piscicides unintentionally. Because piscicides are restricted use pesticides, the general public has almost no risk of coming into contact with undiluted piscicide products. Piscicide applicators, however, are routinely exposed to undiluted products. Both groups may encounter water treated with piscicide but their level of awareness and ability to mitigate that risk would vary.

Of the piscicides considered for use in this EA, powdered rotenone is widely considered the most dangerous to humans (Finlayson et al. 2000; Ling 2003) because dust from the powdered product containing 7.4% rotenone can be inhaled, providing a nearly direct pathway to the blood. Applicators handling rotenone powder are required to wear a respirator to prevent inhalation and other PPE. In the proposed actions under this EA, rotenone powder would only be used to treat springs and seeps after being mixed with sand, gelatin, and water, at which point dust particles no longer exist and the inhalation risk is virtually eliminated. That means that rotenone powder is only an inhalation risk for the brief period it takes to mix it into the sand matrix. This would likely occur only two to four times per project treatment year and the mixing would always be done by a certified piscicide applicator. Under this EA, there is almost no risk of the general public coming into contact with unmixed rotenone powder unless there were a violation of the law or an accident occurred during transportation (see Appendix C). After the rotenone powder has been mixed with the sand matrix, it would still pose a risk for dermal and ingestion exposure, similar to the liquid products discussed below.

Liquid piscicides would be the most widely used piscicide formulations under the proposed actions in this EA. Risks posed by liquid piscicides are largely from dermal and ingestion pathways. Undiluted products have high piscicide concentration and are the most dangerous

form of liquid piscicide. All piscicide MSDS and labels recommend or require the use of respirator, goggles, gloves and Tyvek suit or apron. When handling undiluted liquid piscicides under this EA, NPS staff would always wear respirators and meet or exceed the other PPE requirements set forth in the product labels (see Appendix D). Undiluted product would always be measured and dispensed by certified applicators, as these steps pose the greatest risk of human contact. Trained project staff other than certified applicators would only come into contact with undiluted liquid piscicide when mixing a pre-measured amount of product into a dispensing station, reservoir, or backpack sprayer during a treatment. After it has been diluted to the level used during application, the liquid piscicide would still only be handled by certified applicators and trained project staff wearing the required PPE. Following application to project waters, the piscicide would become extremely dilute (≤ 1 ppm formulation; ≤ 50 ppb active ingredient), drastically lowering but not eliminating the dermal and ingestion risk. The proposed EA would create almost no risk of the general public coming into contact with undiluted liquid rotenone unless there were a violation of the law or an accident during transportation. (See Appendix C for information on the emergency and spill plan.)

After application to project waters piscicides pose a significantly reduced risk because of their extremely low concentrations (AFS 1985; Finlayson et al. 2000), but it is also the time with the highest risk of exposure to the public as well as applicators. Product labeling provides guidance and restrictions for use near drinking water supplies and for public re-entry following piscicide application. The new labeling materials, to be released as part of the re-registration process, are likely to be much more restrictive on public access to project areas (D. Skaar, MFWP. Personal communication, 2010). Regardless of label guidance, public awareness is the most important means of limiting piscicide risk to human health. Under this EA, park staff would use press releases, signage, and neutralization following treatment of project waters (see “Piscicide Neutralization” below) to reduce the risk of public contact with the chemicals.

B.3.2.2. Effect of Piscicides on Humans

Even with the most careful practices and detailed planning, complete elimination of the potential for human exposure to piscicides is not possible. Therefore, it is important to understand the risks posed by piscicides in the case of human exposure. Because very little direct evidence concerning the effects of piscicides on humans exists, animal models are often substituted for toxicological trials and the results are extrapolated to apply to humans. Information from risk analyses conducted by the World Health Organization (WHO 2004), AFS (Finlayson et al. 2000), EPA (2007a and 2007b), State of Washington (Turner et al. 2007a and 2007b), USFS (Durkin 2008), Federal Government of New Zealand (Ling 2003), and the NPS (Moore et al. 2008) is summarized below, along with information from federal and state environmental compliance documents, peer reviewed literature, and other scientific publications.

In a review of incidents of human exposure to rotenone for all previously registered uses (piscidal, agricultural, and residential), the EPA (2007b) found that eye irritation was by far the most commonly reported symptom. Also common were dermal irritation, throat irritation, nausea, and coughing. Less common but more severe symptoms, including headache, dizziness, peripheral neuropathy, numbness, and tremor, have occasionally been reported (EPA 2007b). The EPA (2007b) also noted that “No fatalities or systemic poisonings were reported in relation to ordinary use.” Estimates of the acute oral lethal concentration of rotenone range from 300 to 500 mg/kg (Gleason et al. 1969; USFWS 2005; EPA 2007b; Durkin 2008; USFWS and CDFG 2009). The World Health Organization (WHO 2004), which ranks pesticides as slightly,

moderately, highly, and extremely hazardous based on their oral and dermal toxicity, ranked rotenone as moderately toxic to humans (oral LD₅₀ 200–2000 mg/kg).

Our literature review found two cases of human fatality from exposure to rotenone-based pesticide. One fatality occurred when a child accidentally ingested Galicide, a 6% rotenone product that was registered in Europe for external use on animals (not a fisheries management product) and is no longer available (Hisata 2002). The dose was estimated to be 40 mg/kg, significantly less than the expected lethal dose. Other constituents (etheral oils) in Galicide allegedly promoted abnormal rotenone absorption from the gastrointestinal tract and caused kidney failure that reduced the body's ability to clear the toxicant (De Wilde et al. 1986; EPA 1999). The second occurred when an adult woman with type 2 diabetes intentionally ingested 200 ml of a 0.8% rotenone product commercially available in the United Kingdom (Wood et al. 2005); the estimated rotenone dose was 25 mg/kg.

No human fatalities have been associated with rotenone used for fishery management projects (Gleason et al. 1969; CDFG 1994; Ling 2003), nor could any evidence be found of human fatalities related to antimycin. Even if 25 mg/kg of rotenone were lethal for humans, a person would have to consume 500 times their body weight in treated water (50 ppb) to achieve that dose. If ingestion or inhalation of rotenone occurs, the National Institute for Occupational Safety and Health (NIOSH 2000) indicates that the symptoms of both are easily treatable.

Rotenone is not considered carcinogenic, teratogenic, or an endocrine disruptor. Some evidence suggests that rotenone may be useful in treating certain kinds of cancers (Fang and Casida 1998, from Ling 2003). Chronic effects of rotenone exposure are not well documented, but one study that administered oral doses of up to 75mg/kg to mice found no observed changes in their brains after two years (Marking 1988). This study and others indicate that chronic exposure to treatment concentrations of rotenone, unlikely as it would be, would pose little threat to human health (Siegler and Pillsbury 1946; Hansen et al. 1965; Durkin 2008).

A potential connection between rotenone and Parkinson's disease has emerged as a significant human health concern in the last 10 years. Parkinson's disease (PD) is a degenerative neurological disorder associated with a decrease in the production of the neurotransmitter dopamine. The cause of the disease is poorly understood, but genetic predisposition, exposure to environmental toxins, drug use, and severe head trauma may contribute to the risk of developing PD. In a study published by Emory University (Betarbet et al. 2000), several weeks of exposure to rotenone administered intravenously to the jugular veins of rats produced physical and neurological symptoms similar to PD. Another article, published simultaneously, used the findings of that study to infer that additional questions were likely to be raised about the safety of rotenone, but the role of rotenone in causing PD remained to be determined (Giasson and Lee 2000). In fact, the authors of the original study noted that "rotenone seems to have little toxicity when administered orally," indicating that oral exposure did not produce PD-like symptoms. A more recent study concluded that a 30-day inhalation of rotenone does not cause PD symptoms in mice and rats (Rojo et al. 2007). This demonstrates the differential risk posed by varied exposure pathways.

Since the original study, many others have used the rotenone-PD model to advance scientific research on the disease (Betarbet et al. 2000; Giasson et al. 2000; Gao et al. 2003; Sherer et al. 2003; Panov et al. 2005; Höglinger et al. 2006; Rojo et al. 2007). The intravenous and subcutaneous exposure of rats to rotenone provides a valuable model for studying PD-like

symptoms; however, some researchers have questioned its use because although PD-like symptoms are observed, the model does not completely replicate the disease (Höglinger et al. 2006; Hirsch et al. 2003). Because of the exposure pathway and the doses used to produce the rotenone-PD model, the American Fisheries Society (AFS) and other sources maintain that the Betarbet et al. 2000 study is not relevant to the risks associated with fisheries management use of rotenone (AFS 2001; Durkin 2008; Robertson and Smith-Vaniz 2008). This literature review also found no evidence of piscicidal or pesticidal exposure of rotenone directly linked to PD in humans. Huntington's disease (HD) is another neurodegenerative disorder that is sometimes mentioned as having a possible connection to rotenone. HD is caused by a well-known genetic mutation, however, it is suspected that onset may be affected by environmental factors (Coppede 2009). Regardless, no evidence has been found to suggest a connection between the piscicidal application of rotenone and either PD or HD.

B.3.2.3. Effect of Piscicides on Other Non-target Organisms

Piscicides affect organisms other than fish in varying degrees. These organisms, commonly referred to as non-target organisms, can be grouped into two major categories, aquatic and terrestrial. The aquatic organisms, primarily invertebrates and amphibians, share the same habitat as the fish that are being treated and therefore often come directly into contact with the piscicide. The terrestrial organisms, primarily mammals, birds, and reptiles, come into contact with the piscicide from drinking treated water, eating treated fish or other aquatic organisms, or standing in treated water. Beavers and otters straddle the line between aquatic and terrestrial life, but for the purposes of this discussion are considered to be terrestrial because they breathe air and share similar physiology with other terrestrial organisms.

From the standpoint of risk from piscicide treatment, the most important distinction between aquatic and terrestrial non-target organisms is how they respire. Many aquatic organisms breathe via gills and therefore provide a respiratory pathway for piscicide to enter the bloodstream, much like fish. These animals are often very sensitive to piscicide and are likely to be affected by treatments. Important groups of gill breathing organisms known to be affected by piscicide include aquatic macro invertebrates (AMI) and larval amphibians. Evidence suggests that adult amphibians, those that breathe air, have a susceptibility to piscicide similar to that of terrestrial organisms.

The degree to which piscicides affect susceptible organisms varies widely by species, likely due in part to physiological resistance to the chemicals. A recent study (Finlayson et al. 2010b) that compared the effects of piscicide on rainbow trout and six species of invertebrates from sensitive groups (mayflies, stoneflies, and caddisflies) found that in every case the invertebrates were more resistant to rotenone than was the trout. Some of the invertebrates tested had 8-hour LC₅₀ values greater than that of the highest proposed treatment concentration in this EA (50 ppb rotenone), indicating that treatments would be unlikely to eradicate those populations. Other studies (many summarized in Vinson et al. 2010) indicate that some invertebrate species are more sensitive to piscicides than trout are while others are far more resistant. Sensitivity of aquatic invertebrates appears to be strongly tied to (1) life history—benthic invertebrates appear less sensitive than planktonic invertebrates; (2) size—larger invertebrates appear less sensitive than smaller ones; and (3) respiratory means—gill breathing invertebrates appear more sensitive than those that use other means to acquire oxygen (Vinson et al. 2010).

Given the range of sensitivity of AMI to piscicides, any piscicide treatment would very likely affect some organisms in the AMI community. To what degree and for how long invertebrate

communities are impacted by piscicide treatments is difficult to determine because invertebrate communities are both diverse and dynamic. The number of genera identified in AMI samples collected monthly in the Logan River (Utah) for almost 10 years remained relatively constant at 27.5 genera per sample, but 84 genera had been identified by the end of the study. That means that an average sample represented only 33% of the total genera identified over the course of the study (Vinson et al. 2010). It should also be noted that invertebrates in this study were identified only to the genus level, and that identification to the species level would likely have increased the disparity (Vinson et al. 2010). This suggests that the natural variation of AMI communities in a stream reach is so high that, when assessing the impacts of piscicide treatment, using abundance and diversity of common genera or species is a better indicator than raw measures of diversity. This is also logical because common species are more likely to serve ecosystem roles (e.g., providing prey for amphibians, birds, fish, and other invertebrates) than are rare species. This is not meant to suggest that invertebrate biodiversity is unimportant, only that raw measures of diversity which include rare taxa must be considered in a broader context given the complexity of invertebrate communities even in undisturbed waters.

It should also be noted that the goal of the proposed piscicide applications in Yellowstone is to replace existing non-native fish with native fish assemblages, and the presence of non-native fish very likely has an impact on natural invertebrate communities. It follows that the very act of restoring native fish communities may shift the existing invertebrate community structure to more closely resemble that which existed before the introduction of non-native fish. This process has been demonstrated in historically fishless lakes where trout were introduced and then later removed, although a return to exact pre-disturbance conditions is not guaranteed (Drake and Naiman 2000). In almost all cases, information regarding macro invertebrate community structure prior to non-native fish invasion is non-existent. So, while some shift may be expected, the exact nature of that shift is unknown.

The effects of piscicide treatments on endemic AMIs are an important concern with any piscicide application (USFWS and CDFG 2009). From the 285 AMI samples collected by Yellowstone biologists across the park over the past 10 years, 818 species have been identified, none of them endemic to the park, the likelihood of discovering an AMI endemic to a single drainage in the park is therefore extremely low, and the likelihood of discovering one in the portion of a single drainage being proposed for piscicide treatment is lower still. The relatively small size of project areas buffers against the potential loss of endemic species. Grayling Creek, which would be a relatively large piscicide project with a drainage area of over 16,000 acres, covers only 0.74% of the park and 0.08% of the Greater Yellowstone Ecosystem (BSI 2010). One of the rarest AMI species discovered in the park in the last 10 years was Alexander's rhyacophilian caddisfly (*Rhyacophila alexanderi*), which was found in an inlet spring to High Lake in 2007, a year after the lake and spring had been treated with rotenone.

Regardless of the extremely low risk, potential impacts to undiscovered endemic AMI species are being considered. Any drainage proposed for piscicide treatment would be sampled for AMI for at least three years prior to treatment. If an endemic species were discovered, further sampling would be conducted to delineate its range. Treatments would only be carried out if sources of recolonization in untreated waters were found or if a large number (>500) of the organisms could be collected and removed from the project area for restocking after the treatments were finished. The mitigation measures described below would also help ensure the persistence of any endemic species.

The aim of the proposed piscicide applications in Yellowstone is complete eradication of non-native fish with minimal impacts to non-target organisms and other resources. Measures to mitigate the impacts of piscicide treatment on aquatic invertebrates have been suggested (Finlayson et al. 2010b; Vinson et al. 2010): (1) reduce the piscicide concentration, (2) reduce the treatment duration, (3) treat large drainages in stages, 4) do not treat fishless reaches, and 5) neutralize piscicides downstream of the project area. All of these recommendations would be considered for implementation on proposed projects. Recommendations 1 and 2 are both designed to reduce the dose (concentration x duration) of piscicides to which organisms are exposed; our goal is to apply the lowest possible dose that is effective in eradicating fish. The maximum permissible treatment would be 50 ppb rotenone for 8 hours in streams, but our goal would be to achieve complete fish removal with 25 ppb rotenone for 4 hours, which is the recommended minimum dose in Finlayson et al. (2010b). Under this treatment strategy, first duration and then concentration would be increased if the minimum dose proved ineffective. Recommendations 3, 4, and 5 are designed to leave intact the potential recolonization sources of invertebrates and other organisms. However, the construction of intermediate barriers, which would be required to treat large projects in stages, may sometimes not be possible or prudent.

In almost all cases where piscicide application is used to completely remove a population of non-native salmonids, multiple identical treatments are conducted (USFWS 2005). The purpose of replicate treatments is to ensure complete removal; treatments are conducted until fish are no longer detected in project waters. These repeated treatments may occur in the same year and/or across multiple years. Because repeated treatments are commonly used in native fish restoration projects, the impacts of the treatments on AMI and other organisms are considered cumulatively. Recent studies of rotenone and antimycin (Hamilton et al. 2009; Finlayson et al. 2010b) concluded that AMI communities recovered quickly following repeated treatments at “normal” piscicide doses (≤ 10 ppb antimycin, ≤ 50 ppb rotenone). When normal piscicide doses are exceeded, recovery times for AMI are prolonged (Dinger and Marks 2007; Hamilton et al. 2009) and gross exceedance can lead to long-term impacts (Mangum and Madrigal 1999). Many other studies have demonstrated a similar pattern of impact to AMI (summarized in Vinson et al. 2010). This highlights the importance of developing and strictly adhering to a sound treatment plan that uses a low piscicide dose and other mitigation measures to both effectively remove fish and minimize impacts to AMI. Under the actions proposed in this EA, short-term impacts to AMI would occur, but rapid AMI recovery would be expected and long-term impacts would almost certainly not occur.

The impact of piscicide on amphibians follows a pattern very similar to that of aquatic invertebrates with only a few key differences. Both short-term (<5 years) and long-term (>5 years) impacts are much more easily measured for amphibians because only four species are present in the park. Impacts to amphibians are mitigated using the same measures as for AMI and through timing of the piscicide treatments. Piscicide treatments are very likely to affect larval (gill-breathing) amphibians but unlikely to directly impact adult amphibians (Ling 2003, DOI 2007, Grisak et al. 2007). Because adult amphibians are not killed by treatment doses of piscicide (Grisak et al. 2007), large-scale mortality can be avoided by conducting treatments after amphibians metamorphose to air-breathing stages. While stream flow and water temperature are also considered in the timing of piscicide applications, delaying treatments to mitigate their effects on amphibians would be done to the greatest extent possible. In areas where mortality to amphibians would occur, recovery is expected within the short term. Adult amphibians remained abundant following the 2006 rotenone treatment of High Lake and larval

amphibians were more widely distributed and abundant in 2007 than they were preceding the treatment (Koel et al. 2008). Rapid recovery of amphibian populations has also been noted following other piscicide treatments (DOI 2007; Turner et al. 2007a). Rotenone application in the Adirondack Mountains of New York appeared to have minor, short-term negative impacts on non-target organisms, with all amphibian species recovering post-treatment (DeMong 2001). No evidence of long-term negative impacts to amphibian populations due to piscicide treatment was found during our literature review.

The terrestrial fauna in Yellowstone National Park include several species of federal, state, and agency management concern (see Chapter 3, Affected Environment) that may be exposed to piscicides through ingestion or dermal contact during treatments. Several of these organisms are directly dependent on fish for food, like ospreys and otters, while others only use aquatic resources for drinking water. Extensive laboratory toxicology studies have been done concerning the effects of piscicides on terrestrial organisms, particularly birds and mammals, and have been summarized in several recent risk assessments (Ling 2003; Turner et al. 2007a and 2007b; Durkin 2008). The lowest LD₅₀ value we found for any birds, mammals, or reptiles was an oral LD₅₀ of 39.5 mg/kg in a study of female rats. Toxicity values for other terrestrial animals ranged much higher and were found by other studies to be considerably higher for rats. Using the LD₅₀ value of 39.5 mg/kg, a 10-kg (22-lb) animal would have to drink 7,900 liters (2090 gallons) of water treated with 50 ppb rotenone or eat 7,900 kg (17,380 lbs) of rotenone-treated fish to reach an LD₅₀ value of 39.5 mg/kg. Adult amphibians may be more sensitive; one study reported on adult frogs with an LC₅₀ of 2 mg/kg (Ling 2003), but they would need to consume rotenone-treated prey or water that far exceeded their body weight to obtain a lethal dose. Effects from piscicides may occur at lower concentrations during chronic exposures, but since normal piscicide treatments last only from a few hours to a few days, the risk of chronic exposure is essentially non-existent.

