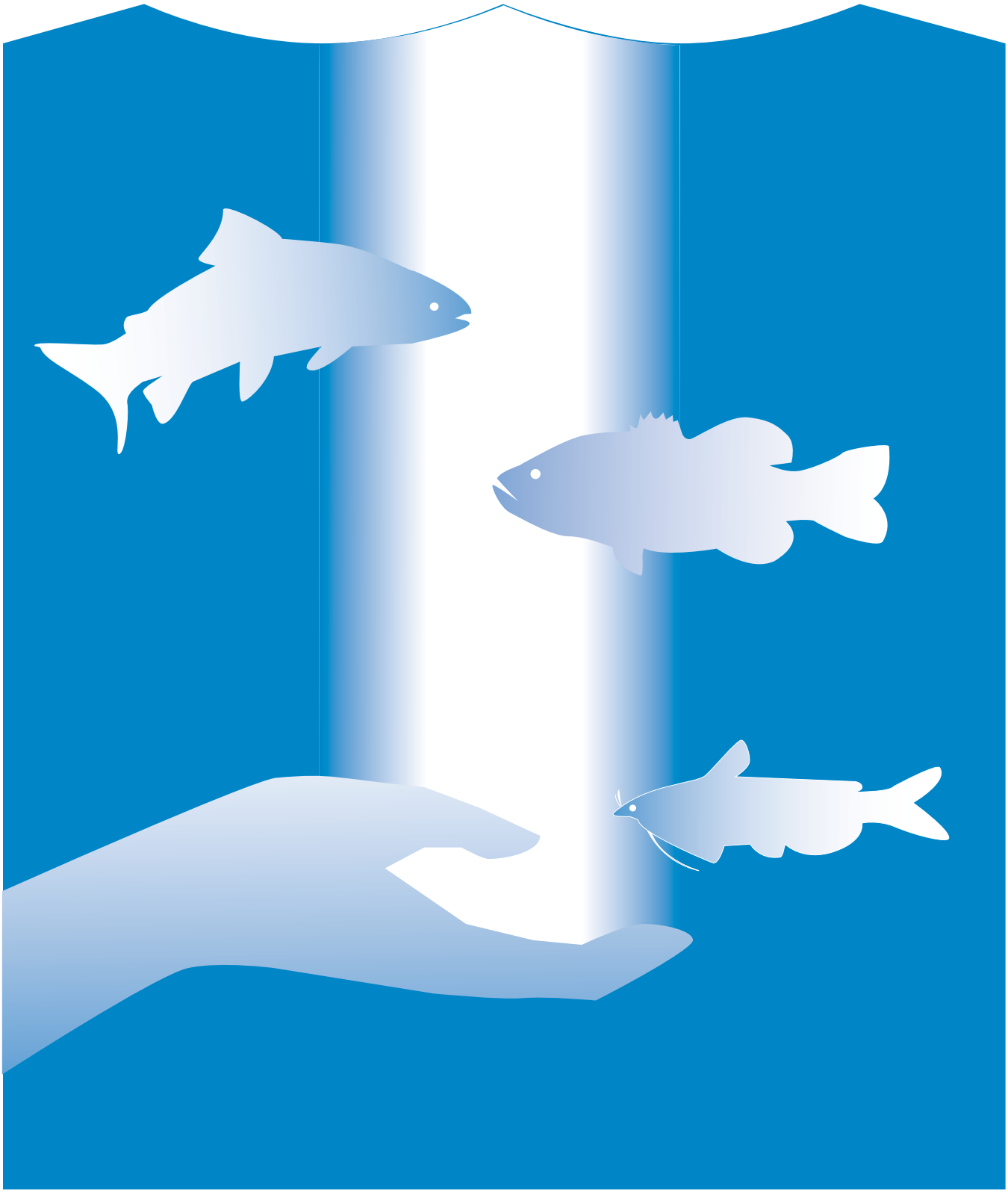
Better Fishing Through Management:

How Rotenone Is Used to Help Manage Our Fishery Resources More Effectively.



Americans love to go fishing!