Rotenone was traditionally applied to plants as an insecticide for gardening and agricultural applications (Ling 2003) with no reported impacts to the target plants. No evidence of rotenone toxicity to terrestrial plants could be found (Turner et al. 2007b). The effects of antimycin on terrestrial plants has not been documented, but as it is a derivative of the streptomyces mold, a natural soil component, it is expected not to have adverse effects on plants (Turner et al. 2007a). Gilderhus (1982) found that piscicides were not significantly taken up by aquatic plants; however, the effects of both rotenone and antimycin on aquatic plants are unknown (Turner et al. 2007a and 2007b).

B.3.2.4. Development of Tolerance for Piscicides by Fish

The EPA registration eligibility decisions for both rotenone and antimycin indicate that no tolerance for these chemicals exist among fish species (EPA 2007a,b). Our literature review revealed one study where golden shiners (*Notemigonus crysoleucas*) developed tolerance (see glossary) following repeated rotenone treatment (Fabacher and Chambers 1972), and another study where mosquito fish (*Gambusia affinis*) developed resistance to rotenone (Orciari 1979). However, in both cases the fish were exposed to sub-lethal concentrations of rotenone because of incomplete mixing of piscicide in the target waters. This demonstrates the importance of careful planning and execution of treatments to ensure that project waters are treated with target concentrations. No evidence of tolerance or resistance to piscicide in trout could be found, likely because trout are highly susceptible to piscicide treatment (table B-4).

B.3.2.5. Piscicide Neutralization

Both of the piscicides considered in this EA can be readily neutralized with an oxidizing agent, most commonly potassium permanganate (KMnO₄), or with other agents such as chlorine bleach and sodium permanganate. For a typical piscicide application, 1 ppm of KMnO₄ for every 1 ppm of rotenone formulation used would be applied at the most downstream point where fish removal is desired. In addition to the 1 ppm KMnO₄ used to neutralize the rotenone, another 1 ppm is applied to satisfy the background oxidation demand and another 1 ppm as residual or buffer. In cases where the background demand is more than 1 ppm KMnO₄, more neutralizing agent must be used. The typical target concentration for neutralizing a piscicide treatment in a stream is therefore 3 ppm, but in cases where background demand is high it could range up to 5 ppm. Neutralization occurs within 30 minutes of contact between the treated water and the KMnO₄, so fish and other aquatic organisms may still be affected by piscicide the distance water moves downstream in 30 minutes. This water would be considered part of the project area.

Monitoring the efficacy of piscicide neutralization using KMnO₄ is done in two ways: (1) placing sentinel fish at 30 and 60 minutes of travel time downstream from the neutralization station and monitoring them for signs of rotenone stress, and (2) measuring the KMnO₄ in the water with a pocket colorimeter. Both monitoring methods must be done to ensure that KMnO₄ concentrations are not too high or low. Given the 30 minutes of contact time to neutralization and the background demand of water, concentrations of KMnO₄ should be measured at the 30-minute sentinel cage. At that point the rotenone should be neutralized and the background demand satisfied, so only the 1 ppm residual KMnO₄ should be present in the water. If concentrations are less than 1 ppm KMnO₄ and fish show signs of stress, it is most likely due to un-neutralized rotenone and the KMnO₄ concentration should be increased. If the KMnO₄ concentration is significantly higher than 1 ppm and fish show signs of stress it is most likely a toxic effect from the KMnO₄ and the treatment concentration should be reduced.

Potassium permanganate is toxic to aquatic and terrestrial organisms. Much like with rotenone, aquatic organisms display a wide range of tolerance to KMnO₄ (table B-4). The 96-hour LC₅₀ for trout is 1.22–1.8 ppm (Phillips et al. 2005), which is why neutralization concentrations at 30 minutes of contact time may cause stress to sentinel fish. The EPA (USFWS and CDFG 2009) cites 1–2 ppm as the concentration at which KMnO₄ is toxic to aquatic organisms. This means that normal stream treatments, such as those proposed in this EA, will likely have an adverse impact on aquatic organisms from the neutralization station to 30 minutes of travel time downstream of the station due to KMnO₄. This area would be considered part of the affected treatment area for the project, and fish as well as non-target organisms would be monitored in this area. Potassium permanganate does not travel long distances downstream and is not persistent in the environment because it is quickly reduced through natural processes (USFWS and CDFG 2009).

While KMnO₄ could be toxic to terrestrial organisms at high concentrations, the chemical is routinely used to treat potable water supplies for organic contaminants, iron, manganese, sulfides, and undesirable colors and odors (USFWS and CDFG 2009).

Application of KMnO₄ to piscicide-treated waters is accomplished through metered dispensation stations that apply either a concentrated liquid or pure crystals directly to piscicide-treated waters. The preferred method in Yellowstone uses a volumetric feeder (Acrison Inc., Moonachie, New Jersey) powered by a small electric generator to dispense pure

KMnO₄ crystals directly to the stream. This method reduces applicator contact with the chemical to the greatest extent possible and allows for extremely accurate and precise application. Safety guidelines for handling KMnO₄ are provided by the MSDS and include the use of gloves, goggles, and a particulate filtering respirator. All guidance set forth by the MSDS would be followed for transportation, storage, and handling of KMnO₄ during proposed treatments in the park.

B.3.2.6. Piscicide Bioaccumulation

Bioconcentration is defined by the EPA as the tendency of a chemical to accumulate in an organism in excess of the concentration in the organism's environment (WHO 2001). In general, chemicals that have the potential to bioconcentrate also have the potential to bioaccumulate, which occurs through the ingestion of contaminated food or water (WHO 2001; EPA 2007a). The potential for a chemical to bioaccumulate in a species is measured as its Bioconcentration Factor (BCF). Since the BCF in fish can readily be measured in the laboratory and bioaccumulation is more difficult to determine, the BCF is frequently used to predict the likelihood of bioaccumulation. A compound is considered likely to bioconcentrate, and thus bioaccumulate, if its BCF is >1000 (EPA 2007a).

Based on a BCF of 350X, the EPA reports that antimycin does not bioconcentrate (2007a). Because of antimycin's relatively low BCF, the chemical is not considered likely to bioaccumulate in aquatic food chains (EPA 2007a). The BCF for rotenone is significantly less (<30X) and has a relatively low potential for bioaccumulating in aquatic organisms. Using conservative bioaccumulation values (maximum residue), the EPA determined that consumption risks were below the agency's level of concern, because there is low propensity for bioaccumulation of rotenone in fish (EPA 2007b). Repeat applications or long-term exposure could potentially result in increased likelihood of bioconcentration; however, the opportunity for these types of exposures are unlikely in typical fisheries management (EPA 2007a).

B.3.2.7. Long-term Environmental Persistence

The EPA reports that long-term piscicide persistence is not a concern. Adequate data are not available to quantitatively estimate the chronic risk of antimycin; however, models and available data indicate that antimycin will not persist in the environment (EPA 2007a). Applied using typical fisheries management practices, rotenone is not persistent in the environment over the long-term. The effects of rotenone on sensitive species may last up to two months in warm-water ecosystems, and rotenone can be quite persistent in cold environments, where rotenone might remain at levels high enough to cause toxicity for approximately 160 days at maximum label treatment concentrations (250 ppb, EPA 2007b). However, given the low BCF for both antimycin and rotenone and that organisms are rarely exposed and exposure is typically short-term, detrimental effects to local ecosystems from long-term persistence of piscicides are not a concern (EPA 2007a).

B.3.2.8. Selection of the Appropriate Piscicide

According to Wydoski and Wiley (1999), the ideal piscicide would have the following properties: reliable for meeting the management objective, specific to the species of fish targeted, easy and safe to apply, harmless to non-target organisms, effective over a broad range of water conditions, registered for use in the aquatic environment, and limited to the treatment area without the use of a detoxicant. As the authors noted, however, no product that meets all these criteria is currently available, so fisheries managers must carefully evaluate the benefits

versus environmental consequences of using piscicide (Wydoski and Wiley 1999). Insofar as the choice is between piscicides, we would evaluate the specific formulations based on the degree to which they meet the above criteria. The discussion below is intended to elucidate the decision making process that would be used to choose specific piscicides for proposed projects.

There are several criteria that would preclude a product from consideration for use in Yellowstone. Most importantly, use of products not registered for piscicidal use with the EPA is illegal and they would not be considered for piscicidal use in the park. Secondly, products clearly demonstrated to have increased impacts to natural or societal resources but no clear benefit in meeting the management objective would not be considered for use. One such product type has recently been identified. Rotenone formulations that are synergized with piperonyl butoxide have been shown to have increased toxicity to aquatic invertebrates comparable to those found in Yellowstone but are not significantly more toxic to rainbow trout (Finlayson et al. 2010b). This suggests that application of this formulation would have no management benefit and would increase impacts to non-target organisms. Rotenone formulations synergized with piperonyl butoxide would therefore not be considered for use in the park.

The remaining products registered and available for use as piscicides can be evaluated based on the type of formulation. Dry or powdered piscicides and liquid piscicides overlap in their potential uses in some areas, but they are also sometimes uniquely suited to certain situations. Powdered piscicide is suited for treating springs and seeps (see “Piscicide Application” above) because it can be mixed with sand, gelatin, and water. Only rotenone (Prentox Fish Toxicant Powder or comparable) is available in dry form and so would be used for the proposed actions in the park. However, large-scale use of powdered rotenone to treat lakes or streams is not being considered because of the risk of inhaling the powder. Our choice here reflects the need to use the appropriate tool to meet management objectives while limiting risks to health and human safety to the greatest extent possible.

More choice exists in the selection of liquid piscicides. Both rotenone and antimycin are registered for use in liquid form. Rotenone is available in three liquid formulations, including the synergized form described above which we have chosen to preclude from use in the park. The remaining formulations (Prentiss Inc., Floral, New York) are both 5% rotenone but have different solvent packages. Prenfish is a traditional liquid formulation with a hydrocarbon-based solvents package. CFT Legumine is a newer formulation with a solvent package that is much lower in hydrocarbon-based solvents. Because of the desire to keep hydrocarbons from entering the environment, CFT Legumine would be preferred for use in the park. However, if CFT Legumine were no longer available or could not be obtained, Prenfish would be considered for use. The decision to use CFT Legumine preferentially over Prenfish reflects our understanding that it may have fewer environmental impacts; however, no scientific evidence is available to support this assumption. If clear evidence becomes available that supports or contradicts our assumption, it would be used in our selection process.

Antimycin, commercially known as Fintrol, is only registered for use in liquid form. However, as of July 2010, Fintrol is not commercially available and has not been for several years. It is unclear if or when Fintrol or another antimycin product will be commercially available. If antimycin became available in a formulation comparable to Fintrol, it would be considered for use in the proposed activities. The choice between rotenone and antimycin for use in inland salmonid conservation is a topic of ongoing debate, most of which focuses on comparing the effects of the two piscicides on AMI (Hamilton et al. 2009; Finlayson et al. 2010a; Hamilton et al. 2010).

Conventional wisdom has held that antimycin has less impact on AMI than rotenone. However, published studies have often differed over the actual impacts of both chemicals and the reasons for them (Vinson et al. 2010). What has become clearer is that treatment concentration and duration (dose) affect the impacts to non-target organisms, with higher doses resulting in more impact. Recent studies have demonstrated that AMI communities can recover following normal treatments of rotenone (50 ppb; Finlayson et al. 2010b) and antimycin (8 ppb; Hamilton et al. 2009), but high concentrations of the chemicals have more severe impacts (Dinger and Marks 2007; Hamilton et al. 2009). Our judgment is that when applied within the label guidelines for normal use, the two chemicals have comparable environmental effects and therefore are equally appropriate for consideration.

The history of the application of rotenone and antimycin in lakes indicates that rotenone is a more reliable choice for achieving complete removal of non-native fish. It appears that rotenone penetrates the thermocline in stratified lakes more reliably (Ling 2003) and it is known that rotenone works over a broader range of pH than does antimycin (Finlayson et al. 2000; USFWS 2005). Rotenone was successfully used to remove non-native trout from High Lake in Yellowstone at a surface water pH of over 9, whereas antimycin was almost completely ineffective in a comparable treatment of very similar water, Johnson Lake, in Great Basin National Park in 2005 (Baker et al. 2008). Later treatments at lower pH using antimycin were successful at removing the brook trout from Johnson Lake. Liquid rotenone would most likely be used to treat lakes under the proposed EA.

Both antimycin and rotenone have been used extensively and successfully to remove non-native fish from streams (table B-2). Both chemicals are considered to have similar environmental effects, although the effect of antimycin, especially on humans, is not as well known (EPA 2007a). Rotenone is less expensive than antimycin. So, while both chemicals would be considered for use in the park, given the similar environmental impacts, higher cost, and unknown availability of antimycin, it is most likely that rotenone would be used on stream treatments in the park. New evidence concerning the suitability of either chemical will be taken into consideration as it becomes available. Given the products and information currently available, CFT Legumine and Prentox Fish Toxicant Powder (or comparable products) are the most likely piscicides to be used in the proposed native trout conservation activities.

B.4 Conclusions

Given the information provided in this document, we believe that the methods proposed within the Native Fish Conservation Plan EA are scientifically sound and do not pose an unreasonable threat to the environment or human health and safety.

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Appendix C: Piscicide and Potassium Permanganate Emergency and Spill Plan

C.1 Description of Rotenone and Permanganate Products and Packaging

Two commercial formulations of rotenone, one commercial formula of antimycin A (collectively known as piscicides), and potassium permanganate (KMnO₄; collective with piscicides known as chemicals) are proposed for use by the Native Fish Conservation Plan EA. CFT Legumine would most likely be purchased in 18.9-liter (5-gallon) drums, Prentox Fish Toxicant Powder would be purchased in 50-kg (110-lb) drums, Fintrol would be purchased in 0.95-liter (0.25-gallon) units, and KMnO₄ would be purchased in 25-kg drums. All products would remain in their original packaging with product labels attached during normal pre-treatment storage. All products except Prentox Fish Toxicant Powder would be transported in their original packaging with product labels attached. Prentox Fish Toxicant Powder, which only comes from the manufacturer in large quantities and is only required for each treatment in small quantities, would be transferred to double bag lined screw-top buckets and sealed for transport to project areas. A complete product label and Material Safety Data Sheet (MSDS) would be physically attached to the buckets.

C.2 List of Chemicals

1. Fintrol (antimycin A), EPA Reg. No. 655-422. 0.95-liter units of liquid in metal cans
2. CFT Legumine (rotenone), EPA Reg. No. 75338-2. 18.9-liter metal drums of liquid
3. Prentox Fish Toxicant Powder (rotenone), EPA Reg. No. 655-691. 50-kg lined cardboard drums of powder
4. Potassium permanganate (KMnO₄), 25-kg plastic drums of crystals

C.3 Description of Storage Areas

The primary storage area for piscicides during periods of inactivity would be the NPS pesticide storage container in Mammoth Hot Springs, Yellowstone National Park, Wyoming. This storage container is specifically designed to house pesticides and as such is lockable, climate controlled, and includes a spill containment system. Potassium permanganate cannot be stored with piscicide and therefore would be stored in a secure cool, dry, area in accordance with the product's MSDS.

During active treatment periods, chemicals would need to be stored in remote field locations. Field storage locations would be away from water and near but not in campsite locations where they could be closely monitored. Storage locations would be clearly marked to avoid accidents and would be covered to protect chemicals from the weather. Piscicide and KMnO₄ would be stored in separate areas.

All chemical storage areas would have copies of the product labels and MSDSs for all constituent chemicals posted in an accessible location. Entry to chemical storage areas would be

restricted to certified pesticide applicators and trained employees under their immediate control.

C.4 Transportation of Chemicals

All transportation of chemicals would occur in the presence or under the direct supervision of a certified pesticide applicator and in accordance with the product labeling and MSDS requirements. Label and MSDS information would be readily available at all times during transport.

During transport in a motor vehicle, chemicals would be placed outside the occupied driving cabin, such as in the back of a truck or in a trailer, but restrained so that they would be unable to move under normal driving conditions. Piscicide and KMnO_4 would not be transported in the same vehicle. For transport to remote field locations, the chemicals would either be flown via helicopter or packed on pack stock. Using livestock for transportation would most often be the first choice, and use of helicopters would be as limited as possible.

For helicopter transport, the chemicals would be stowed outside the flight cabin but secured in the aircraft's exterior baskets or internal storage compartments. Chemicals would not be flown via long-line below the helicopter. If transported via pack stock, chemicals would be double bagged before being placed into panniers. All packing would be conducted under the supervision of professional packers. Only unopened chemicals would be transported to the site, except powdered rotenone as described above, and only those containers which are in use would be opened at the application site. However, empty but un-rinsed containers and partially used contents would sometimes need to be transported after treatment. In that case, chemical containers would be double bagged and transported as described above.

C.5 Precautions

All personnel involved with the application will be knowledgeable of the chemicals' toxicity, potential modes of exposure, the Site Safety Plan, the rotenone and permanganate product labels, the MSDSs, and this emergency and spill plan. All personnel would wear proper clothing, eye protection, and respirators as specified by the product labels and MSDSs. In case of an emergency or spill, all personnel would have the knowledge and ability to contact the project manager, emergency services, and safety coordinator by telephone or NPS radio.

C.6 Communication and Chain of Command

In case of an emergency, the flow of information and responsibility during application of chemicals would follow the chain of command listed below.

Yellowstone Office of the Supervisory Fisheries Biologist: 307-344-2281

Yellowstone Safety Office: 307-344-2029

Yellowstone Structural Fire Office: 307-344-2190

Yellowstone Emergency Services (Communications Center): 911 or 307-344-2640

Communication would occur in person, by telephone, or by NPS radio, and a viable means of communication would be required on-site. The project coordinator, who would be a certified

pesticide applicator, would be the first contact in the event of an emergency. The project coordinator would be responsible for initial efforts to stop and contain the emergency and initiate the appropriate emergency response.

In the case of a small spill (<18.9 liters) that can be stopped and contained, and no human contact with chemical has occurred, the project coordinator must record the incident and report it to the Supervisory Fisheries Biologist and NPS Safety Officer within 24 hours. In the case of a large (>18.9 liters) or uncontained spill, fire, or human exposure to chemicals, the project coordinator would immediately contact NPS emergency services, the Supervisory Fisheries Biologist, and the NPS Safety Officer. The NPS emergency services in coordination with the NPS Safety Officer would then contact the appropriate emergency response (fire management, medical services, poison control center, etc.). In the case of large spills or other emergencies that had potential human health effects, the NPS public relations office would immediately inform the public of potential risks.

C.7 Containment of Spills

In the event a spill occurs, it would be of paramount importance that the spilled material be contained. Shovels and other hand tools would be used for immediate containment or channelization of the spilled material into a containment area. The following actions would be taken as necessary to contain a spill on ground:

1. Stopping the spillage at its source
2. Diking in pools as appropriate
3. Using materials such as clay, soil, sawdust, or straw to absorb standing material or collection of standing rotenone by pump or sponge and deposition into target area
4. Neutralizing the spill site as necessary

C.8 Spill Treatment

In the event that chemical is spilled and absorbed into the soil, the contaminated soil would be treated as if it were the undiluted chemical, and all required pesticide application safety gear would be worn. The contaminated soil would be removed from the area, then disposed of as required by the product label and MSDS. All contaminated materials and equipment used to handle the spill would also be cleaned and disposed of in a manner consistent with the product label and MSDS.

C.9 Site Safety Plans

A specific site safety plan would be developed for each piscicide application that details site information, training requirements, site safety meetings, chemical hazards, personal protective equipment requirements, general field safety guidelines, specific emergency response plan, and specific emergency contacts. This plan would be signed by the Yellowstone safety officer, structural fire chief, and supervisory fisheries biologist. It would be the responsibility of the project coordinator to provide and review the plan with all project staff.

Appendix D: Material Safety Data Sheets and Product Labels for Fisheries Restoration Chemicals

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D.1 CFT Legumine

D.1.1. Product Label

RESTRICTED USE PESTICIDE
 Due to aquatic toxicity
 For retail sale to, and use only by, Certified Applicators or persons under their direct supervision
 and only for those uses covered by the Certified Applicator's certification.

CFT Legumine™

Fish Toxicant

For Control of Fish in Lakes, Ponds, Reservoirs, and Streams

ACTIVE INGREDIENTS:

Rotenone	5.0%	w/w
Other Associated Resins	5.0%	

OTHER INGREDIENTS ¹	90.0%	
Total	100.0%	

¹ Contains Petroleum Distillates
 CFT Legumine is a trademark of CWE Properties Ltd., LLC

KEEP OUT OF REACH OF CHILDREN

WARNING

FIRST AID

Have product container or label with you when obtaining treatment advice.

If swallowed	<ul style="list-style-type: none"> Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice. Do not give any liquid to the person. Do not anything to an unconscious person Do not induce vomiting unless told to do so by the poison control center or doctor.
If on skin or clothing	<ul style="list-style-type: none"> Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
If inhaled	<ul style="list-style-type: none"> Move person to fresh air. If person is not breathing, call an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
If in eyes	<ul style="list-style-type: none"> Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.

Note to Physician: Contains Petroleum Distillates. Vomiting may cause aspiration pneumonia. For information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378.

EPA Reg. No. 75338-2

EPA Est. No. 655-GA-1

Manufactured for CWE Properties Ltd., LLC, P.O. Box 336277, Greeley CO 80633

**PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
WARNING**

May be fatal if inhaled or swallowed. Causes moderate eye irritation. Harmful if absorbed through skin. Do not breathe spray mist. Do not get in eyes, on skin, or on clothing. Wear goggles or safety glasses.

When handling undiluted product, wear either a respirator with an organic-vapor-removing cartridge with a prefilter approved for pesticides (MSHA/NIOSH approval number prefix TC-23C), or a canister approved for pesticides (MSHA/NIOSH approval number prefix 14G), or a NIOSH approved respirator with an organic vapor (OV) cartridge or canister with any R, P, or HE prefilter.

Wash thoroughly with soap and water after handling and before eating, drinking, or using tobacco. Remove contaminated clothing and wash before reuse. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

ENVIRONMENTAL HAZARDS

This pesticide is extremely toxic to fish. Fish kills are expected at recommended rates. Consult your State Fish and Game Agency before applying this product to public waters to determine if a permit is needed for such an application. Do not contaminate untreated water when disposing of equipment washwaters.

CHEMICAL AND PHYSICAL HAZARDS

FLAMMABLE: KEEP AWAY FROM HEAT AND OPEN FLAME. FLASH POINT MINIMUM 45°F (7°C).

For information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

STORAGE: Store only in original containers, in a dry place inaccessible to children and pets. This product will not solidify nor show any separation at temperatures down to 40°F and is stable for a minimum of one year when stored in sealed drums at 70°F.

PESTICIDE DISPOSAL: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your state pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL: Triple rinse or equivalent. Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. CFT Legumine is registered for use by or under permit from, and after consultation with State and Federal Fish and Wildlife Agencies.

GENERAL INFORMATION

This product is a specially formulated product containing rotenone to be used in fisheries management for the eradication of fish from lakes, ponds, reservoirs and streams.

Since such factors as pH, temperature, depth and turbidity will change effectiveness, use this product only at locations, rates, and times authorized and approved by appropriate State and Federal Fish and Wildlife Agencies. Rates must be within the range specified on the label.

Properly dispose of unused product. Do not use dead fish for food or feed.

Do not use water treated with rotenone to irrigate crops or release within ½ mile upstream of a potable water or irrigation water intake in a standing body of water such as a lake, pond or reservoir.

Re-entry Statement: Do not allow swimming in rotenone-treated water until the application has been completed and all pesticide has been thoroughly mixed into the water according to labeling instructions.

FOR USE IN PONDS, LAKES, AND RESERVOIRS

The actual application rates and concentrations of rotenone needed to control fish will vary widely, depending on the type of use (e.g., selective treatment, normal pond use, etc.) and the factors listed above. The table below is a general guide for the proper rates and concentrations.

This product disperses readily in water both laterally and vertically, and will penetrate below the thermocline in thermally stratified bodies of water.

Computation of Acre-Feet: An acre-foot is a unit of volume of a body of water having the area of one acre and the depth of one foot. To determine acre-feet in a given body of water, make a series of transects across the body of water taking depths with a measured pole or weighted line. Add the soundings and divide by the number made to determine the average depth. Multiply this average depth by the total surface area in order to determine the acre-feet to be treated. If number of surface acres is unknown, contact your local Soil Conservation Service, which can determine this from aerial photographs.

Amount of CFT Legumine Needed for Specific Uses: To determine the approximate number of gallons needed, find your “Type of Use” in the first column of the table below and then divide the corresponding numbers in the fourth column, “Number of Acre-Feet Covered by One Gallon” into the number of acre-feet in your body of water.

Type of Use	Parts per Million		Number of Acre-Feet Covered by One Gallon
	CFT Legumine	Active Rotenone	
Selective Treatment	0.10 to 0.13	0.005 to 0.007	30 to 24
Normal Pond Use	0.5 to 1.0	0.025 to 0.050	6.0 to 3.0
Remove Bullheads or Carp	1.0 to 2.0	0.050 to 0.100	3.0 to 1.5
Remove Bullheads or Carp in Rich Organic Ponds	2.0 to 4.0	0.100	1.5 to 0.75
Preimpoundment Treatment Above Dam	3.0 to 5.0	0.150 to 0.250	1.0 to 0.60

*Adapted from Kinney, Edward. 1965. Rotenone in Fish Pond Management. USDI Washington, DC Leaflet FL-576

Pre-Mixing and Method of Application: Pre-mix with water at a rate of one gallon of CFT Legumine to 10 gallons of water. Uniformly apply over water surface or bubble through underwater lines.

Detoxification: Water treated with this product will detoxify under natural conditions within one week to one month depending upon temperatures, alkalinity, etc. Rapid detoxification can be accomplished by adding chlorine or potassium permanganate to the water at the same rate as CFT Legumine in parts per million, plus enough additional to meet the chlorine demand of the untreated water.

Removal of Taste and Odor: Waters treated with this product do not retain a detectable taste or odor for more than a few days to a maximum of one month. Taste and odor can be removed immediately by treatment with activated charcoal at a rate of 30 ppm for each 1 ppm of CFT Legumine remaining. (Note: As this product detoxifies, less charcoal is required.)

Restocking After Treatment: Wait 2 to 4 weeks after treatment. Place a sample of fish to be stocked in wire cages in the coolest part of the treated waters. If the fish are not killed within 24 hours, the water may be restocked.

USE IN STREAMS IMMEDIATELY ABOVE LAKES, PONDS, AND RESERVOIRS

The purpose of treating streams immediately above lakes, ponds and reservoirs is to improve the effectiveness of lake, pond and reservoir treatments by preventing target fish from moving into the stream corridors, and not to control fish in streams per se. The term "immediately" means the first available site above the lake, pond or reservoir where treatment is practical, while still creating a sufficient barrier to prevent migration of target fish into the stream corridor.

In order to completely clear a fresh water aquatic habitat of target fish, the entire system above or between fish barriers must be treated. See the use directions for streams and rivers on this label for proper application instructions.

In order to treat a stream immediately above a lake, pond or reservoir you must: (a) Select the concentration of active rotenone, (b) Compute the flow rate of the stream, (c) Calculate the application rate, (d) Select an exposure time, (e) Estimate the amount of product needed, (f) Follow the method of application.

To prevent movement of fish from the pond, lake, or reservoir, the stream treatment should begin before and continue throughout treatment of the pond, lake or reservoir until mixing has occurred.

1. Concentration of Active Rotenone

Select the concentration of active rotenone based on the type of use from those listed on the table. Example: If you select "normal pond use" you could select a concentration of 0.025 parts per million.

2. Computation of Flow Rate for Stream

Select a cross section of the stream where the banks and bottom are relatively smooth and free of obstacles. Divide the surface width into 3 equal sections and determine the water depth and surface velocity at the center of each section. In slowly moving streams, determine the velocity by dropping a float attached to 5 feet of loose monofilament fishing line. Measure the time required for the float to move 5 feet. For fast-moving streams, use a longer distance. Take at least three readings at each point. To calculate the flow rate from the information obtained above, use the following formula:

$$F = \frac{W_s \times D \times L \times C}{T}$$

Where F = flow rate (cubic feet/second), W_s = surface width (feet), D = mean depth (feet), L = mean distance traveled by float (feet), C = constant (0.8 for rough bottoms and 0.9 for smooth bottoms), T = mean time for float (sec.).

3. Calculation of Application Rate

In order to calculate the application rate (expressed as gallons/second), convert the rate in the table (expressed as gallons/acre-feet) to gallons per cubic feet and multiply by the flow rate (expressed as cubic feet/second). Depending on the size of the stream and the type of equipment, the rate could be expressed in other units, such as ounces/hour, or cc/minute.

The application rate for the stream is calculated as follows:

$$R_s = R_p \times C \times F$$

Where R_s = application rate for stream (gallons/second), R_p = application rate for pond (gallons/acre-feet), $C = 1$ acre-foot/43560 cubic feet and F = flow rate of the stream (cubic feet/second).

4. Exposure Time

The exposure time would be the period of time (expressed in hours or minutes) during which CFT Legumine is applied to the stream in order to prevent target fish from escaping from the pond into the stream corridor.

5. Amount of Product

Calculate the amount of product for a stream by multiplying the application rate for streams by the exposure time.

$$A = R_s \times H$$

Where A = the amount of product for the stream application, R_s = application rate for stream (gallons/second) and H = the exposure time expressed in seconds.

FOR USE IN STREAMS AND RIVERS

Only state or Federal Fish and Wildlife personnel or professional fisheries biologists under the authorization of state or Federal Fish and Wildlife agencies are permitted to make applications of CFT Legumine for control of fish in streams and rivers. Informal consultation with Fish and Wildlife personnel regarding the potential occurrence of endangered species in areas to be treated should take place. Applicators must reference the Stream and River use Monograph before making any application to streams or rivers.

CFT LEGUMINE STREAM AND RIVER USE MONOGRAPH

USE IN STREAMS AND RIVERS

The following use directions are to provide guidance on how to make applications of CFT Legumine to streams and rivers. The unique nature of every application site could require minor adjustments to the method and rate of application. Should these unique conditions require major deviation from the use directions, a Special Local Need 24(c) registration should be obtained from the state.

Before applications of CFT Legumine can be made to streams and rivers, authorization must be obtained from state or federal Fish and Wildlife agencies. Since local environmental conditions will vary, consult with the state Fish and Wildlife agency to ensure the method and rate of application are appropriate for that site.

Contact the local water department to determine if any water intakes are within one mile downstream of the section of stream, river, or canal to be treated. If so, coordinate the application with the water department to make sure the intakes are closed during treatment and detoxification.

Application Rates and Concentration of Rotenone

Slow Moving Rivers: In slow moving rivers and streams with little or no water exchange, use instructions for ponds, lakes and reservoirs.

Flowing Streams and Rivers: Apply rotenone as a drip for 4 to 8 hours to the flowing portion of the stream. Multiple application sites are used along the length of the treated stream, spaced

approximately ½ to 2 miles apart depending on the water flow travel time between sites. Multiple sites are used because rotenone is diluted and detoxified with distance. Application sites are spaced at no more than 2 hours or at no less than 1-hour travel time intervals. This assures that the treated stream remains lethal to fish for a minimum of 2 hours. A non-toxic dye such as Rhodamine-WTR or fluorescein can be used to determine travel times. Cages containing live fish placed immediately upstream of the downstream application sites can be used as sentinels to assure that lethal conditions exist between sites.

Apply rotenone at each application site at a concentration of 0.25 to 1.0 part per million of CFT Legumine. The amount of CFT Legumine needed at each site is dependent on stream flow (see Computation of Flow Rate for Stream).

Application of Undiluted Material

CFT Legumine can drain directly into the center of the stream at a rate 0.85 to 3.4 cc per minute for each cubic foot per second of stream flow. Flow of undiluted CFT Legumine into the stream should be checked at least hourly. This is equivalent to from 0.5 to 2.0 ppm of this product, or from 0.025 to 0.100 ppm rotenone. Backwater, stagnant, and spring areas of streams should be sprayed by hand with a 10% v/v solution of CFT Legumine in water to assure a complete coverage.

Calculation of Application Rate:

$$X = F (1.699 B)$$

X = cc per minute of CFT Legumine applied to the stream, F = the flow rate (cu.ft/sec.) see Computation of Flow Rate for Stream section of the label, B = parts per million desired concentration of CFT Legumine

Total Amount of Product Needed for Treatment: Streams should be treated for 4 to 8 hours in order to clear the treated section of stream of fish. To determine the total amount of CFT Legumine required, use the following equation:

$$Y = X (0.0158 C)$$

Y = gallons of CFT Legumine required for the stream treatment, X = cc per minute of CFT Legumine applied to the stream, C = time in hours of the stream treatment.

Application of Diluted Material

Alternatively, for stream flows up to 25 cubic feet per second, continuous drip of diluted CFT Legumine at 80 cc per minute can be used. Flow of diluted CFT Legumine into the stream should be checked at least hourly. Use a 5 gallon reservoir over a 4 hour period, a 7.5 gallon reservoir over a 6 hour period, or a 10 gallon reservoir over an 8 hour period. The volume of the reservoir can be determined from the equation:

$$R = H \times 1.25$$

Where R = the volume of the reservoir in gallons, H = the duration of the application in hours.

The volume of CFT Legumine diluted with water in the reservoir is determined from the equation:

$$X = Y(102 F)H$$

Where X = the cc of CFT Legumine diluted in the reservoir, Y = parts per million desired concentration of CFT Legumine, F = the flow rate (cubic feet/second), H = the duration of the application (hours).

For flows over 25 cubic feet per second, additional reservoirs can be used concurrently. Backwater, stagnant and spring areas of streams should be sprayed by hand with a 10% v/v solution of CFT Legumine in water to assure a complete coverage.

Detoxification

To limit effects downstream, detoxification with potassium permanganate can be used at the downstream limit of the treated area. Within ½ to 2 miles of the furthest downstream CFT Legumine application site, the rotenone can be detoxified with a potassium permanganate solution at a resultant stream concentration of 2 to 4 parts per million, depending on rotenone concentration and permanganate demand of the water. A 2.5% (10 pounds potassium permanganate to 50 gallons of water) permanganate solution is dripped in at a continuous rate using the equation:

$$X = Y(70 F)$$

Where X = cc of 2.5% permanganate solution per minute, Y = ppm of desired permanganate concentration, F = cubic feet per second of stream flow.

Flow of permanganate should be checked at least hourly. Live fish in cages placed immediately above the permanganate application site will show signs of stress signaling the need for beginning detoxification. Detoxification can be terminated when replenished fish survive and show no signs of stress for at least four hours.

Detoxification of rotenone by permanganate requires between 15 to 30 minutes contact time (travel time). Cages containing live fish can be placed at these downstream intervals to judge the effectiveness of detoxification. At water temperatures less than 50°F detoxification may be retarded, requiring a longer contact time.

WARRANTY STATEMENT

Our recommendations for the use of this product are based upon tests believed to be reliable. The use of this product being beyond the control of the manufacturer, no guarantee, expressed or implied, is made as to the effects of such or the results to be obtained if not used in accordance with directions or established safe practice. To the extent consistent with applicable law, the buyer must assume all responsibility, including injury or damage, resulting from its misuse as such, or in combination with other materials.

D.1.2. Material Safety Data Sheet:

CWE Properties Ltd., LLC – P.O. Box 336277 – Greeley, CO 80633

CFT Legumine™

EPA Reg. No. 75338-2

Material Safety Data Sheet

SECTION 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT/CHEMICAL NAME: CFT Legumine™

Emergency Contact: 1-800-858-7378 (National Pesticide Information Center)

Transportation Emergency Contact: 1-800-858-7378 (National Pesticide Information Center)

Manufactured for: CWE Properties Ltd., LLC
P.O. Box 336277
Greeley, CO 80633

SECTION 2: HAZARDS IDENTIFICATION SUMMARY

KEEP OUT OF REACH OF CHILDREN –WARNING – May be fatal if inhaled. May be fatal if swallowed. Causes substantial, but temporary, eye injury. Causes skin irritation. Do not breathe spray mist. Do not get in eyes, on skin, or on clothing. Wear goggles or safety glasses. This product is an orange, viscous liquid with slight petroleum odor.

SECTION 3: COMPOSITION / INFORMATION ON INGREDIENTS

Chemical Ingredients:	Percentage By Weight	CAS No.	TLV (Units)
Rotenone	5.00	83-79-4	5 mg/m ³
Other Associated Resins	5.00		
Inert Ingredients, Including N-Methylpyrrolidone	90.00	872-50-4	not listed

SECTION 4: FIRST AID MEASURES

IF SWALLOWED: Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-900-858-7378 immediately for treatment advice. Do not induce vomiting unless told to do so by the Poison Control Center or physician. Do not give any liquid to the person. Do not give anything by mouth to an unconscious or convulsing person.

IF INHALED: Remove victim to fresh air. If not breathing, give artificial respiration, preferably by mouth-to-mouth. Call a physician, Poison Control Center, or the National Pesticide Information

Emergency Telephone Number: 1-800-858-7378

Revision Date: July 12, 2007

Center at 1-800-858-7378 immediately for treatment advice.

IF IN EYES: Hold eyelids open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.

IF ON SKIN OR CLOTHING: Take off contaminated clothing. Rinse skin with plenty of water for 15-20 minutes. Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.

Note: Have the product container or label with you when obtaining treatment advice.

SECTION 5: FIRE FIGHTING MEASURES

Flash Point (Method Used): 192°F (89°C) (Closed Cup)

Flammable Limits: LFL: Not established
UFL: Not established

Extinguishing Media: CO₂, foam, dry chemical water spray.

Special Fire Fighting Procedures: Use self-contained breathing apparatus and full protective equipment. Fight fire from upwind from a safe distance and keep non-essential personnel out of area.

SECTION 6: ACCIDENTAL RELEASE MEASURES

SPILL/LEAK PROCEDURES: Wear protective clothing as described in Section 8 (Exposure Controls / Personal Protection) of this MSDS. Absorb liquid with material such as clay, sand, sawdust, or dirt. Sweep up and place in a suitable container for disposal and label the contents. Area can be washed down with a suitable solution of bleach or soda ash and an appropriate alcohol (methanol, ethanol, or isopropanol). Follow this by washing with a strong soap and water solution. Absorb any excess liquid as indicated above, and add to the disposal container. This product is extremely toxic to fish. Fish kills are expected at recommended use rates. Keep spills and cleaning runoff out of municipal sewers and open bodies of water.

Emergency Telephone Number: 1-800-858-7378

Revision Date: July 12, 2007

SECTION 7: HANDLING AND STORAGE

HANDLING: Avoid inhalation of vapors. Harmful if swallowed, inhaled or absorbed through skin. Avoid contact with skin. Wear clean protective clothing. Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet. Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

STORAGE: Store in original containers only. Store in a dry place away from children and domestic animals. Do not store at temperatures below 40 F/4.4°C. This product is stable for a minimum of 1 year when stored in sealed drums at 70°F/21.1 °C. Do not contaminate water, food or feed by storage or disposal.

SECTION 8: EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (see section 3).