In fact, we love it so much that each year, more than 35 million people go fishing. We spend 626 million days and more than $38 billion annually in pursuit of this favorite pastime.

As our population grows, the demand for quality fishing also increases. Anglers continue to bring high expectations to already heavily impacted aquatic areas. Unfortunately, the number of available ponds, lakes, and rivers is limited.

State and Federal resource agencies are entrusted with the task of maintaining healthy aquatic environments, protecting our bodies of water from misuse, and balancing the demands made by navigation, commercial, residential, recreational, and environmental activities. Since the likelihood of creating new water areas is very low, agencies in charge of fishery resources must manage existing resources to assure that the environment continues to thrive and to ensure that our fisheries are not depleted.

Active intervention may be required to maintain a healthy aquatic balance, such as stocking desirable fish or eradicating fish that threaten ecosystems. Careful management will be required if our waters are to provide the quality fishing we want and still ensure that future generations will be able to enjoy the same privilege. This includes continued existence of desired aquatic species and maintenence of a sufficient resource to support a reasonable sport fishery. Fish managers rely on a wide variety of tools for the management and assessment of fish populations to maintain diverse and productive aquatic ecosystems and high quality recreational fisheries. One of the most valuable tools is rotenone, which has been used by fish managers since 1934. Rotenone is a naturally occurring substance derived from the roots of tropical plants in the bean family. Rotenone has been used for centuries to capture fish for food in areas where these plants are naturally found.

This publication discusses how rotenone is used in fisheries management, presents scientific evidence that rotenone is safe to use, and lists the precautions that have been taken to assure the safety of rotenone to people and to the environment. Its purpose is to provide information based on research findings that will help you better understand the use of rotenone as a treatment and sampling aid.

USE OF ROTENONE

The use of rotenone and other fish management substances is the only method, other than complete draining, that will eliminate entire populations of fishes. However, dewatering is not a viable option in any stream and most lakes. Complete elimination of fish is often needed to accomplish fish management activities such as eradicating undesirable or harmful exotic fish, eradicating competing fish in rearing facilities, treating drainages prior to impoundment, restoring threatened or endangered species, and eliminating fish to control diseases. Also, rotenone is the only sampling method that provides for an accurate estimation of diverse fish communities.

To be acceptable, a fish management substance must work quickly, break down in a short period of time, and leave no harmful residues. It must not pose a health hazard to those applying, or to animals or birds that might consume treated water or organisms. It also must not affect aquatic plants or deplete the dissolved oxygen in the water. After application, the substance must break down rapidly so populations of non-target organisms can quickly recover from any short-term adverse effects and allow early restocking of desired fish species.

Rotenone meets all these requirements and is the best option to restore waters to a natural balance and provide a quality fishing experience. Rotenone offers an effective means of eradicating unwanted fish species without endangering the surrounding habitat.

ROTENONE: THE APPROVAL PROCESS

Before rotenone can be used in the environment, it must be registered by the U.S. Environmental Protection Agency (EPA). In order for a fish management substance to be registered, research must be

A busy afternoon at the Strawberry Reservoir marina, Utah. It provides in excess of 1,000,000 angler hours annually following the 1990 rotenone treatment.

PHOTO: Sott Root, Utah Department of Wildlife Resources.

conducted to show that the product does not constitute a health hazard or have a long-term effect on humans or the environment. If a substance meets these requirements after years of rigorous testing, it is then considered safe for use in the environment and is registered.

The U.S. Fish and Wildlife Service conducted extensive testing on rotenone in a 10-year period from 1978 to 1988. More than $3 million was invested in developing the data required by the EPA as part of its evaluation process. Rotenone has met all of the safety requirements and is currently registered for fishery uses. The EPA concluded that the use of rotenone for fish management does not present a risk of unreasonable adverse effects to humans or the environment.