RESPIRATORY PROTECTION: When working with an undiluted product in a confined space, use a non-powered air purifying respirator equipped with an N-, R-, or P-series filter. For emergency or non-routine operations (cleaning reactor vessels or storage tanks), wear an SCBA"

Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres. If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **PROTECTIVE CLOTHING/EQUIPMENT:** Wear chemical-resistant gloves, boots, and aprons to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Physical State: Viscous liquid

Appearance and Odor: Orange liquid with slight solvent odor.

Specific Gravity: 1.019 g/ml

Bulk Density: 8.506 lbs./gal.

Emergency Telephone Number: 1-800-858-7378

Revision Date: July 12, 2007

SECTION 10: STABILITY AND REACTIVITY

Stability: Stable at room temperature in closed containers under normal storage and handling conditions.

Conditions to Avoid: None known.

Incompatibility: Strong acids and strong oxidizers,

Hazardous Decomposition Products: Oxides of carbon.

Hazardous Polymerization: Will not occur.

SECTION 11: TOXICOLOGICAL INFORMATION

Acute Oral LD₅₀ (rat): 55.3 – 264 mg/kg

Acute Dermal LD₅₀ (rabbit): >2020 mg/kg

Inhalation LC₅₀ (rat): 0.048 mg/L (4 HR)

Eye Irritation (rabbit): Moderately irritating

Skin Irritation (rabbit): Moderately irritating

Skin Sensitization (guinea pig): Not a sensitizer

Carcinogenic Potential: Not listed by IARC, NTP, or OSHA. ACGIH lists Rotenone as TLV A4: Not classifiable as to human carcinogenicity.

SECTION 12: ECOLOGICAL INFORMATION

This product is extremely toxic to fish. Fish kills are expected at recommended usage rates. Consult local Fish and Game agencies before applying this product to public waters to determine if a permit is needed for such an application.

SECTION 13: DISPOSAL CONSIDERATIONS

Do not reuse empty containers. **Plastic:** Triple rinse (or equivalent), then offer for recycling, or puncture and dispose of in a sanitary landfill, or incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke. **Metal:** Triple rinse (or equivalent), then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill or by other procedures approved by state and local authorities. Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of Federal law and may contaminate groundwater. Do not contaminate water, food or feed by storage or disposal.

SECTION 14: TRANSPORT INFORMATION

U.S DOT Shipping Description: Pesticide, Liquid, Toxic, N.O.S. (Rotenone), 6.1, UN2902, III, Marine Pollutant, ERG Guide 151
Emergency Telephone Number: 1-800-858-7378

Revision Date: July 12, 2007

CWE Properties Ltd., LLC – P.O. Box 336277 – Greeley, CO 80633

SECTION 15: REGULATORY INFORMATION

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) HAZARD RATINGS:

Category	Rating	0: Least
Health	4	1: Slight
Flammability	2	2: Moderate
Instability	0	3: High
		4: Severe

SARA Hazard Notification/Reporting:**SARA Title III Hazard Category:**

Immediate: Yes – Fire: No – Delayed: No – Reactive: No

Reportable Quantity (RQ) U.S. CERCLA: Not listed**SARA Title III, Section 313:** N-methylpyrrolidone (CAS: 872-50-4) 10.0%**RCRA Waste Code:** Not listed**California Proposition 65: WARNING:** This product contains chemicals known to the State of California to cause cancer or birth defects or other reproductive harm.

SECTION 16: OTHER INFORMATION

Prepared by: ERR**Issue Date:** July 12, 2007**Revision Notes:** July 12, 2007**NOTE:** *CFT Legumine is a Restricted Use Pesticide due to Aquatic Toxicity*

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state, and local laws and regulations.

Emergency Telephone Number: 1-800-858-7378

Revision Date: July 12, 2007

D.2 Prentox Powder:

D.2.1 Product Label:

RESTRICTED USE PESTICIDE
DUE TO AQUATIC, ACUTE ORAL AND INHALATION TOXICITY
 For retail sale to, and use by, Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.



ROTENONE FISH TOXICANT POWDER

ACTIVE INGREDIENTS:		
Rotenone- Minimum Guaranteed		7.4% w/w
Other Associated Resins		11.1%
OTHER INGREDIENTS:		81.5%
	TOTAL:	100.0% w/w
ROTENONE ASSAY _____		% ROTENONE

PRENTOX® - Registered Trademark of Prentiss Incorporated

KEEP OUT OF REACH OF CHILDREN



DANGER
POISON



FIRST AID

Have the product container or label with you when calling a poison control center or physician, or going for treatment.

If swallowed	<ul style="list-style-type: none"> • Call a Poison Control Center, physician, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by the Poison Control Center or physician. • Do not give anything by mouth to an unconscious or convulsing person.
If on skin or clothing	<ul style="list-style-type: none"> • Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a Poison Control Center, physician, or the National Pesticide Information Center at 1-800-858-7378 for treatment advice.
If in eyes	<ul style="list-style-type: none"> • Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a Poison Control Center, physician, or the National Pesticide Information Center at 1-800-858-7378 for treatment advice.
If inhaled	<ul style="list-style-type: none"> • Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. • Call a Poison Control Center, physician, or the National Pesticide Information Center at 1-800-858-7378 for treatment advice.

For information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378.

SEE INSIDE LEAFLET FOR ADDITIONAL PRECAUTIONARY STATEMENTS AND DIRECTIONS FOR USE

Manufactured by:

5/02

E.P.A. REG. NO. 655-691

E.P.A. EST. NO. 655-GA-1

PRENTISS INCORPORATED

Plant: Kaolin Road, Sandersville, GA 31082
 Office: C.B. 2000, Floral Park, NY 11002-2000

**PRECAUTIONARY STATEMENTS
 HAZARDS TO HUMANS AND DOMESTIC ANIMALS
 DANGER**

Fatal if inhaled or swallowed. Harmful if absorbed through the skin. Causes moderate eye irritation. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not breathe dust. Use a dust/mist filtering respirator (MSHA/NIOSH approval number prefix TC-21C), or a NIOSH approved respirator with any N, R, P or HE filter. Avoid contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash clothing before reuse.

ENVIRONMENTAL HAZARDS

This pesticide is extremely toxic to fish. Fish kills are expected at recommended rates. Consult your State Fish and Game Agency before applying this product to public waters to determine if a permit is needed for such an application. Do not contaminate untreated water when disposing of equipment washwaters.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

STORAGE: Store only in original container, in a dry place inaccessible to children and pets. If spilled, sweep up and dispose of as below.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Completely empty bag into application equipment. Then dispose of bag in a sanitary landfill or by incineration, or if allowed by State and local authorities by burning. If burned, stay out of smoke.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

USE RESTRICTIONS:

Use against fish in lakes, ponds, and streams (immediately above lakes and ponds).

Since such factors as pH, temperature, depth, and turbidity will change effectiveness, use this product only at locations, rates, and times authorized and approved by appropriate state and Federal fish and wildlife agencies. Rates must be within the range specified in the labeling.

Properly dispose of dead fish and unused product. Do not use dead fish as food or feed.

Do not use water treated with rotenone to irrigate crops or release within 1/2 mile upstream of a potable water or irrigation water intake in a standing body of water such as a lake, pond or reservoir.

Note to User: Adjust pounds of Rotenone according to the actual Rotenone Assay as noted under the Ingredient Statement on this label. For example, if the required amount of 5% rotenone is 21 pounds, and the Rotenone Assay is 75%, use 7/7 of 21 pounds or 15 pounds of this product to yield the proper amount of active rotenone.

APPLICATION DIRECTIONS:

Treatment of Lakes and Ponds

1. **Application Rates and Concentrations of Rotenone**
The actual application rates and concentrations of rotenone needed to control fish will vary widely, depending on the type of use (e.g. selective treatment, normal pond treatment, etc.) and the factors listed above. The table below is a general guide for the proper rates and concentrations.

2. **Total Amount of Product Needed for Treatment**
To determine the total number of pounds needed for treatment, divide the number of acre-feet covered by one pound for a specific type of use (e.g. selective treatment, etc.), as indicated in the table below, into the number of acre-feet in the body of water.

General Guide to the Application Rates and Concentrations of Rotenone Needed to Control Fish in Lakes and Ponds:

Type of Use	No. of Acre-Feet Covered by One Pound	Parts Per Million	
		Active Rotenone	5% Product
Selective Treatment	3.7 to 2.8	0.005 - 0.007	0.10 - 1.3
Normal Pond Use	0.74 to 0.37	0.025 - 0.050	0.5 - 1.0
Remove Bullheads or Carp	0.37 to 0.185	0.050 - 0.100	1.02 - 2.0
Remove Bullheads or Carp in Rich Organic Ponds	0.185 to 0.093	0.100 - 0.200	2.0 - 4.0
Pre-impoundment Treatment above Dam	0.123 to 0.074	0.150 - 0.250	3.0 - 5.0

5. Restocking

Waters treated with this product detoxify within 2 to 4 weeks after treatment, depending on pH, temperature, water hardness, and depth. To determine if detoxification has occurred, place live boxes containing samples of fish to be stocked in treated waters. More rapid detoxification can be accomplished by adding Potassium Permanganate or chlorine at a 1:1 ratio with the concentration of rotenone applied, plus sufficient additional compound to satisfy the chemical oxidation demand caused by organic matter that may be present in the treated water.

Treatment of Streams Immediately Above Lakes and Ponds

The purpose of treating streams immediately above lakes and ponds is to improve the effectiveness of lake and pond treatments and not to control fish in streams per se. The term "immediately" means the first available site above the lake or pond where treatment is practical.

In order to treat a stream immediately above a lake or pond, you must select a concentration of active rotenone, compute the flow rate of a stream, calculate the application rate, select an exposure time, estimate the amount of product needed, and follow the method of application.

1. Concentration of Active Rotenone

Select the "Concentration of Active Rotenone" based on the type of use from those on the table. For example, if you select "Normal Pond Use" you could select a concentration of "0.025 Parts per Million".

2. Computation of Flow Rate for Stream

Select a cross section of the stream where the banks and bottom are relatively smooth and free of obstacles. Divide the surface width into 3 equal sections and determine the water depth and surface velocity at the center of each section. In slowly moving streams, determine the velocity by dropping a float attached to 5 feet of loose, monofilament fishing line. Measure the time required for the float to move 5 feet. For fast-moving streams, use a longer distance. Take at least three readings at each point. To calculate the flow rate from the information obtained above, use the following formula:

$$F = \frac{W_s \times D \times L \times C}{T}$$

where F = flow rate (cu. ft./sec.), W_s = surface width (ft.), D = mean depth (ft.), L = mean distance traveled by float (ft.), C = constant (0.8 for rough bottoms and 0.9 for smooth bottoms), and T = mean time for float (sec.).

For example, after using the above formula, you might have computed the stream's flow rate to be "10 cu. ft. per sec."

3. Calculation of Application Rate

In order to calculate the application rate (expressed as "pound per sec."), you convert the rate in the table (expressed as "pound per acre-foot"), to "pound per cu. feet" and multiply by the flow rate (expressed as "cu. ft. per sec."). Depending on the size of the stream and the type of equipment, the rate could be expressed in other units, such as "ounces per hr."

The application rate for the stream above is calculated as follows:

$$R_s = R_p \times C \times F$$

where R_s = Application Rate for Stream (lb/sec), R_p = Application Rate for Pond (lb/acre feet), C = 1 acre foot/43560 cu. ft., and F = Flow Rate (cu. ft/sec).

In the example, the Application Rate for Stream would be:

$$R_s = 1 \text{ lb}/0.74 \text{ acre-foot} \times 1 \text{ acre-foot}/43560 \text{ cu. ft.} \times 10 \text{ cu. ft./sec.}$$

$$R_s = .00031 \text{ lb/sec or } 17.9 \text{ oz./hr.}$$

4. Exposure Time

The "Exposure Time" would be the period of time (expressed in hours or seconds) during which target fish should not enter the lake or pond under treatment. In the example, this period of time could be 4 hours.

5. Amount of Product

Calculate the "Amount of Product" for a stream by multiplying the "Application Rate for Stream" by the "Exposure Time". In the example, the "Amount of Product" would be 71.6 oz. (17.9 oz./hr. x 4 hr.) or 4.5 lb.

RE-ENTRY STATEMENT

Do not allow swimming in rotenone-treated water until the application has been completed and all pesticide has been thoroughly mixed into the water according to labeling instructions.

¹Adapted from Kinney, Edward, 1965 Rotenone in Fish Pond Management. USDI Washington, D.C. Leaflet FL-576.

Computation of acre-feet for lake or pond: An acre-foot is a unit of water volume having a surface area of one acre and a depth of one foot. Make a series of transects across the surface, taking depths with a measured pole or weighted line. Add the measurements and divide by the number made to determine the average depth. To compute **total acre-feet**, multiply this average depth by the number of surface acres, which can be determined from an aerial photograph or plat drawn to scale.

3. **Pre-Mixing Method of Application**

Pre-mix one pound of Rotenone with 3 to 10 gallons of water. Uniformly apply over water surface or bubble through underwater lines.

Alternately place undiluted powder in burlap sack and trail behind boat. When treating deep water (20 to 25 feet) weight bag and tow at desired depth.

4. **Removal of Taste and Odor**

Rotenone treated waters do not retain a detectable taste or odor for more than a few days to a maximum of one month. Taste and odor can be removed immediately by treatment with activated charcoal at a rate of 30 ppm. for each 1 ppm. Rotenone remaining (Note: As Rotenone detoxifies, less charcoal is required).

SPECIMEN

D.2.2 Material Safety Data Sheet:

Product: 655-3 Prentox® Cube Powder

Material Safety Data Sheet
U.S. Department of Labor (OSHA 29 CFR 1910.1200)

Section I: Product and Company Identification

Product: 655-3 Prentox® Cube Powder

Manufacturer's Name: Prentiss Incorporated
 C. B. 2000
 Floral Park, NY 11001

Telephone Number: (516) 326-1919

Section II: Composition/Information on Ingredients

Ingredient Name:	OSHA PEL	ACGIH TLV	%
Rotenone (CAS # 83-79-4)	(TWA) 5 mg/M ³	(TWA) 5 mg/M ³	7.4
Other Cube Resins	None	None	11.1
Other Ingredients	None	None	81.5

Section 3: Hazards Identification:

Emergency Overview:

A tan powder with a wet chalk or dirt-like odor.

- Fatal if inhaled or swallowed
- Harmful if absorbed through skin
- Causes moderate eye irritation
- May cause allergic skin reactions in some individuals
- This pesticide is extremely toxic to fish

Potential Health Effects:

Primary Route(s) of Entry:

Ingestion, inhalation, and skin contact

Eyes:

Causes moderate eye irritation

Skin:

Harmful if absorbed through the skin. Prolonged or frequently repeated skin contact may cause allergic skin reactions in some individuals.

Ingestion:

Fatal if swallowed

Inhalation:

Fatal if inhaled

Signs and symptoms of acute overexposure:

May cause irritation of the eyes, nose and throat in addition to temporary numbness. Prolonged or repeated exposure can cause nausea, vomiting, abdominal cramps, muscle tremors, poor muscle coordination, seizures, shallow breathing, skin rashes and eye, nose and mouth lesions.

Section 4: First Aid Measures:

Eyes:

Flush eyes with plenty of water for 15 minutes. Get medical attention if irritation persists

Skin:

Wash with plenty of soap and water. Get medical attention if irritation persists

Ingestion:

Call a physician or Poison Control Center. Drink 1 or 2 glasses of water and induce vomiting by touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person.

Inhalation:

Remove person to fresh air. If not breathing, give artificial respiration, preferably mouth to mouth. Get medical attention

Note to Physician:

If a small amount is ingested (or if treatment is delayed), oral administration of large amounts of activated charcoal and a cathartic is probably sufficient therapy.

Do not administer milk, cream or other substances containing vegetable or animal fats, which enhance the absorption of lipophilic substances.

Section 5: Fire Fighting Measures:

Extinguishing Media:

Carbon dioxide, dry chemical, foam or water

Fire Fighting Instructions:

As in any fire, wear self-contained breathing apparatus, pressure demand, MSHA/NIOSH approved (or equivalent), and full protective gear. Keep upwind. Isolate hazard area. Avoid inhalation of smoke and fumes. Use water or foam to reduce fumes. Do not touch spilled material. If possible, move containers from area. Extinguish only if flow can be stopped. Use flooding amounts of water as a fog. Cool containers with flooding amounts of water from as far a distance as possible. Avoid breathing vapors.

Flammability Classification/Rating:

NFPA/OSHA Class: III B

NFPA Rating (Fire): 1

Section 6: Accidental Release Measures:

General and Disposal: Use proper protective equipment to minimize personal exposure (see Section 8). Take all necessary action to prevent and to remedy the adverse effect of the spill. Ensure that the disposal is in compliance with all Federal, State/Provincial, and local regulations (see Section 13 for applicable RCRA number). Refer to Section 15 for applicable Reportable Quantity (RQ) and other regulatory requirements.

Land Spill: Sweep or shovel spilled material into a tightly sealed container. Dispose of with chemical waste.

Section 7: Handling and Storage:

Handling Precautions:

Do not breathe dust. Avoid contact with eyes, skin or clothing.

Storage Precautions:

Do not contaminate water, food or feed by storage. Store in a dry place, away from excessive temperature extremes.

Work/Hygienic Practices:

Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash before reuse.

Section 8: Exposure Controls/Personal Protection:

Manufacturing, formulation and other Non-Agricultural uses,

Engineering controls:

Control airborne concentrations below the appropriate exposure guideline (see Section 2 for applicable OSHA/ACGIH Exposure Limits). Local exhaust ventilation may be necessary.

Eye/Face Protection:

Wear safety glasses, splash goggles or face shield.

Skin Protection:

Wear chemical resistant gloves (Neoprene, Nitrile rubber or PVC) and other protective clothing to avoid skin contact.

Respiratory Protection:

Ensure good ventilation. If not adequate, use a chemical cartridge type respirator approved by the National Institute of Occupational Health and Safety.

General Protection:

Eye wash facility and safety shower should be available. Wear a protective apron, long sleeves and pants to prevent skin contact.

Section 9: Physical and Chemical Properties:

Appearance:

Tan powder

Odor:

Wet chalk or dirt-like odor.

Basic Physical Properties:

Physical State: Solid

Solubility (H₂O): Insoluble

Bulk Density: Fluffed – 0.24 gm/cm³ (14.7 lb./cu. Ft.). Packed – 0.45 gm/cm³ (28.1 lb./cu. Ft.)

Section 10: Stability and Reactivity:

Stability: Stable.

Conditions to Avoid (Stability): High temperatures and constant exposure to sunlight

Incompatible Materials: Avoid strong oxidizers and reducing agents

Hazardous Polymerization: Will not occur

Section 11: Toxicological Information:

The following data were developed with rotenone dust containing 5% rotenone.

Eye Effects:

Irritation (Rabbit): Slightly irritating.

Skin Effects:

Irritation (Rabbit): Non-irritating.

Absorption (Rabbit): LD₅₀ > 2,020 mg/kg (Slightly Toxic).

Sensitization (Guinea Pig): Sensitizing

Acute Oral Effects:

LD₅₀ (Rat, male): 874 mg/kg (Slightly Toxic).

(Rat, female): 99.2 mg/kg (Moderately Toxic).

Acute Inhalation Effects:

4 hour LC₅₀ (Rat, Male): 0.087 mg/L (Moderately Toxic).

4 hour LC₅₀ (Rat, Female): 0.045 mg/L (Highly Toxic).

4 hour LC₅₀ (Rat): 0.056 mg/L (Moderately Toxic).

Note: the severity classifications listed above are those of Prentiss Incorporated, and, particularly for eye irritation, may not always coincide with EPA-mandated Precautionary Statements.

The following data were developed with rotenone, the active ingredient in this product.

Chronic (Cancer) Information:

Rotenone was not carcinogenic when tested in rats and mice.

Carcinogenicity: NTP: No IARC: No OSHA: No

Teratogenicity (Birth Defects):

Rotenone was not teratogenic or fetotoxic when tested in rats and mice.

Reproductive Effects:

Rotenone had no adverse effects on reproduction when tested over two successive generations in rats.

Mutagenicity (Genetic Effects):

Rotenone was not mutagenic nor clastogenic when tested in the Ames test, Yeast test, Mouse Lymphoma test, Mouse Micronucleus test, Chromosome Aberration test and the Mitotic Recombination test in Yeast.

Section 12: Ecological Information:

Other Environmental Information:

This pesticide is extremely toxic to fish. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans or other waters, unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance, contact your State Water Board or Regional Office of the EPA.

Product: 655-3 Prentox® Cube Powder

Section 13: Disposal Considerations:

Do not contaminate water, food or feed by disposal.

Pesticide Disposal:

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

Container Disposal:

Completely empty liner by shaking and tapping sides and bottom to loosen clinging particles. Empty residue into application equipment. Then dispose of liner in a sanitary landfill or by incineration if allowed by State and local authorities. If drum is contaminated and cannot be reused, dispose of in the same manner.

RCRA Information:

RCRA Hazardous Waste Ingredients: None.

Section 14: Transport Information:

Proper Shipping Name: Pesticide, Solid, Toxic, n.o.s. (Rotenone)

Hazard Class: 6.1, PG I

DOT Identification Number: UN2588

DOT Shipping Label: POISON

Additional Shipping Paper Description: Marine Pollutant

Note: For transport purposes (49 CFR Part 173.132), the calculated 1 hour LC₅₀ (Rat) is:
0.224 mg/L (dust)

Section 15: Regulatory Information:

U.S. Federal Regulatory Information:

EPA Reg. No.: 655-3

TSCA Inventory: Registered pesticide, exempt from TSCA.

SARA Title III Notification and Information:

Section 302 (EHS) ingredients: None.

Section 304 (CERCLA & EHS) ingredients (RQ): None.

Section 313 ingredients: None.

SARA Title III Notifications and Information:

SARA Title III Hazard Classes:

Acute Health Hazard: Yes

Chronic Health Hazard: No

Fire Hazard: No

Sudden Release of Pressure Hazard: No

Reactivity Hazard: No

Product: 655-3 Prentox® Cube Powder

Regulated Ingredients:

Ingredient: Rotenone

CAS Number: 83-79-4

Percent by Weight: 7.4

Regulations:

Illinois Toxic Substance

Massachusetts Hazardous Substance

New Jersey Special Health Hazardous Substance

New Jersey Workplace Hazardous Substance

Pennsylvania Workplace Hazardous Substance

U.S. State Regulatory Information:

California (Proposition 65): This product does not contain any chemical which is known to the State of California to cause cancer or birth defects, or other reproductive harm.

Canadian Regulatory Information:

CPC Number: None

WHMIS Classification for Control Product Regulations (CPR): Registered pesticide under US FIFRA regulations; exempt from CPR classification.

The MSDS contains all CPR required hazard-related information.

WHMIS Hazard Rating: See HMIS rating (Section 16).

Section 16: Other Information:

NFPA Hazard Rating:

Health: 2 – Moderate

Fire: 1 – Slight

Reactivity: 0 – Negligible

Special:

HMIS Hazard Rating:

Health: 2 – Moderate

Fire: 1 – Slight

Reactivity: 0 – Negligible

Protection: J

Date Prepared: August 14, 2000

Supersedes: November 3, 1997

Reason: Revision of sections 3, 5, 6, 7, 8, 9, 11, 13, 14, 15

The information and recommendations contained herein are based upon data believed to be correct. However, no guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein.

D.3 Prentox Prenfish

D.3.1 Product Label

Front Panel

RESTRICTED USE PESTICIDE
DUE TO AQUATIC AND ACUTE INHALATION TOXICITY
 For retail sale to, and use only by, Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.



PRENFISH TOXICANT

Liquid Emulsifiable

*For Control of Fish in Lakes, Ponds, Reservoirs and Streams

ACTIVE INGREDIENTS:

Rotenone

Other Associated Resins

INERT INGREDIENTS*

TOTAL

5.0%
5.0%
90.0%
100.0%

*This product contains aromatic hydrocarbons.

PRENTOX® - Registered Trademark of Prentiss Incorporated

KEEP OUT OF REACH OF CHILDREN



DANGER - POISONOUS



See inside booklet for additional precautionary statements.

FIRST AID

Have product container or label with you when obtaining treatment advice.

If swallowed	<ul style="list-style-type: none"> • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice. • Do not induce vomiting unless told to do so by the Poison Control Center or physician. • Do not give any liquid to the person. • Do not give anything by mouth to an unconscious or convulsing person.
If inhaled	<ul style="list-style-type: none"> • Remove victim to fresh air. • If not breathing, give artificial respiration, preferably mouth-to-mouth. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
If in eyes	<ul style="list-style-type: none"> • Hold eyelids open and rinse slowly and gently with water for 15-20 minutes. • Remove contacts, if present, after the first 5 minutes, then continue rinsing eye. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
If on skin or clothing	<ul style="list-style-type: none"> • Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.

For information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378.

EPA Reg. No. 655-422

9/02

EPA Est. No. 655-GA-1

Manufactured by:

PRENTISS INCORPORATED

Plant: Kaolin Road, Sandersville, GA 31082
 Office: C.B. 2000, Floral Park, NY 11002-2000

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
DANGER

Fatal if inhaled. May be fatal if swallowed. Harmful if absorbed through skin. Causes substantial but temporary eye injury. Causes skin irritation. Do not breathe spray mist. Do not get in eyes, on skin or on clothing. Wear goggles or safety glasses. When working with undiluted product, wear either a respirator with an organic-vapor-removing cartridge with a prefilter approved for pesticides (MSHA/NIOSH approval number prefix TC-23C), or a canister approved for pesticides (MSHA/NIOSH approval number prefix 14G), or a NIOSH approved respirator with an organic vapor (OV) cartridge or canister with any R, P or HE prefilter. Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash before reuse.

ENVIRONMENTAL HAZARDS

This pesticide is extremely toxic to fish. Fish kills are expected at recommended rates. Consult your State Fish and Game Agency before applying this product to public waters to determine if a permit is needed for such an application. Do not contaminate untreated water when disposing of equipment washwaters.

CHEMICAL AND PHYSICAL HAZARDS

FLAMMABLE: KEEP AWAY FROM HEAT AND OPEN FLAME. FLASH POINT MINIMUM 45° F (7° C).

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.
Storage: Store only in original containers, in a dry place inaccessible to children and pets. Prentox Prentfish Toxicant will not solidify nor show any separation at temperatures down to 40°F and is stable for a minimum of one year when stored in sealed drums at 70°F.
Pesticide Disposal: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of federal law. If these wastes cannot be disposed of by use according to label instructions contact your state pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.
Container Disposal: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.
General Information
 Prentox Prentfish Toxicant is a specially formulated product containing rotenone, to be used in fisheries management for the eradication of fish from lakes, ponds, reservoirs and streams.
 Since such factors as pH, temperature, depth and turbidity will change effectiveness, use this product only at locations, rates, and times authorized and approved by appropriate state and federal fish and wildlife agencies. Rates must be within the range specified on the label.

Properly dispose of unused product. Do not use dead fish for food or feed. Do not use water treated with rotenone to irrigate crops or release within 1/2 mile upstream of a potable water or irrigation water intake in a standing body of water such as a lake, pond or reservoir.

Re-entry Statement: Do not allow swimming in rotenone-treated water until the application has been completed and all pesticide has been thoroughly mixed into the water according to labeling instructions.

For Use in Ponds, Lakes and Reservoirs

The actual application rates and concentrations of rotenone needed to control fish will vary widely, depending on the type of use (e.g., selective treatment, normal pond use, etc.) and the factors listed above. The table below is a general guide for the proper rates and concentrations.

Prentox Prentfish Toxicant disperses readily in water both laterally and vertically, and will penetrate below the thermocline in thermally stratified bodies of water.

Computation of Acre-Feet: An acre-foot is a unit of volume of a body of water having the area of one acre and the depth of one foot. To determine acre feet in a given body of water, make a series of transects across the body of water taking depths with a measured pole or weighted line. Add the soundings and divide by the number made to determine the average depth. Multiply this average depth by the total surface area in order to determine the acre feet to be treated. If number of surface acres is unknown, contact your local Soil Conservation Service, which can determine this from aerial photographs.

Amount of Prentox Prentfish Toxicant Needed for Specific Uses: To determine the approximate number of gallons of Prentox Prentfish Toxicant (5.0% Rotenone) needed, find your "Type of Use" in the first column of the table below and then divide the corresponding number in the fourth column, "Number of Acre-Feet Covered by One Gallon" into the number of acre-feet in your body of water.

General Guide to the Application Rates and Concentrations of Rotenone Needed to Control Fish in Lakes, Ponds and Reservoirs

Type of Use	Parts Per Million		Number of Acre-Feet Covered by One Gallon
	Prentfish Toxicant	Active Rotenone	
Selective Treatment	0.10 to 0.12	0.005 to 0.007	30 to 24
Normal Pond Use	0.5 to 1.0	0.025 to 0.050	6.0 to 3.0
Remove bullheads or carp	1.0 to 2.0	0.050 to 0.100	3.0 to 1.5
Remove bullheads or carp in rich organic ponds	2.0 to 4.0	0.100 to 0.200	1.5 to 0.75
Preinpointment treatment above dam	3.0 to 5.0	0.150 to 0.250	1.0 to 0.60

Adapted from Kinney, Edward. 1965. Rotenone in Fish Pond Management. USDI Washington, D.C. Leaflet FL-576.

Pre-Mixing and Method of Application: Pre-mix with water at a rate of one gallon Prentox Prentfish Toxicant to 10 gallons of water. Uniformly apply over water surface or bubble through underwater lines.

Detoxification: Prentox Prentfish Toxicant treated waters detoxify under natural conditions within one week to one month depending upon temperatures, alkalinity, etc. Rapid detoxification can be accomplished by adding chlorine or potassium permanganate to the water at the same rate as Prentox Prentfish Toxicant in parts per million, plus enough additional to meet the chlorine demand of the untreated water.

Removal of Taste and Odor: Prentox Prentfish Toxicant treated waters do not retain a detectable taste or odor for more than a few days to a maximum of one month. Taste and odor can be removed immediately by treatment with activated charcoal at a rate of 30 ppm for each 1 ppm Prentox Prentfish Toxicant remaining. (Note: As Prentox Prentfish Toxicant detoxifies, less charcoal is required.)

Restocking After Treatment: Wait 2 to 4 weeks after treatment. Place a sample of fish to be stocked in wire cages in the coolest part of the treated waters. If the fish are not killed within 24 hours, the water may be restocked.

Use in Streams Immediately Above Lakes, Ponds and Reservoirs

The purpose of treating streams immediately above lakes, ponds and reservoirs is to improve the effectiveness of lake, pond and reservoir treatments by preventing target fish from moving into the stream corridors, and not to control fish in streams per se. The term "immediately" means the first available site above the lake, pond or reservoir where treatment is practical, while still creating a sufficient barrier to prevent migration of target fish into the stream corridor.

In order to completely clear a fresh water aquatic habitat of target fish, the entire system above or between fish barriers must be treated. See the use directions for streams and rivers on this label for proper application instructions.

In order to treat a stream immediately above a lake, pond or reservoir you must: (a) select the concentration of active rotenone, (b) compute the flow rate of the stream, (c) calculate the application rate, (d) select an exposure time, (e) estimate the amount of product needed, (f) follow the method of application. To prevent movement of fish from the pond, lake or reservoir, stream treatment should begin before and continue throughout treatment of the pond, lake or reservoir until mixing has occurred.

1. Concentration of Active Rotenone

Select the concentration of active rotenone based on the type of use from those listed on the table. Example: If you select "normal pond use" you could select a concentration of 0.025 part per million.

2. Computation of Flow Rate for Stream

Select a cross section of the stream where the banks and bottom are relatively smooth and free of obstacles. Divide the surface width into 3 equal sections and determine the water depth and surface velocity at the center of each section. In slowly moving streams, determine the velocity by dropping a float attached to 5 feet of loose monofilament fishing line. Measure the time required for the float to move 5 feet. For fast-moving streams, use a longer distance. Take at least three readings at each point. To calculate the flow rate from the information obtained above, use the following formula:

$$F = \frac{W_s \times D \times L \times C}{T}$$

Where F = flow rate (cubic feet/second), W_s = surface width (feet), D = mean depth (feet), L = mean distance traveled by float (feet), C = constant (0.8 for rough bottoms and 0.9 for smooth bottoms), and T = mean time for float (sec.).

Calculation of Application Rate

In order to calculate the application rate (expressed as gallons/second), you convert the rate in the table (expressed as gallons/acre-foot), to gallons per cubic feet and multiply by the flow rate (expressed as cubic feet/second). Depending on the size of the stream and the type of equipment, the rate could be expressed in other units, such as ounces/hour, or cc/minute.

The application rate for the stream is calculated as follows:

$$R_s = R_p \times C \times F$$

where R_s = application rate for stream (gallons/second), R_p = application rate for pond (gallons/acre-foot), C = 1 acre foot/43560 cubic feet, and F = flow rate of the stream (cubic feet/second).

4. Exposure Time

The exposure time would be the period of time (expressed in hours or minutes) during which Prentox Prentfish Toxicant is applied to the stream in order to prevent target fish from escaping from the pond into the stream corridor.

5. Amount of Product

Calculate the amount of product for a stream by multiplying the application rate for streams by the exposure time.

$$A = R_s \times H$$

where A = the amount of product for the stream application, R_s = application rate for stream (gallons/second), and H = the exposure time expressed in seconds.

For use in Streams and Rivers

Only state or federal Fish and Wildlife personnel or professional fisheries biologists under the authorization of state or federal Fish and Wildlife Agencies are permitted to make applications of Prentox Prentfish Toxicant for control of fish in streams and rivers. Informal consultation with Fish and Wildlife personnel regarding the potential occurrence of endangered species in areas to be treated should take place. Applicators must reference Prentox Incorporated's Prentox Prentfish Toxicant Stream and River Use Monograph before making any application to streams or rivers.

Warranty Statement: Our recommendations for the use of this product are based upon tests believed to be reliable. The use of this product being beyond the control of the manufacturer, no guarantee, expressed or implied, is made as to the effects of such or the results to be obtained if not used in accordance with directions or established safe practice. The buyer must assume all responsibility, including injury or damage, resulting from its misuse as such, or in combination with other materials.

**PRENTOX® PRENFISH TOXICANT STREAM AND RIVER
USE MONOGRAPH
USE IN STREAMS AND RIVERS**

The following use directions are to provide guidance on how to make applications of Prentox Prenfish Toxicant to streams and rivers. The unique nature of every application site could require minor adjustments to the method and rate of application. Should these unique conditions require major deviation from the use directions, a Special Local Need 24(c) registration should be obtained from the state.

Before applications of Prentox Prenfish Toxicant can be made to streams and rivers, authorization must be obtained from state or federal Fish and Wildlife agencies. Since local environmental conditions will vary, consult with the state Fish and Wildlife agency to ensure the method and rate of application are appropriate for that site.

Contact the local Water Department to determine if any water intakes are within one mile down flow of the section of stream, river or canal to be treated. If so, coordinate the application with the water department to make sure the intakes are closed during treatment and detoxification.

Application Rates and Concentration of Rotenone

Slow Moving Rivers: Apply rotenone as a drip for 4 to 8 hours to the flowing portion of the stream. Multiple application sites are used along the length of the treated stream, spaced approximately 1/2 to 2 miles apart depending on the water flow travel time between sites. Multiple sites are used because rotenone is diluted and detoxified with distance. Application sites are spaced at no more than 2 hours or at no less than 1 hour travel time intervals. This assures that the treated stream remains lethal to fish for a minimum of 2 hours. A non-toxic dye such as Rhodamine-WT or fluorescein can be used to determine travel times. Cages containing live fish placed immediately upstream of the downstream application sites can be used as sentinels to assure that lethal conditions exist between sites.

Apply rotenone at each application site at a concentration of 0.25 to 1.0 part per million of Prentox Prenfish Toxicant. The amount of Prentox Prenfish Toxicant needed at each site is dependent on stream flow (see Computation of Flow Rate for Streams).

Application of Undiluted Material

Prentox Prenfish Toxicant can drain directly into the center of the stream at a rate of 0.85 to 2.4 cc per minute for each cubic foot per second of stream flow. Flow of undiluted Prentox Prenfish Toxicant into the stream should be checked at least hourly. This is equivalent to from 0.25 to 1.0 ppm Prentox Prenfish Toxicant, or from 0.012 to 0.050 ppm rotenone. Back-water, stagnant and spring areas of streams should be sprayed by hand with a 10% w/v solution of Prentox Prenfish Toxicant in water to assure a complete coverage.

Calculation of Application Rate:

$$X = F(1.69 B)$$

X = cc per minute of Prentox Prenfish Toxicant applied to the stream, F = the flow rate (cu. ft./sec.) see Computation of Flow Rate for Stream section of the label, B = parts per million desired concentration of Prentox Prenfish Toxicant.

Total Amount of Product Needed for Treatment: Streams should be treated for 4 to 8 hours in order to clear the treated section of stream of fish. To determine the total amount of Prentox Prenfish Toxicant required use the following equation:

$$Y = X(0.0158 C)$$

Y = gallons of Prentox Prenfish Toxicant required for the stream treatment, X = cc per minute of Prentox Prenfish Toxicant applied to the stream, C = time in hours of the stream treatment.

Application of Diluted Material

Alternatively, for stream flows up to 15 cubic feet per minute, continuous drip of diluted Prentox Prenfish Toxicant at 80 cc-per minute can be used. Flow of diluted Prentox Prenfish Toxicant into the stream should be checked at least hourly. Use a 5 gallon reservoir over a 4 hour period, a 7.5 gallon reservoir over a 6 hour period, or a 10 gallon reservoir over an 8 hour period. The volume of the reservoir can be determined from the equation:

$$R = H * 1.25$$

where R = the volume of the reservoir in gallons, and H = the duration of the application in hours.

The volume of Prentox Prenfish Toxicant diluted with water in the reservoir is determined from the equation:

$$X = Y(102 F)H$$

where X = the cc of Prentox Prenfish Toxicant diluted in the reservoir, Y = parts per million desired concentration of Prentox Prenfish Toxicant, F = the flow rate (cubic feet/second), H = the duration of the application (hours).

For flows over 15 cubic feet per minute, additional reservoirs can be used concurrently. Back-water, stagnant and spring areas of streams should be sprayed by hand with a 10% w/v solution of Prentox Prenfish Toxicant in water to assure a complete coverage.

Detoxification

To limit effects downstream, detoxification with potassium permanganate can be used at the downstream limit of the treated area. Within 1/2 to 2 miles of the furthest downstream Prentox Prenfish Toxicant application site, the rotenone can be detoxified with a potassium permanganate solution at a resultant stream concentration of 2 to 4 parts per million, depending on rotenone concentration and permanganate demand of the water. A 2.5% (10 pounds potassium permanganate to 50 gallons of water) permanganate solution is dripped in at a continuous rate using the equation:

$$X = Y(70 F)$$

where X = cc of 2.5% permanganate solution per minute, Y = ppm of desired permanganate concentration, and F = cubic feet per second of stream flow.

Flow of permanganate should be checked at least hourly. Live fish in cages placed immediately above the permanganate application site will show signs of stress signaling the need for beginning detoxification. Detoxification can be terminated when replenished fish survive and show no signs of stress for at least four hours.