State approval is also necessary before fish management substances can be lawfully used; however, the registration process varies for each state. Generally, rotenone must be registered for aquatic use with the state agency charged with this responsibility (usually a state agricultural or environmental agency). In addition, the state agency responsible for management of the natural resources also has policies and procedures governing the use of rotenone in that state. Further, the American Fisheries Society (an organization of professional fisheries scientists) has developed and published a manual to guide fisheries managers in the safe and effective use of rotenone *(Rotenone Use in Fisheries Management: Administrative and Technical Guidelines Manual).*

SUCCESS STORIES

Benefits of Large Reservoir Restoration of Trout Fishery with Rotenone

For almost a century, Strawberry Reservoir has been Utah's most important trout fishery. Rotenone treatments have played a major role in this success. Although the reservoir was constructed to provide water for agriculture, it quickly became a major trout fishery. The fishery was managed with rainbow, cutthroat, and brook trout. A typical opening weekend supported in excess of 50,000 angler hours of fishing recreation. By the late 1950's the fish population was dominated by Utah chub, Utah sucker, yellow perch, and carp. These nongame species were introduced into the reservoir through illegal use of live bait, and fishing recreation was seriously impacted. The Utah Division of Wildlife Resources (UDWR) treated the reservoir with rotenone to remove all fish in 1961. The treatment was successful and the trout fishery quickly recovered.

In 1975, fishing pressure was estimated at 900,000 angler hours. However, Utah chub were again found in the reservoir in 1973, and Utah sucker reappeared in 1978. By 1986, the fishery was providing only about 250,000 to 300,000 angler recreation hours, and about 95% of the reservoir's production was nongame fish. The UDWR began planning another rotenone treatment in 1986 that was completed in 1990. The volume of water treated was about 300,000 acre-feet and 880,000 pounds of powdered and 4,000 gallons of liquid rotenone were used in the treatment. Bear Lake strain cutthroat trout, rainbow trout, and kokanee salmon were restocked and the fishery quickly recovered. For eight years following the treatment, the fishery has provided from approximately 1,000,000 to 1,500,000 angler hours of recreation annually and is again Utah's most important trout fishery.

Concerned with maintaining environmental quality, a chemist with the California Department of Fish and Game analyses water samples for rotenone concentrations using a high performance liquid chromatograph.

PHOTO: Robert Hosea, California Department of Fish and Game.

Benefits of Threatened Trout Restoration with Rotenone in California

California is home to 12 species or subspecies of native trout, three of which are Federally-listed as threatened species, including the Lahontan cutthroat trout, Paiute cutthroat trout, and Little Kern golden trout. Due to habitat changes, bull trout are no longer found in California. Although habitat degradation has played a significant role in native trout population declines, impacts from competing species and hybridization have resulted in near extinction of certain native trout species.

Since the 1970's, rotenone has played a key role in eliminating nonnative trout species, primarily in the Sierra Nevada mountains. The strategy has been to chemically treat the headwaters of drainages with rotenone above fish barriers to remove non-native trout species that compete or hybridize with native trout. After that, native trout are reintroduced to the reclaimed habitats. To date, a total of 10 waters have

A very happy angler showing-off the rainbow trout she caught from Strawberry Reservoir, Utah's most important trout fishery.

PHOTO: ScottRoot

been successfully treated and restored with genetically pure native trout populations. Five of these waters now have Lahontan cutthroat trout, two have Paiute cutthroat trout, one has Little Kern golden trout, one has California golden trout, and one has McCloud River redband trout. Six of the treatments removed non-native brook trout which have a history of displacing California native cutthroat trout in streams. One treatment removed non-native brown trout, which was a voracious predator on California golden trout. The remaining three treatments removed rainbow trout, a native to California, but not in the treated streams. Rainbow readily hybridize with cutthroat trout, golden trout, and redband trout, compromising their genetic integrity.

The Truckee, Walker, Carson, Kern, and McCloud River drainages have been the sites for these successful restoration projects, along with the North Fork of Cottonwood Creek. Several of the restored waters are now open to catch-and-release fishing, allowing unique opportunities for anglers to catch and appreciate these rare and beautiful native trout. More rotenone projects are planned with the ultimate goal of recovering enough native trout populations to delist the three species currently listed and make future listings unnecessary. Future project benefits are increased native species biodiversity in California trout populations and improved angling opportunities.

Benefits of Pond Reclamation with Rotenone in New York

Rotenone has been used since the early 1950's in New York to restore brook trout populations. Approximately 150 waters have been treated. Recent restoration projects have focused on perpetuation of native Adirondack strains of brook trout. Following successful removal of competitors, brook trout ponds typically are capable of supporting several times the number of trout than prior to treatment. The resulting improvement in fishing quality is often dramatic. In many cases, the brook trout populations become self-sustaining and only require one or two introductory stockings of fingerling fish. Many anglers highly value the opportunity to catch wild heritage brook trout. Pond reclamation with rotenone has been shown to have restoration benefits beyond those to the fish fauna. Cornell University researchers documented that restoring native fish communities had cascading effects on zooplankton and phytoplankton communities.

The new community structures were consistent with native communities, unlike those in ponds that were dominated by non-native fishes.

QUESTIONS AND ANSWERS

From time to time, people have questions about the use of rotenone to manage fish communities and sample populations. They want to know, "Has rotenone been adequately tested to assure our safety and protect the environment?" The answer is "Yes." Below are questions that have been raised in the past and the answers to those questions based on scientific evidence and studies.

GENERAL INFORMATION

Q. What other uses are there for rotenone?

A. Rotenone is used as an "organic" garden insecticide to control chewing insects, has been used as a dust on cattle, and as a dog and sheep dip to control external parasites.

Q. How does rotenone work?

A. Rotenone inhibits a process at the cellular level making it impossible for fish to use the oxygen absorbed in the blood and needed in the release of energy during respiration.

Use of rotenone in Fisheries Management

Q. Why use rotenone to manage fish communities?

A. Sometimes managers need to eradicate an entire population or communityof fishes and replace them with a desirable population or community. Rotenone can be used to accomplish these objectives with minimum impact to non-target wildlife.

Q. What other methods are used to control fish?

A. The other methods include (1) modifications of angling regulations, (2) physical removal, (3) biological control, (4) draining, water fluctuation, and stream flow augmentation, (5) fish barriers, and (6) explosives. These methods are often too slow, ineffective, expensive and labor intensive and produce unpredictable results.

PHOTO: Leo Demong, New York Department of Environmental Conservation

Fly casting for heritage eastern brook trout on Black Pond, Adirondacks, New York. Rotenone is a critical tool in maintaining the wild heritage brook trout fishery.

Q. Why use rotenone to sample fish communities?

A. Biological information is often necessary for the development of management strategies for fish communities. The use of rotenone is often the only sampling method that enables managers to take a snapshot of a fish population at a specific time and makes it possible to clearly follow growth and abundance of the restocked fish.

Q. What other methods are used to sample fish communities?

A. The other methods include (1) electrofishing, (2) nets, (3) explosives, (4) underwater observations, (5) hook and line, and (6) sonar. These methods often have limitations restricting sampling to certain sizes of fish, type of habitats, and weather conditions. These limitations often limit the effectiveness of these other methods.

Q. How is rotenone applied?

A. Rotenone is applied either as a powder made from ground-up plant roots, or as a liquid. Rotenone is very water insoluble (i.e., like oil). Liquid formulations of rotenone contain additional materials (dispersants and emulsifiers such as naphthalene, methylnaphthalenes and xylenes) that aid in the dispersal of rotenone throughout the water column.

Q. Why is rotenone treatment cost effective?

A. It has been estimated that for each dollar spent on rotenone and stocked trout, anglers gained from $32 to $105 worth of fishing. On trout lakes that were stocked but not treated, the gain from fish stocking alone was only $10 to $15.

Q. How much rotenone is used?

A. Treatment rates range from 0.5 to 10.0 parts per million (ppm) of the commercial products. Because commercial products contain only 2.5% to 5% of rotenone, the actual concentration in the water is only 0.012 to 0.250 ppm of rotenone. The commercial products are most commonly applied at a concentration 1.0 to 2.0 ppm (0.025 to 0.100 ppm of rotenone). The 1 ppm rate is 1 part of the commercial formulation in 1,000,000 parts of water; or the 2 ppm rate is roughly equivalent to 1.3 ounces of the commercial formulation in a 5,000-gallon swimming pool.