Detoxification of rotenone by permanganate requires between 15 to 30 minutes contact time (travel time). Cages containing live fish can be placed at these downstream intervals to judge the effectiveness of detoxification. At water temperature of less than 50° F detoxification may be retarded, requiring a longer contact time.

Adhesive Panel

**RESTRICTED USE PESTICIDE
DUE TO AQUATIC AND ACUTE INHALATION TOXICITY**
For retail sale to, and use only by, Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.



PRENFISH TOXICANT
Liquid Emulsifiable

*For Control of Fish in Lakes, Ponds, Reservoirs and Streams

ACTIVE INGREDIENTS:

Rotenone 5.0%
Other Associated Resins 5.0%

INERT INGREDIENTS*: 90.0%
TOTAL 100.0%

*This product contains aromatic hydrocarbons.

PRENTOX® - Registered Trademark of Prentiss Incorporated

KEEP OUT OF REACH OF CHILDREN



DANGER - POISONOUS



See inside booklet for additional precautionary statements.

FIRST AID

Have product container or label with you when obtaining treatment advice.

If swallowed	<ul style="list-style-type: none"> • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice. • Do not induce vomiting unless told to do so by the Poison Control Center or physician. • Do not give any liquid to the person. • Do not give anything by mouth to an unconscious or convulsing person.
If inhaled	<ul style="list-style-type: none"> • Remove victim to fresh air. • If not breathing, give artificial respiration, preferably mouth-to-mouth. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
If in eyes	<ul style="list-style-type: none"> • Hold eyelids open and rinse slowly and gently with water for 15-20 minutes. • Remove contacts, if present, after the first 5 minutes, then continue rinsing eye. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
If on skin or clothing	<ul style="list-style-type: none"> • Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.

For information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378.

EPA Reg. No. 655-422

9/02

EPA Est. No. 655-GA-1

Manufactured by:

PRENTISS INCORPORATED

Plant: Kaolin Road, Sandersville, GA 31082
Office: C.B. 2000, Floral Park, NY 11002-2000

D.3.2 Material Safety Data Sheet:

Product: 655-422 Prentox® Prenfish™ Toxicant

Material Safety Data Sheet
U.S. Department of Labor (OSHA 29 CFR 1910.1200)

Manufacturer's Name: Prentiss Incorporated
 C. B. 2000
 Floral Park, NY 11001
Telephone Number: (516) 326-1919

Section 1: Chemical Identification

Product: 655-422 Prentox® Prenfish™ Toxicant
EPA Signal Word: DANGER

Active Ingredient (%): Rotenone (5%) (CAS # 83-79-4)
 Other Cube Resins (10%) N/A
Chemical Names: Rotenone – N/A
Chemical Class: Mixture

Section 2: Composition/ Information on Ingredients

Material:	OSHA PEL	ACGIH TLV	NTP/IARC/OSHA Other Carcinogen
Rotenone	(TWA) 5 mg/ M ³	(STEL) 10 mg/M ³ (TWA) 5 mg/M ³	No/No/No
Other associated cube resins	Not Est.	Not Est.	
Aromatic Petroleum Solvent (Supplier recommendation 100 ppm) (CAS # 64742-94-5) (Not to exceed 80%)			
Contains the following ingredients, by weight (typical):			
Naphthalene (CAS # 91-20-3)		9.9%	(TWA) 10 ppm
1,2,4-trimethylbenzene (CAS # 95-63-6)		1.7%	(TWA) 25 ppm
Acetone (CAS # 67-64-1) (not to exceed 7.5%)			(TWA) 250 ppm
Emulsifier #1 (CAS # N/A)		1.5%	N/D
Emulsifier #2 (CAS # N/A)		4.5%	N/D

Section 3: Hazards Identification

Clear liquid with mild odor. Fatal if inhaled. May be fatal if swallowed. Harmful if absorbed through skin. Causes substantial but temporary eye injury. Causes skin irritation. This pesticide is extremely toxic to fish.

Potential Health Effects:

Primary Routes of Entry: Inhalation, ingestion, skin and eye contact.

Section 7: Handling and Storage

Do not contaminate water, food or feed by storage or disposal. Store in a dry place away from temperature extremes. Avoid inhalation of vapors. Harmful if swallowed, inhaled or absorbed through skin. Avoid contact with skin. Wear clean protective clothing.

Other precautions: Periodically inspect stored materials.

Section 8: Exposure Controls/Personal Protection

Respiratory protection: Mixers and handlers: Do not inhale. Use NIOSH certified respirator for organic vapor protection.

Ventilation:

Local Exhaust: As required to meet TLV.

Special: Not applicable.

Mechanical: As required to meet TLV.

Other: Not applicable.

Protective Gloves: Chemical resistant.

Eye Protection: Safety glasses, face shield or goggles.

Other protective clothing or equipment: Wear long pants, long sleeved shirt or other body covering clothes. Avoid skin or eye contact.

Work/Hygienic practices: Wash thoroughly after handling and before eating or smoking. Remove contaminated clothing and wash thoroughly before reuse.

Section 9: Physical and Chemical Properties

Appearance:	Amber Liquid
Odor:	Aromatic Solvent Odor
Boiling Point:	N/D
Specific Gravity (H₂O = 1):	0.9226
Vapor Pressure (mmHg):	N/D
Melting Point:	N/D
Vapor Density (Air = 1):	N/D
Evaporation Rate (Butyl Acetate = 1):	N/D
Solubility in Water:	Emulsifies.

Section 10: Stability and Reactivity

Stability:	Stable.
Conditions to avoid for stability:	None.
Incompatibility:	Strong acids and oxidizers.
Hazardous Decomposition or Byproducts:	CO, CO ₂
Hazardous Polymerization:	Will not occur.
Conditions to avoid for Hazardous Polymerization:	None.

Section 11: Toxicological Information

Acute Toxicity/Irritation Studies:

(The following data were developed with Prenfish)

Ingestion:	Oral LD ₅₀	55.3 mg/Kg (Rat – female) 264 mg/Kg (Rat – male) 178 mg/Kg (Rat – overall)
Dermal:		>2020 mg/Kg (Rabbit) (Slightly toxic)
Inhalation:		4-hour LC ₅₀ 0.048 mg/l. (Rat) (Highly toxic)
Eye Contact:		Moderately irritating (Rabbit)
Skin Contact:		Moderately irritating (Rabbit)
Skin Sensitization:		Non-sensitizing (Guinea Pig)

(The following data were developed with rotenone technical)

Mutagenic Potential: Rotenone was not mutagenic when tested.

Reproductive Hazard Potential: Rotenone had no reproductive effects when tested

Chronic/Subchronic Toxicity Studies:

Cancer Information: Rotenone was not carcinogenic when tested in rats and mice.

Toxicity of Other Components:

Petroleum solvent: The supplier reports that inhalation of high vapor concentrations (over 1,000 ppm) may cause nervous system effects such as headaches, dizziness, anesthesia and respiratory tract irritation

Surfactant: Causes severe eye irritation, which could lead to permanent eye damage. Prolonged or repeated skin contact may cause discomfort and local redness. Mist can irritate the respiratory tract, experienced as nasal discomfort and discharge with chest pain and coughing.

Target Organs: Eyes, skin, respiratory tract.

Section 12: Ecological Information

Summary of Effects: This product is extremely toxic to fish. Fish kills are expected at recommended rates. Consult your State Fish and Game Agency before applying this product to public waters to determine if a permit is needed for such an application. Do not contaminate untreated water when disposing of equipment washwaters.

Section 13: Disposal Considerations

Disposal: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility. Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

Container disposal: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by State and local authorities.

Product: 655-422 Prentox® Prenfish™ Toxicant

Section 14: Transport Information

DOT Classification: Pesticide liquid, flammable, toxic, n.o.s. (Acetone, Rotenone)

Hazard Class: 3, PG I

Subsidiary hazard class: 6.1

DOT Shipping Label: Poison and/or Toxic

Note: For transport purposes (49FR Part 173.132), the calculated 1-hour LC50 (Rat) is: 0.192 mg/L

Section 15: Regulatory Information

SARA Title III Classification:

Section 311/312:

Acute health hazard

Fire hazard

Section 313 Chemicals:

Aromatic Petroleum Solvent (Supplier recommendation 100 ppm) (CAS # 64742-94-5)

(Not to exceed 80%)

Contains the following ingredients, by weight (typical):

Naphthalene (CAS # 91-20-3)	9.9%	(TWA) 10 ppm
1,2,4-trimethylbenzene (CAS # 95-63-6)	1.7%	(TWA) 25 ppm

This product contains a toxic chemical or chemicals subject to the reporting requirements of Section 313 of Title III and of 40 CFR 372. Any copies or redistribution of this MSDS must include this notice.

Proposition 65: This product does not contain any chemical which is known to the State of California to cause cancer or birth defects or other reproductive harm.

CERCLA Reportable Quantity (RQ): None.

RCRA Classification: Ignitable.

TSCA Status: Registered pesticide, exempt from TSCA regulation. All ingredients are on the TSCA inventory.

Other: Rotenone

Illinois toxic substance

Massachusetts Hazardous Substance

New Jersey Special Health Hazardous Substance

Pennsylvania Workplace Hazardous Substance

Acetone

Massachusetts Hazardous Substance

New Jersey Environmental Hazardous Substance

New Jersey Special Health Hazardous Substance

New Jersey Workplace Hazardous Substance

Pennsylvania Workplace Hazardous Substance

Product: 655-422 Prentox® Prenfish™ Toxicant

Section 16: Other Information

NFPA Hazard Ratings:	Health:	3	0	Least
	Flammability:	4	1	Slight
	Reactivity:	0	2	Moderate
			3	High
			4	Severe

Date Prepared: August 10, 2000

Supersedes: February 2, 1994

Reason: Revised Format

The information and recommendations contained herein are based upon data believed to be correct. However, no guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein.

D.4 Fintrol

D.4.1 Product Label

TAKE TIME



OBSERVE LABEL DIRECTIONS

FINTROL DILUENT

FOR USE WITH

PRECAUTIONARY STATEMENTS
Hazards to Humans & Domestic Animals

CAUTION: Harmful if swallowed. Harmful if inhaled. Harmful if absorbed through skin. Causes moderate eye irritation. Avoid contact with skin and clothing. Do not breathe spray mist. Do not get in eyes, on skin or on clothing. Wear protective goggles. Wear chemical gloves. Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash before reuse.

Physical or Chemical Hazards:
Extremely Flammable: Keep away from fire, sparks and heated surfaces.
First Aid: See Outer Can Label
EPA Reg. No. 39096-2
EPA Est. No. 39096-WA-01

FINTROL®

(Antimycin)

Fish Toxicant Kit

Ingredients	(w/w%)
Inert Ingredients	
Diethyl Phthalate (surfactant)	30.5%
Nonoxynol-9 (detergent)	16.7%
Acetone	52.8%
	100%

CAUTION

Keep out of reach of children

DIRECTIONS FOR USE
It is a violation of federal law to use this product in a manner inconsistent with its labeling. See "USE DIRECTIONS LEAFLET" for FINTROL (Antimycin A) Fish Toxicant Kit.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal. SEE OUTER CAN LABEL FOR PROPER STORAGE, PESTICIDE DISPOSAL AND CONTAINER DISPOSAL.

AQUABIOTICS CORP.
P.O. Box 10576
Bainbridge Island, WA 98110

TAKE TIME



OBSERVE LABEL DIRECTIONS

FINTROL-®

CONCENTRATE

(antimycin A) (solution 20%)

PRECAUTIONARY STATEMENTS
Hazards to Humans and Domestic Animals

DANGER: Fatal if swallowed. May be fatal if absorbed through skin. Causes substantial but temporary eye injury. Causes skin irritation. Do not breathe spray mist. Do not get in eyes, on skin or on clothing. Wear protective goggles. Wear chemical gloves. Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash before reuse.

Environmental Hazards
This product is very highly toxic to fish.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal. SEE OUTER CAN LABEL FOR PROPER STORAGE, PESTICIDE DISPOSAL AND CONTAINER DISPOSAL.

EPA Reg. No. 39096-2
EPA Est. No. 39096-WA-01

Fintrol Concentrate for use with Fintrol (Antimycin) Fish Toxicant Kit

Ingredients	(w/w%)
Active Ingredients	
Antimycin A	20%
Inert Ingredients	
Soy lipids	15%
Acetone	62%
	100%

DANGER



POISON

KEEP OUT OF REACH OF CHILDREN

Aquabiotics Corp.
PO Box 10576
Bainbridge Island, WA

Physical or Chemical Hazards:
Extremely Flammable: Keep away from fire, sparks and heated surfaces.

FIRST AID IF SWALLOWED: Call a physician or Poison Control Center. Drink 1 or 2 glasses of water and induce vomiting by touching back of throat with finger if person is unconscious, do not give anything by mouth and do not induce vomiting.

IF INHALED: Remove victim to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. Get medical attention.

IF ON SKIN: Wash with plenty of soap and water. Get medical attention.

IF IN EYES: Hold eyelids open and flush with a steady, gentle stream of water for 15 minutes. Get medical attention.

DIRECTIONS FOR USE
It is a violation of federal law to use this product in a manner inconsistent with its labeling. See "USE DIRECTIONS LEAFLET" for "FINTROL (Antimycin A) Fish Toxicant Kit".

Appendix D: MSDS & Product Labels for Potential Fisheries Restoration Chemicals 323

D.4.2 Material Safety Data Sheet:

FINTROL CONCENTRATE

Antimycin A in Acetone (Fintrol Concentrate 20% solution w/v, 23% w/w)

Issued 04/17/97

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Material Name: Antimycin A in Acetone

MANUFACTURER: Aquabiotics Corporation
10750 Arrow Point Drive
Bainbridge Island, WA 98110

TELEPHONE NUMBER: 1-206-842-1708

FAX NUMBER: 1-206-842-7266

2. COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENT NAME: Acetone *

CONCENTRATION: 80.0000% (v/v)

CAS/RTECS NUMBERS: 67-64-1 / AL3150000

OSHA-PEL 8HR TWA: 750 ppm

STEL: 1000ppm

CEILING: N/L

ACGIH-TLV 8HR TWA: 750 PPM

STEL: 1000 PPM

CEILING: N/L

OTHER 8HR TWA: N/A

LIMITS STEL: N/A

CEILING: N/A

* Hazardous per OSHA criteria

INGREDIENT NAME: Antimycin A *

CONCENTRATION: 20.0000 % (w/v)

CAS/RTECS NUMBERS: 1397-94-0 / CD0350000

OSHA-PEL 8HR TWA: N/L

STEL: N/L

CEILING: N/L

ACGIH-TLV 8HR TWA: N/L

STEL: N/L

CEILING: N/L

OTHER 8HR TWA: N/A

LIMITS STEL: N/A

CEILING: N/A

* Hazardous per OSHA criteria

3. HAZARDS INFORMATION

EMERGENCY OVERVIEW: Flammable Liquid and a marine hazard. The active component is toxic by ingestion and may

also by skin absorption. It is an eye, skin and respiratory irritant.

ROUTE(S) OF ENTRY: Skin: Yes

Inhalation: Yes

Ingestion: Yes

INGESTION RATING: Highly Toxic

SKIN ABSORPTION RATING: Possibly highly toxic

INHALATION RATING: N/D

CORROSIVENESS RATING: N/D

SKIN CONTACT RATING: Irritant

SKIN SENSITIZATION RATING: N/D

EYE CONTACT RATING: Irritant

TARGET ORGANS: Eyes, skin, respiratory tract, cardiovascular system, nervous system, kidneys, possibly fetus

CARCINOGENICITY RATING: NTP: N/L IARC: N/L OSHA: N/L

ACGIH: N/L

None

SIGNS AND SYMPTOMS: N/D. Inhalation of vapors or aerosol could irritate the eyes, nose and respiratory tract. Direct contact with skin or eyes could produce severe irritation. Systemic intake could produce a decrease in blood pressure, nausea, light headedness, dizziness, excitement, incoordination, weakness, loss of coordinated speech and drowsiness.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: N/D. Available information suggests pre-existing eye, skin, respiratory, kidney, nervous system or cardiovascular ailments.

4. FIRST AID MEASURES

EYES: Remove from source of exposure. Flush with copious amounts of water. If irritation persists or signs of toxicity occur, seek medical attention. No known antidote. Provide symptomatic/supportive care as necessary.

SKIN: Remove from source of exposure. Flush with copious amounts of water. If irritation persists or signs of toxicity occur, seek medical attention. No known antidote. Provide symptomatic/supportive care as necessary.

INGESTION: Remove from source of exposure. Seek immediate medical attention. No known antidote. Provide symptomatic/supportive care as necessary.

INHALATION: Remove from source of exposure. If signs of irritation or toxicity occur, seek medical attention. No known antidote. Provide symptomatic/supportive care as necessary.

5. FIRE FIGHTING PROCEDURES

FLASH POINT: 0 F (for acetone)

FLASH POINT METHOD: Closed Cup

LOWER EXPLOSIVE LIMIT(%): 2.6% (for acetone)

UPPER EXPLOSIVE LIMIT(%): 12.8% (for acetone)

AUTOIGNITION TEMPERATURE: 869 F (for acetone)

FIRE & EXPLOSION HAZARDS: Flammable Liquid. Keep away from heat, sparks and open flame.

EXTINGUISHING MEDIA: Use "alcohol" foam, dry chemical or carbon dioxide. Water may be ineffective.

FIRE FIGHTING INSTRUCTIONS: Wear protective clothing and self-contained breathing apparatus.

6. ACCIDENTAL RELEASE MEASURES

SPILL OR RELEASE PROCEDURES: Recover product and place in an appropriate container for disposal. Ventilate and wash the spill area.

7. HANDLING AND STORAGE

HANDLING: Ground and bond all containers during transfer operations.

STORAGE: Tight container.

SPECIAL PRECAUTIONS: Wash hands and face after handling this compound.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS: Use local exhaust.

RESPIRATORY PROTECTION: Air purifying respirator with organic vapor cartridge.

SKIN PROTECTION: Butyl rubber.

EYE PROTECTION: Full-face respirator.

OTHER PROTECTION: Wear saranex tyvek coverings with hood and shoe covers if contact may occur.

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE/PHYSICAL STATE: Brown to black liquid

ODOR: Acetone

BOILING POINT: 56.2 C (for acetone)

MELTING/FREEZING POINT: -94.6 C (for acetone)

VAPOR PRESSURE (mm Hg): N/D

VAPOR DENSITY (Air=1): N/D

EVAPORATION RATE: N/D
BULK DENSITY: N/D
SPECIFIC GRAVITY: 0.8 (for acetone)
SOLUBILITY: Miscible in water, alcohols, ethers and most
organic solvents.
pH: N/D
VISCOSITY: N/D

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Neutralize active component with bleach, potassium permanganate, or other strong oxidizer.

INCOMPATIBILITIES: Oxidizers.

HAZARDOUS DECOMPOSITION PRODUCTS: N/D

HAZARDOUS POLYMERIZATION: N/D

11. TOXICOLOGICAL INFORMATION

ORAL TOXICITY: N/D. LD50 = 30 mg/kg in rats for antimycin A. LD50 = 1738-10,700 mg/kg in mice, rats and rabbits for acetone.

DERMAL TOXICITY: N/D. Cumulative lethal dosage for antimycin A in rabbits about 65-150 mg/kg in animals receiving one gram of a 5% suspension in carbowax twice daily for three applications. Death possibly the result of absorption through broken skin as marked inflammation present after second application. LD50 = 20,000 mg/kg in rabbits for acetone.

INHALATION TOXICITY: N/D. A 10% formulation of antimycin A in alcohol administered to rats and guinea pigs as an aerosol for 10 minutes a day for 5 days at a nominal concentration of 170 mg/m³ produced eye irritation with corneal lesions and respiratory irritation and damage. LCLo = 16,000 ppm/4H in rats and 467,300 ppm/1H in mice for acetone. Vapors can cause irritation of the respiratory tract.

CORROSIVENESS: N/D

DERMAL IRRITATION: N/D. No irritation found following dermal application of 0.5 gram of a 5% suspension of antimycin A in carbowax (25 mg antimycin A); however, exudation, edema and scab formation were found after the first two of six applications over three days. Acetone mildly irritating to rabbit skin. Repeated or prolonged contact can cause dermatitis.

OCULAR IRRITATION: N/D. Corneal opacity clearing in four weeks resulted following application of 0.1 gram of antimycin A to the eyes of guinea pigs. Application of 0.5 grams of 5% antimycin A in alcohol to the eyes of rabbits resulted in slight redness. Acetone severely irritating, with corneal injury in rabbits. Vapors can cause eye irritation and burning. Can cause stinging if splashed in the eyes.

DERMAL SENSITIZATION: N/D.

SPECIAL TARGET ORGAN EFFECTS: N/D. Dietary administration of antimycin A a dosage of 10 mg/kg/day for four weeks produced soft stools and reduced weight gain in rats. Dietary administration at a dosage of 0.5 mg/kg/day to rats prior to and during pregnancy resulted in reduced body weight of the offspring (about 10%). Infusion to dogs at a rate of 1mcg/kg/minute for 1 hour produced no adverse effects; however, infusion of 10 mcg/kg/minute produced decreased blood pressure, slowed heart rate and death. Acetone causes central nervous system depression at elevated vapor concentrations and irritation at lower concentrations. Produced kidney injury in rats at oral dosages of 500 mg/kg/day or more.

CARCINOGENICITY INFORMATION: N/D

12. ECOLOGICAL INFORMATION

ECOLOGICAL INFORMATION: Marine hazard. Used in conjunction with a detergent to kill fish.

13. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHODS: Dispose of product in accordance with federal, state and local regulations.

14. TRANSPORTATION INFORMATION

DOT STATUS: Regulated

PROPER SHIPPING NAME: Flammable Liquids, toxic, n.o.s. (Acetone, Antimycin A), 3, UN1992, II

HAZARD CLASS: 3

UN NUMBER: UN1992

PACKING GROUP: II

REPORTABLE QUANTITY: 5000/2270
IATA/ICAO STATUS: Regulated
PROPER SHIPPING NAME: Flammable liquid, toxic, n.o.s., (Acetone, Antimycin A)
HAZARD CLASS: 3
UN NUMBER: UN1992
PACKING GROUP: II
REPORTABLE QUANTITY: 5000/2270
IMO STATUS: Regulated
PROPER SHIPPING NAME: Not Authorized
HAZARD CLASS: N/D
UN NUMBER: N/D
PACKING GROUP: N/D
REPORTABLE QUANTITY: N/D
FLASH POINT: O F (for acetone)

15. REGULATORY INFORMATION

TSCA STATUS: Exempt
CERCLA STATUS: N/D
SARA STATUS: N/D
RCRA STATUS: N/D
PROP 65 (ca): N/D

16. OTHER INFORMATION

LEGEND: N/A =
N/D = Not Determined
N/L = Not Listed
L = Listed
C = Ceiling
S = Short-term
® = Registered Trademark of Aquabiotics Corporation
™ = Registered Trademark of Aquabiotics Corporation

The information and recommendations contained herein are based upon tests believed to be reliable. However, Aquabiotics Corporation does not guarantee their accuracy or completeness NOR SHALL ANY OF THIS INFORMATION CONSTITUTE A WARRANTY, WHETHER EXPRESSED OR IMPLIED, AS TO THE SAFETY OF THE GOODS, THE MERCHANTABILITY OF THE GOODS, OR THE FITNESS OF THE GOODS FOR A PARTICULAR PURPOSE. Adjustments to conform with actual conditions of usage may be required. Aquabiotics Corporation assumes no responsibility for results obtained or for incidental or consequential damages arising from the use of these data. No freedom from infringement of any patent, copyright or trademark is to be inferred.

D.4.3 Product Leaflet

FINROL® **Fish Toxicant Kit** **Use Direction Leaflet**

Directions For Use

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

FINROL-CONCENTRATE is designed for use in running water, streams and shallow waters. This liquid form of FINROL may be applied to lakes and ponds by boat bailer method or spray equipment. Spray methods are useful at depths to 1 foot. Boat bailer and drip tubes, applied at the propeller wash, are used at other depths. Application from an airplane is NOT recommended.

Each can of Finrol-Concentrate (Antimycin A) Fish Toxicant Kit (containing 240 cc. Finrol-Concentrate (solution 20%) and 240 cc. Diluent) will, after mixing, make 480 cc., which treats approximately 38 acre-feet of water at 1 p.p.b. (1 part per billion).

AQUABIOTICS CORP.
P.O. Box 10576
10750 Arrow Point Dr. NE
Bainbridge Island, WA 98110

EPA Reg. No. 39096-2
EPA Est. No. 39096-WA-01

Licensed by: Wisconsin Alumni Research
Foundation

Trademark licensed by: Ayerst Laboratories, Inc.

Before applying FINROL to either public or private waters, contact the Director of the State Fish and Game Department or Conservation Department for State and Federal regulators governing the use of fish toxicants in your area.

DESCRIPTION

The active ingredient of FINROL is antimycin A. When absorbed through the gills of fish, antimycin A kills by interfering with the respiration of body cells. Antimycin A does not repel fish. This is an important advantage, particularly when running waters, bog lakes, and the epilimnion, or upper layer, of large lakes are treated. Fish make no attempt to escape contact with the toxicant by seeking to move into waters that are clear of it. FINROL'S action is rapid and irreversible.

Sensitivity to FINROL varies widely among fish species. Hence it may be employed to selectively destroy certain species, without affecting other species concurrently inhabiting the same body of water.

Sensitive:

Gizzard shad, trout, pike, carp, minnows, suckers, brook stickleback, white bass, sunfishes, perch, freshwater drum, sculpin.

Least Sensitive:

Shortnose gar, bowfin, goldfish, catfish

FINROL also may be used to selectively destroy certain age groups of species; younger fish are more sensitive to FINROL.

Providing the concentration is correctly estimated, FINROL can be used effectively at any time of year in either cold, warm, soft, hard, acid, alkaline, clear or turbid (muddy) waters. (See TABLE 1 and instruction for bioassay.)

FINROL does not impart detectable taste or odor to treated waters. In the usual, recommended concentrations it causes no apparent harm to aquatic plants, insects, or bottom fauna. Since FINROL'S active ingredient degrades rapidly, the reclaimed waters may be restocked soon after treatment. (See HOW TO DETERMINE WHEN TREATED WATER MAY BE RESTOCKED.) There is very little interruption in availability of the waters for recreational, agricultural, industrial, or other purpose.

USES

FINROL is used to cull undesirable species of fish from freshwater lakes, ponds, and streams. It can be used to eliminate all fish from a body of water (complete kill). Or, it can be used to remove only certain fish species or size groups from mixed populations (selective kill).

A complete kill may be achieved with a concentration of anywhere from 5 to 25 p.p.b. of active ingredient. (See HOW TO DETERMINE THE MOST EFFECTIVE CONCENTRATION.) FINROL is particularly advantageous for complete kills because it detoxifies so rapidly the pond can usually be restocked in about a week, or as soon as caged fish survive 48 hours' exposure to the treated waters.

Under optimal circumstances, in ponds managed for sports fishing, selective kills may be achieved at concentrations as low as 0.5 to 1.0 p.p.b. However, because these concentrations are extremely low, there is no rule of thumb that can be relied upon to determine them accurately. A BIOASSAY IS ALWAYS REQUIRED TO PINPOINT THE OPTIMAL CONCENTRATION FOR SELECTIVE KILLS. (Literature describing this procedure is available upon request.)

A selective kill has these advantages: It can be made without interrupting sport fishing for more than a week or so, and fishing may be gradually improved without restocking. In the past, when bluegill, minnows, or green sunfish dominated a pond managed for bass, the usual solution to the problem was the total removal of all the fish with a fish toxicant. This meant restocking and little or no fishing for one or two years. Now — with FINTROL — this is no longer necessary. Low concentrations of FINTROL will affect small bluegill, green sunfish, and minnows primarily. Only a few of the very small bass will succumb. The bulk of the adult bluegill and green sunfish will not be affected. Thus FINTROL helps to bring about a balanced relationship between the bass and bluegill populations. This improves fishing without interrupting it for any appreciable length of time.

In catfish farming FINTROL can be used to *selectively eliminate* the trash fish (scale fish) that commonly reduce the yields and increase the costs of the commercial catfish farmer. It is possible to do this with FINTROL because concentrations that will eliminate scale fish generally will not harm adult catfish. The scale fish most often encountered by the catfish farmer will succumb to anywhere from 5 to 10 p.p.b. of active ingredient. (See TABLE 1) whereas, under ordinary circumstances, it takes in excess of 20 p.p.b. to kill catfish. (Caution should be exercised during stress conditions of unusually high water temperature and reduced oxygen content when the sensitivity of fishes to chemicals may increase.)

HOW TO SELECT THE APPROPRIATE FORMULATION

The nature of the water to be treated (its depth and rate of flow) and the character of the surrounding land are factors to be taken into consideration when determining the formulation of FINTROL to employ in a given situation.

HOW TO DETERMINE THE MOST EFFECTIVE CONCENTRATION

For complete kills and also,
for removal of scale fish from catfish ponds.

The concentration of antimycin A required to kill one or more species of fish in any given body of water depends upon: 1) the sensitivity of the species to be eradicated, and 2) the chemical and physical properties of the water at the time of application of the toxicant; the pH and the temperature of the water are the most important of these chemical and physical factors under ordinary circumstances. Therefore, to determine what concentration of antimycin A will be required to kill the undesirable fish in your pond or lake:

- 1) identify the species to be eradicated;
- 2) determine the pH and average water temperature by measuring at various sites and depths;
- 3) refer to TABLE 1 for approximate concentrations;
- 4) conduct a bioassay to pinpoint the optimal concentration.

TABLE 1 provides a rough estimate of the concentrations required for a complete kill under various environmental conditions. However, since water chemistry is subject to sudden alteration by many variables and often unpredictable factors (pollution, heavy algae bloom, weather, drawdown, etc.) it should be realized that such changes may affect the performance of the toxicant. For this reason, measurements of pH and water temperature should always be taken as close to the time of treatment as is feasible.

TABLE 1—FOR ROUGH ESTIMATION OF CONCENTRATIONS* OF FINTROL (ANTIMYCIN A) NEEDED FOR COMPLETE† ERADICATION OF DIFFERENT FISH SPECIES, UNDER VARIOUS COMBINATION OF WATER TEMPERATURE AND WATER pH

TARGET SPECIES	SENSITIVITY OF TARGET SPECIES TO FINTROL (in p.p.b. of active ingredient)	EFFECTIVE CONCENTRATION OF FINTROL* (in p.p.b. of active ingredient)			
		When pH is 8.5 or less		When pH is 8.5 or more	
		water temperature above 60°F	water temperature below 60°F	water temperature above 60°F	water temperature below 60°F
gizzard shad trouts pikes carp minnows suckers brook stickleback white bass sunfishes perches freshwater drum sculpine	5-10	5	7.5	7.5	10
short nose gar bowfin goldfish catfish	15-25	15	20	20	25
*The concentration level suggested by this table should be confirmed by an on-site bioassay. † This table is applicable only when a complete kill is desired. Do not use it for a selective kill. (See the following section.)					

* Fish nomenclature according to American Fisheries Society

Note (columns 1 and 2) that the sensitivity of the target species determines the concentration range. To eradicate sensitive species, it is recommended that the appropriate formulation of FINTROL be applied so that the body of water will have a concentration of from 5 to 10 p.p.b. of antimycin A, depending upon variation in pH and water temperature. For more tolerant species, higher concentrations are recommended. Laboratory Studies indicate that less sensitive fish will succumb at concentrations of from 15 to 25 p.p.b. of antimycin A, depending upon variations in pH and water temperature. Columns 3 to 6 show how to adjust for pH and water temperature. Note that, in general, the lower the pH, the less FINTROL required. The higher the water temperature, the less FINTROL required. The ideal situation for a complete kill would combine a highly sensitive species, low pH and high water temperature.

For selective kills in ponds managed for sports fishing

The only way to determine the concentration of FINTROL needed for a selective kill is to perform a bioassay. This involves subjecting both the target and nontarget fish to several concentrations of FINTROL to determine the minimum lethal dose. (A description of the bioassay procedure is available upon request.)

HOW TO CALCULATE THE AMOUNT OF FINTROL TO BE ADDED TO A BODY OF WATER TO OBTAIN A GIVEN CONCENTRATION

To calculate the amount of FINTROL to be added to a body of water for eradication of undesired species, the following steps should be taken:

- * Determine the volume of water to be treated in acre-feet. This can be arrived at by multiplying the surface area in acres by the average depth in feet.
- * Determine the concentration to be used from Table 1
- * Multiply the number of acre-feet by the value given in Table 2, opposite the desired concentration
- * Divide this number by the total kit volume (480 cc. or 16 oz.) to get number of Fish Toxicant Kits needed.

TABLE 2—RAPID ESTIMATION OF FINTROL-CONCENTRATE REQUIREMENTS

Desired Concentration (p.p.b. active ingredient)	Amount of FINTROL-CONCENTRATE per acre-foot	
	cc*	oz. (approx.)
1 p.p.b.	12.3	½
2 p.p.b.	24.6	1
3 p.p.b.	36.9	1½
4 p.p.b.	49.2	2
5 p.p.b.	61.5	2½
6 p.p.b.	73.8	3
7 p.p.b.	86.1	3½
8 p.p.b.	98.4	4
9 p.p.b.	110.7	4½
10 p.p.b.	123.0	5

*Obtained by multiplying 12.3 cc. by the p.p.b.
Note: 1 measuring teaspoon = 5 cc., 1 measuring tablespoon = 15 cc., ¼ standard measuring cup = 60 cc., ⅓ standard measuring cup = 120 cc., 1 standard meas. cup = 240 cc.

Sample calculation:

To treat 75 acre-feet at 3 p.p.b., use
 $75 \times 36.9 \text{ cc} = 2,767 \text{ cc. of FINTROL-CONCENTRATE} / 480 \text{ cc} = 5.8 \text{ Kits, or}$
 $75 \times 1\frac{1}{2} \text{ fl. oz.} = 93\frac{3}{4} \text{ fl. oz. of FINTROL-CONCENTRATE} / 16 \text{ oz} = 5.8 \text{ kits}$

METHODS OF APPLICATION

IMPORTANT: DURING APPLICATION OF FINTROL, ALL PERSONS IN THE IMMEDIATE VICINITY SHOULD WEAR PROTECTIVE GOGGLES AND PROTECTIVE GLOVES

Liquid formulation: Directions for mixing: Add the Diluent [blue label] to the FINTROL CONCENTRATE (solution 20%) [Green label] in the oversize mixing container. Cap tightly and invert 2 to 3 times to mix thoroughly. Further dilute with AT LEAST five (5) gallons of water to insure that the acetone contained in FINTROL CONCENTRATE will not affect rubber parts on any equipment that might be used to apply it. After water has been added, apply within eight (8) hours. [Note: The solution obtained by mixing the Diluent with FINTROL-CONCENTRATE (solution 20%) retains potency for up to seven (7) days. But once water has been added to this solution, it must be used within eight (8) hours to ensure potency.]

After appropriate dilution with water, the liquid formulation of FINTROL can be applied to lakes and ponds by the boat bailer method or spray equipment. Spray methods are useful at depths to one foot. Boat bailer and drip tubes when applied at the propeller wash are useful at greater depths. Pinpoint applications to shoal areas and small, isolated ponds can readily be made with backpack sprayers. (See CAUTION on use of PROTECTIVE GOGGLES AND PROTECTIVE GLOVES.)

In streams, FINTROL-CONCENTRATE is most often applied through drip stations established to meter the toxicant at a precalculated rate. Information on the use of such equipment may be obtained from state and/or federal agencies, experienced in stream treatment.

It is recommended that all applications of FINTROL be made at daybreak or as soon as there is enough light to work by.

PRECAUTIONS

Fish killed with antimycin A should not be consumed by man or animals. Treated waters must not be used for drinking by man or animals, or for crop irrigation, until fingerling rainbow trout or fingerling bluegills survive 48 hours' exposure in livecars in the treated waters.

Leftover portions of mixed liquid formulation retain potency for up to seven (7) days. But once water has been added to FINTROL-CONCENTRATE, it must be used within eight (8) hours to ensure potency.

Due to its acetone component, FINTROL-CONCENTRATE is flammable: keep away from heat and flame.

HOW TO DETERMINE WHEN TREATED WATER MAY BE RESTOCKED

Since antimycin A degrades rapidly following application, waters can usually be restocked about one week following treatment with FINTROL. Place livecars containing a sensitive species of fish in the treated water. It is recommended that these fish be fingerling rainbow trout or fingerling bluegills if the water temperature is between 35° and 68° F. When the water temperature exceeds 68° F, only fingerling bluegills should be used. If the fish survive for 48 hours, the water may be restocked.

HOW TO DETOXYIFY FINTROL WITH POTASSIUM PERMANGANATE (KMnO₄)

If it should be necessary to detoxify FINTROL in the outflow of a pond to prevent killing fish downstream, apply potassium permanganate at 1 part per million (1 p.p.m.) to the outflow. (More potassium permanganate may be needed if the stream has a high permanganate demand). Drip systems of hose-and-clamp or carburetor types can be employed to continuously dispense a solution of potassium permanganate into the water at the discharge outlet.

To evaluate the effectiveness of the detoxification process, place livecars containing fingerling rainbow trout or fingerling bluegills approximately 100 yards downstream from the site of KMnO₄ introduction. The water is considered detoxified if the fish survive for at least 48 hours in the livecar.

To detoxify FINTROL-treated streams, apply KMnO₄ at 1 p.p.m. at detoxification stations. (More KMnO₄ may be needed if the stream has a high permanganate demand). Continue the application of KMnO₄ until all FINTROL-treated water has passed the station. The water may be considered detoxified when fingerling rainbow trout or fingerling bluegills survive for at least 48 hours in livecars placed 100 yards downstream from the site of potassium permanganate (KMnO₄) introduction.

RE-ENTRY STATEMENT

Do not allow swimming in, drinking, or irrigation with FINTROL (Antimycin) treated water until a livecar of sensitive species of fish (fingerling rainbow trout or bluegill) survive for 48 hours in the treated waters. (See statement of How To Determine When Treated Water May Be Restocked).

SPECIAL INSTRUCTIONS

Prior to the use of a fish toxicant in either public or private waters, the Director of the State Fish and Game Department or Conservation Department must be contacted to determine whether a permit is required. Such products must be used by or under the technical supervision of personnel of state and federal fish and game agencies, trained in fisheries management, who will provide any special instructions applicable to the particular geographical area.

D.5 Potassium Permanganate

D.5.1 Material Safety Data Sheet:

MSDS Number: P6005 * * * * * Effective Date: 11/21/08 * * * * * Supersedes: 02/13/06

MSDS Material Safety Data Sheet	24 Hour Emergency Telephone: 908-859-2151 CHEMTREC: 1-800-424-9300
	National Response in Canada CANUTEC: 613-996-6666
From: Mallinckrodt Baker, Inc. 222 Red School Lane Phillipsburg, NJ 08865	Outside U.S. and Canada Chemtrec: 703-527-3887
 	NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.
All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.	