Q. How do fisheries biologists determine when it is safe to restock fish?

A. The simplest test used by most fishery specialists is to place several fish in a cage and hold them in the treated water for several days. If they survive, the water is safe for restocking. Analytical techniques can also be used to determine how much rotenone is still present.

PUBLIC HEALTH

Q. How safe is rotenone to people?

A. Millions of dollars were spent on research to determine safety of rotenone prior to registration by the U.S. Environmental Protection Agency (EPA). The EPA concluded that the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans and the environment when used according to label instructions.

Q. What is a safe exposure level for rotenone?

A. The National Academy of Sciences has suggested a safe level in drinking water of 0.014 ppm of rotenone. The California Department of Health Services has suggested 0.004 ppm of rotenone. These safe levels assume a lifetime exposure to rotenone. For comparison, most rotenone treatments result in

exposure levels within the range of 0.012 to 0.25 ppm of rotenone, but rotenone generally persists for no longer than a few weeks, making lifetime exposure highly unlikely.

Q. Is there any danger associated with accidentally drinking rotenone-treated water?

A. The hazard associated with drinking water containing rotenone is very slight because of the low concentration of rotenone used in the treatment (0.012 to 0.25 ppm of rotenone) and the rapid breakdown of rotenone. Estimates on the oral toxicity to humans are 0.023 to 0.039 ounces of rotenone per pound of body weight. Hence, a 160-pound person would have to drink more than 23,000 gallons of water treated at 0.25 ppm of rotenone at one time to receive an effect.

Q. Can rotenone-treated water be used for public consumption or irrigation of crops?

A. Tolerances for rotenone in drinking and irrigation water have not yet been established by EPA even though the studies required for setting tolerances have been completed. This does not mean that rotenone concentrations in drinking or irrigation waters is actually unsafe; it just means that the EPA has not established rotenone tolerances at this time. As a result, water containing residues of rotenone cannot be legally allowed for use as a domestic water source or on crops.

Q. Are there any risks to human health from non-rotenone materials in the powdered formulation?

A. No, the non-rotenone material in the powdered formulations is inert plant root material.

Q. Are there any risks to human health from materials in the liquid rotenone formulations?

A. The EPA has concluded that the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans and the environment. Liquid rotenone formulations contain trace amounts of the carcinogen trichloroethylene (TCE). However, the TCE concentration in water immediately following treatment (less than 0.005 ppm of TCE) is below the level permissible in drinking water (0.005 ppm of TCE), and these levels quickly dissipate within a few days.

Q. How soon can people safely enter water treated with rotenone?

A. The EPA concluded that a reentry interval was not needed for persons who swim in waters treated with rotenone based on an assessment of the toxicology data and exposure level. The EPA said there was no reason to restrict the use of rotenone in waters intended for livestock consumption and recreational swimming.

Q. Is there any risk to public health from airborne rotenone?

A. No public health effects from rotenone use as a fish management substance are known. The use of the powder and liquid formulations have been monitored for airborne drift into adjacent areas. The highest rotenone concentrations that were monitored during a treatment were approximately 1,000-fold lower than the estimated safe level of rotenone in air.

Q. Why can't we eat fish killed by rotenone?

A. The EPA has not established guidelines for consuming fish killed with rotenone. There is a valid concern of salmonella and other bacteriological poisoning that may occur from consuming fish that have been dead for a period of time. However, fish that end up on land as a result of wave or wind action are no more a threat to public health than fish that die of natural causes.

Q. Why is there no risk to people from consuming fish that have been stocked into a recently treated water body?

A. Fish are not stocked into a treated area until rotenone has neutralized. Hence, stocked fish cannot accumulate residues of rotenone from the water. Residues of rotenone in tolerant fish that survive a rotenone treatment will not last for more than several days because the fish quickly metabolize and excrete rotenone.