POTASSIUM PERMANGANATE

1. Product Identification

Synonyms: Permanganic acid, potassium salt; Condy's crystals

CAS No.: 7722-64-7

Molecular Weight: 158.03

Chemical Formula: KMnO₄

Product Codes:

J.T. Baker: 3227, 3228, 3232

Mallinckrodt: 7056, 7068

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Potassium Permanganate	7722-64-7	90 - 100%	Yes

3. Hazards Identification

Emergency Overview

DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. CORROSIVE. CAUSES BURNS TO ANY AREA OF CONTACT. HARMFUL IF SWALLOWED OR INHALED.

SAF-T-DATA^(tm) Ratings (Provided here for your convenience)

Health Rating: 3 - Severe (Life)

Flammability Rating: 0 - None

Reactivity Rating: 3 - Severe (Oxidizer)

Contact Rating: 3 - Severe (Corrosive)

Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES

Storage Color Code: Yellow (Reactive)

Potential Health Effects

Inhalation:

Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath. High concentrations can cause pulmonary edema.

Ingestion:

Ingestion of solid or high concentrations causes severe distress of gastro-intestinal system with possible burns and edema; slow pulse; shock with fall of blood pressure. May be fatal. Ingestion of concentrations up to 1% causes burning of the throat, nausea, vomiting, and abdominal pain; 2-3% causes anemia and swelling of the throat with possible suffocation; 4-5% may cause kidney damage.

Skin Contact:

Dry crystals and concentrated solutions are caustic causing redness, pain, severe burns, brown stains in the contact area and possible hardening of outer skin layer. Diluted solutions are only mildly irritating to the skin.

Eye Contact:

Eye contact with crystals (dusts) and concentrated solutions causes severe irritation, redness, blurred vision and can cause severe damage, possibly permanent.

Chronic Exposure:

Prolonged skin contact may cause irritation, defatting, and dermatitis. Chronic manganese poisoning can result from excessive inhalation exposure to manganese dust and involves impairment of the central nervous system. Early symptoms include sluggishness, sleepiness, and weakness in the legs. Advanced cases have shown symptoms of fixed facial expression, emotional disturbances, spastic gait, and falling.

Aggravation of Pre-existing Conditions:

No information found.

4. First Aid Measures

Inhalation:

Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Ingestion:

If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:

Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention immediately. Wash clothing before reuse. Thoroughly clean shoes before reuse.

Eye Contact:

Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

5. Fire Fighting Measures

Fire:

Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition. Contact with oxidizable substances may cause extremely violent combustion.

Explosion:

Strong oxidants may explode when shocked, or if exposed to heat, flame, or friction. Also may act as initiation source for dust or vapor explosions. Contact with oxidizable substances may cause extremely violent combustion. Sealed containers may rupture when heated. Sensitive to mechanical impact.

Fire Extinguishing Media:

Use water spray to blanket fire, cool fire exposed containers, and to flush non-ignited spills or vapors away from fire. Suffocating type extinguishers are not as effective as water. Do not allow water runoff to enter sewers or waterways.

Special Information:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Remove all sources of ignition. Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Clean up spills in a manner that does not disperse dust into the air. Use non-sparking tools and equipment. Reduce airborne dust and prevent scattering by moistening with water. Pick up spill for recovery or disposal and place in a closed container. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage and moisture. Isolate from any source of heat or ignition. Avoid storage on wood floors. Separate from incompatibles, combustibles, organic or other readily oxidizable materials. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:

- OSHA Permissible Exposure Limit (PEL):
5 mg/m³ Ceiling for manganese compounds as Mn

- ACGIH Threshold Limit Value (TLV):
0.2 mg/m³ (TWA) for manganese, elemental and inorganic compounds as Mn

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne

Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded and engineering controls are not feasible, a half facepiece particulate respirator (NIOSH type N95 or better filters) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece particulate respirator (NIOSH type N100 filters) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. **WARNING:** Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:

Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:

Use chemical safety goggles and/or full face shield where dusting or splashing of solutions is possible. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:

Purple-bronze crystals.

Odor:

Odorless.

Solubility:

7 g in 100 g of water.

Density:

2.7

pH:

No information found.

% Volatiles by volume @ 21C (70F):

0

Boiling Point:

Not applicable.

Melting Point:

ca. 240C (ca. 464F)

Vapor Density (Air=1):

5.40

Vapor Pressure (mm Hg):

No information found.

Evaporation Rate (BuAc=1):

No information found.

10. Stability and Reactivity

Stability:

Stable under ordinary conditions of use and storage.

Hazardous Decomposition Products:

Toxic metal fumes may form when heated to decomposition.

Hazardous Polymerization:

Will not occur.

Incompatibilities:

Powdered metals, alcohol, arsenites, bromides, iodides, phosphorous, sulfuric acid, organic compounds, sulfur, activated carbon, hydrides, strong hydrogen peroxide, ferrous or mercurous salts, hypophosphites, hyposulfites, sulfites, peroxides, and oxalates.

Conditions to Avoid:

Heat, flames, ignition sources and incompatibles.

11. Toxicological Information

Investigated as a mutagen, reproductive effector. Oral rat LD50: 750 mg/kg.

-----\Cancer Lists\-----			
Ingredient	---NTP Carcinogen---		IARC Category
	Known	Anticipated	
Potassium Permanganate (7722-64-7)	No	No	None

12. Ecological Information

Environmental Fate:

No information found.

Environmental Toxicity:

Dangerous to the environment. Very toxic to aquatic organisms; may cause long term adverse effects in the aquatic environment.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: POTASSIUM PERMANGANATE

Hazard Class: 5.1

UN/NA: UN1490

Packing Group: II

Information reported for product/size: 12KG

International (Water, I.M.O.)

Proper Shipping Name: POTASSIUM PERMANGANATE

Hazard Class: 5.1

UN/NA: UN1490

Packing Group: II

Information reported for product/size: 12KG

15. Regulatory Information

```
-----\Chemical Inventory Status - Part 1\-----  
Ingredient                               TSCA  EC   Japan  Australia  
-----  
Potassium Permanganate (7722-64-7)      Yes  Yes  Yes    Yes
```

```
-----\Chemical Inventory Status - Part 2\-----  
Ingredient                               Korea  DSL  NDSL  Phil.  
-----  
Potassium Permanganate (7722-64-7)      Yes   Yes  No    Yes
```

```
-----\Federal, State & International Regulations - Part 1\-----  
Ingredient                               -SARA 302-  -SARA 313-  
RQ    TPQ    List  Chemical Catg.  
-----  
Potassium Permanganate (7722-64-7)      No    No    No    Manganese co
```

```
-----\Federal, State & International Regulations - Part 2\-----  
Ingredient                               CERCLA      -RCRA-      -TSCA-  
-----          261.33      8 (d)  
-----  
Potassium Permanganate (7722-64-7)      100         No          No
```

Chemical Weapons Convention: No TSCA 12(b): No CDTA: Yes
SARA 311/312: Acute: Yes Chronic: Yes Fire: Yes Pressure: No
Reactivity: No (Pure / Solid)

Australian Hazchem Code: 2Y

Poison Schedule: S6

WHMIS:

This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: 1 Flammability: 0 Reactivity: 0 Other: **Oxidizer**

Label Hazard Warning:

DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. CORROSIVE. CAUSES BURNS TO ANY AREA OF CONTACT. HARMFUL IF SWALLOWED OR INHALED.

Label Precautions:

- Keep from contact with clothing and other combustible materials.
- Store in a tightly closed container.
- Do not store near combustible materials.
- Remove and wash contaminated clothing promptly.
- Do not get in eyes, on skin, or on clothing.
- Do not breathe dust.
- Keep container closed.
- Use only with adequate ventilation.
- Wash thoroughly after handling.

Label First Aid:

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. In all cases get medical attention immediately.

Product Use:

Laboratory Reagent.

Revision Information:

No Changes.

Disclaimer:

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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

Appendix E:



MINIMUM REQUIREMENT ANALYSIS WORKSHEET YELLOWSTONE NATIONAL PARK

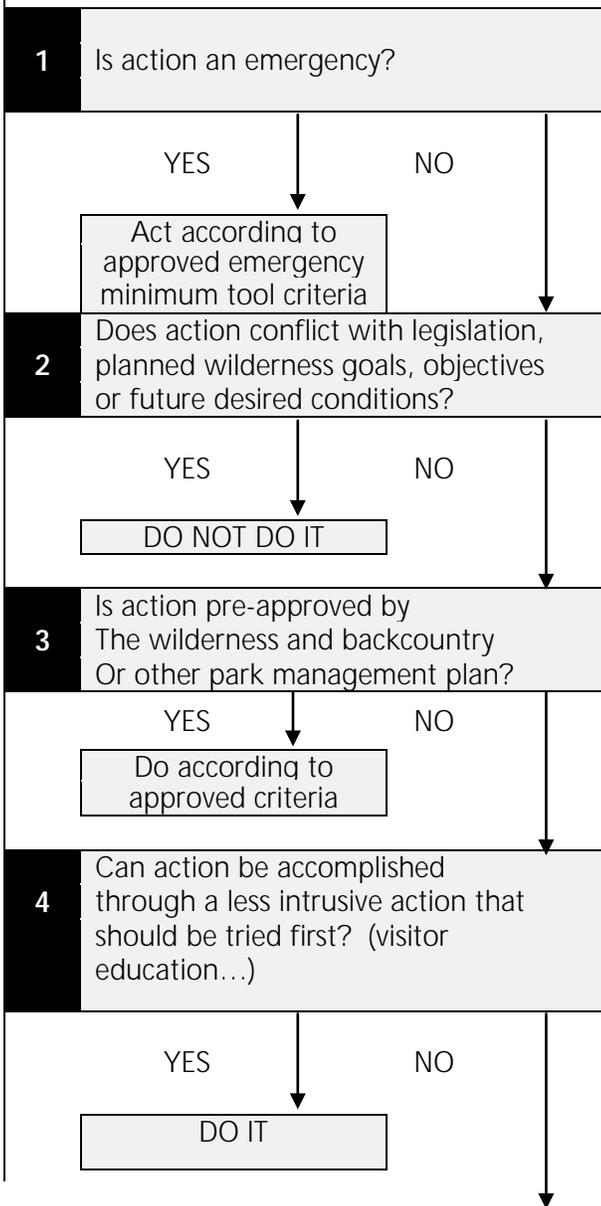


YELL 6/2003

PROPOSED ACTION: EXAMPLE: Native Fish Conservation Plan **DATE:** XXXXXX

Lead Person(s): Todd Koel **UNIT(S):** Fisheries & Aquatic Sciences

PART A: Minimum Requirement *(should the action be done in proposed wilderness)*



Answer: Yes No

Explain:

Answer: Yes No

Explain:

Answer: Yes No

Explain:

Answer: Yes No

Explain:

Appendix F: Impairment

National Park Service's Management Policies, 2006 require analysis of potential effects to determine whether or not actions would impair park resources. The fundamental purpose of the national park system, established by the Organic Act and reaffirmed by the General Authorities Act, as amended, begins with a mandate to conserve park resources and values. National Park Service managers must always seek ways to avoid, or to minimize to the greatest degree practicable, adversely impacting park resources and values.

However, the laws do give the National Park Service the management discretion to allow impacts to park resources and values when necessary and appropriate to fulfill the purposes of a park, as long as the impact does not constitute impairment of the affected resources and values. Although Congress has given the National Park Service the management discretion to allow certain impacts within parks, that discretion is limited by the statutory requirement that the National Park Service must leave park resources and values unimpaired, unless a particular law directly and specifically provides otherwise. The prohibited impairment is an impact that, in the professional judgment of the responsible National Park Service manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of these resources or values. An impact to any park resource or value may, but does not necessarily, constitute impairment, but an impact would be more likely to constitute impairment when there is a major or severe adverse effect upon a resource or value whose conservation is:

- necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park;
- key to the natural or cultural integrity of the park; or
- identified as a goal in the park's general management plan or other relevant NPS planning documents.

An impact would be less likely to constitute impairment if it is an unavoidable result of an action necessary to pursue or restore the integrity of park resources or values and it cannot be further mitigated.

The park resources and values that are subject to the no-impairment standard include:

- the park's scenery, natural and historic objects, and wildlife, and the processes and conditions that sustain them, including, to the extent present in the park: the ecological, biological, and physical processes that created the park and continue to act upon it; scenic features; natural visibility, both in daytime and at night; natural landscapes; natural soundscapes and smells; water and air resources; soils; geological resources; paleontological resources; archeological resources; cultural landscapes; ethnographic resources; historic and prehistoric sites, structures, and objects; museum collections; and native plants and animals;
- appropriate opportunities to experience enjoyment of the above resources, to the extent that can be done without impairing them;
- the park's role in contributing to the national dignity, the high public value and integrity, and the superlative environmental quality of the national park system, and the benefit and inspiration provided to the American people by the national park system; and

- any additional attributes encompassed by the specific values and purposes for which the park was established.

Impairment may result from National Park Service activities in managing the park, visitor activities, or activities undertaken by concessioners, contractors, and others operating in the park. The NPS's threshold for considering whether there could be impairment is based on whether an action would have major (or significant) effects.

Impairment findings are not necessary for visitor use and experience, socioeconomics, public health and safety, environmental justice, land use, and park operations, because impairment findings relates back to park resources and values, and these impact areas are not generally considered park resources or values according to the Organic Act, and cannot be impaired in the same way that an action can impair park resources and values.

After dismissing the above topics, those remaining to be evaluated for impairment fall in the categories of environmental setting, biological resources, and special status species. Only those impact categories where analysis conclusions were found to be up to the moderate adverse level are discussed in this impairment analysis.

F.1 Geologic Resources

Geologic resources, including hydrothermal resources, are one of the fundamental resources for which Yellowstone was set aside. The preferred alternative would result in direct, short-term and long-term, negligible to moderate adverse impacts to geological and hydrothermal resources. This is because a small proportion of the hydrothermal features in Yellowstone Lake would be modified by gill nets; and temporary disturbance to lake or terrestrial sediments would take place during implementation of lake and stream actions. Because of the localized nature of these impacts, there would be no impairment to geologic resources.

F.2 Wetlands

Over 357 square miles of wetlands are found in Yellowstone. These wetlands add to the species diversity of the park as well as provide essential habitat for Yellowstone's rare plants, reptiles, amphibians, insects, birds, mammals and fish. The preferred alternative would result in direct, short-and long-term, negligible to moderate adverse impacts to wetland resources in Yellowstone. This is because actions related to fish barrier construction and non-native fish removal would impact wetland vegetation and wetland associated fauna. Mitigation measures would include interdisciplinary collaboration on each stream segment to minimize changes to hydrologic processes (and therefore changes to wetlands); survey and restoration actions after implementation to reduce the chance of exotic species invasion as well as compensation for wetlands disturbance through such actions as culvert replacement. Because these impacts will be localized to specific stream corridors where actions to restore native fish will take place and because impacts from these actions would be minimized through extensive mitigation, there would be no impairment to wetland resources.

F.3 Aquatic Resources

Aquatic resources found in Yellowstone that would be impacted from the preferred alternative include plankton, aquatic macroinvertebrates and amphibians. These organisms are important components to the processes of an aquatic ecosystem. The preferred alternative would have direct and indirect, short- and long-term, negligible to moderate adverse impacts as well as indirect, long-term, negligible to minor beneficial impacts to aquatic resources in the park. The moderate adverse impacts would be primarily because the chemical removal actions used for non-native fish removal would impact zooplankton, macroinvertebrates and larval amphibians. While chemical removal would mean that resident populations would be killed, impacts would be retained at the moderate level due to extensive mitigation measures incorporated during implementation. These mitigation measures would emphasize surveys prior to treatment to identify non-target species and consequently adjusting treatments to minimize impacts through such modifications as timing of treatments to avoid sensitive life history stages of aquatic organisms found, avoiding non-target organisms through relocation, or simply not treating if impacts beyond moderate would be a possibility. Ultimately, the impacts to aquatic resources would be beneficial though, based on the premise that an ecosystem based on a healthy native fish component would eventually (1 to 3 years after treatment) support a higher diversity of native aquatic organisms. Because of the extensive mitigation measures in place and because of the long-term beneficial impacts, there would be no impairment to aquatic resources.

F.3.1 Fish Resources

The Yellowstone fishery is comprised of 12 native species. The park's native fish populations have been altered by fish stocking as well as by overharvest, whirling disease, drought, dewatering of streams and predation from non-native fish species such as lake trout. The preferred alternative would have indirect and direct, short- and long-term, negligible to moderate adverse impacts, but in the long-term, direct and indirect, moderate beneficial impacts to native fish resources in the park. The adverse impacts would be due to the immediate removal of native fish during chemical removal; natives such as sculpin would be impacted. This treatment would only be used after determination that mechanical removal would not be effective to eradicate non-natives. After treatment though, all native fish species would be restocked and native fish populations would benefit from returning to their historic range within the park and reducing extirpation risk within the Yellowstone ecosystem. Therefore, while immediate adverse impacts would take place, in the long term, native fish would benefit from the elimination of non-native predators and the re-establishment of native ecological processes. Because the long-term results of these efforts would be beneficial to native fish, there would be no impairment to fish resources.

F.4 Special Status Species

Special Status species are animal and plant species that scientific evidence indicates need protection, restoration, and/or conservation within a park because they are declining or have exceptionally limited distribution. Protection of special status species is discussed in the park's strategic plan (NPS 2000) and is required by statute (Endangered Species Act) and NPS policy. Special status species include mammals, birds, fish (including YCT, WCT, and GRY), macro invertebrates and plant species in Yellowstone. Some of these species are also federally listed under the Endangered Species Act (gray wolf, grizzly bear, and Canada lynx) or are considered Species of Special Concern by the FWS.

The preferred alternative would have direct and indirect, short- and long-term, moderate and adverse impacts, as well as indirect, long-term, moderately beneficial impact to special status species. Adverse impacts in the Yellowstone Lake ecosystem would be due to the increased potential to capture individual special status bird and fish species during gill netting operations; the use of trap nets would minimize the impacts from increased operations, though. Impacts to species would also be mitigated by avoiding high concentrations of these species during gill netting operations. Another mitigating measure to protect special status species would be that tributary reconnection actions would not take place in areas where the Yellowstone sand verbena is located during pre-treatment surveys.

The potential to impact an aquatic macro invertebrate and amphibian species of concern would be possible outside the Yellowstone Lake ecosystem. While chemical removal would mean that resident populations would be killed, impacts would be retained at the moderate level due to extensive mitigation measures incorporated during implementation. These mitigation measures would emphasize surveys prior to treatment to identify non-target species and consequently adjusting treatments to minimize impacts through such modifications as timing of treatments to avoid sensitive life history stages of aquatic organisms found, avoiding non-target organisms through relocation, or simply not treating if impacts beyond moderate would be a possibility.

Finally, the return of YCT could also increase the incidence of human/bear conflicts and could precipitate a long-term, minor adverse impact on grizzly bears in these areas. In order to mitigate this minor adverse effect, mitigation measures (e.g. area closures during spawning season, sinking of gill netted fish, removing fish carcasses from treatment areas) will be used to reduce bear-human interactions, conflicts, and confrontations so that management removals of grizzly bears are not necessary. Therefore NPS can reach a ‘may affect, not likely to adversely affect’ determination in consultation with the FWS.

Given all the mitigation measures discussed, and because the long-term results of these efforts would be beneficial to several special status species, there would be no impairment to special status species.

F.5 Conclusion

As guided by this analysis, good science and scholarship, advice from subject matter experts and others who have relevant knowledge and experience, and the results of public involvement activities; and given the impacts discussed have been mitigated as much as possible and are unavoidable results of an action necessary to pursue or restore the integrity of park resources or values, it is the Superintendent’s professional judgment that there would be no impairment of park resources and values from implementation of the preferred alternative