ENVIRONMENTAL QUALITY

Q. Why are there no problems with dead and decaying fish on the recovery of fishing?

A. Most dead fish will sink in several days to the bottom of the treated body of water, decompose, and release nutrients back into the water. These nutrients will directly stimulate phytoplankton and indirectly stimulate insect and zooplankton pro-

duction. These organisms are a good food base for fish.

Q. How can the effects of rotenone to fish and other aquatic life be neutralized?

A. If biologists want to quickly neutralize the effects of rotenone in lakes or rivers, potassium permanganate can be used. Potassium permanganate is an oxidizing agent. This substance is used worldwide in treatment plants to purify drinking water.

Q. What is the smell sometimes associated with the use of liquid rotenone formulations?

A. The aromatic (mothball) smell associated with the use of liquid rotenone formulations is from naphthalene and methylnaphthalene. This smell may last for several days, depending on air and water temperatures and wind direction. These compounds remain close to the ground and move down-wind. There are no health effects from this smell.

Q. What happens to rotenone after it has been applied?

A. Rotenone is a compound that breaks down very rapidly when exposed to light, heat, oxygen, and alkaline water. Ultimately, rotenone breaks down into carbon dioxide and water.

Q. How long does rotenone's effects persist?

A. Rotenone is generally neutralized in lakes in less than four weeks and in running waters in a matter of hours. The time for natural neutralization of rotenone is governed primarily by temperature. Studies show that rotenone completely degrades within one to eight weeks within the temperature range of 50°F to 68°F.

Q. How long do the materials other than rotenone persist from liquid formulation treatments?

A. Researchers have found most of the other ingredients in the liquid formulations degrade more rapidly than rotenone through exposure to light, heat, oxygen, and alkaline waters. Many of these materials are the same as those found in fuel oil and are commonly in water because of frequent use of outboard motors and motorized personal watercraft. None of these materials pose a health hazard at the concentrations available in the environment from any rotenone treatment.

Q. Why is rotenone unlikely to enter ground water and pollute water supplies?

A. The ability of rotenone to move through soil is low. This is because rotenone is strongly bound to organic matter in soil so it is unlikely that rotenone would even enter ground water. Monitoring studies in ground waters adjacent to treatment areas have found no contamination associated with rotenone treatments.

Q. Why are there no degradation products from rotenone that can cause environmental problems?

A. The degradation product rotenolone can persist longer than rotenone, especially in cold, alpine lakes. To err on the side of safety, fish stocking would be delayed until both rotenone and rotenolone residues have completely dissipated. Since rotenolone has less effect than rotenone, it poses even less risk to human health and the environment than rotenone.

FISH AND WILDLIFE

Q. How does rotenone affect aquatic animals?

A. All animals including fish, insects, birds and mammals have natural enzymes in the digestive tract that neutralize rotenone, and the gastrointestinal absorption of rotenone is inefficient. However, fish (and some forms of amphibians and aquatic invertebrates) are more susceptible because rotenone is readily absorbed directly into their blood through their gills (non-oral route). Studies have shown that amphibians and invertebrates will repopulate an area when rotenone neutralizes.

Q. Will wildlife that eat dead fish and drink treated water be affected?

A. Birds and mammals that eat dead fish and drink treated water will not be affected. Rotenone residues in dead fish are generally very low, are broken down quickly, and not readily absorbed through the gut of the animal eating the fish.

Q. How will wildlife species be affected by the loss of their food supply following a rotenone treatment?

A. During treatments, fish-eating birds and mammals can be found foraging on dying and re-

cently dead fish for several days following a treatment. Following this abundance of dead fish, a temporary reduction in food supplies may result until the fish and invertebrates are restored. However, most of the affected species are mobile and will seek alternate food sources or forage in other areas.

Q. What about the loss of food supplies to sensitive nesting birds?

A. The temporary loss in food resources for sensitive animals during mating may cause unavoidable impacts. Agencies have mitigated an impact to nesting bald eagles during mating by removing their eggs from the nest to an approved eagle recovery program out of the area. Likewise, some agencies have delayed treatments until young birds have matured and forage elsewhere.

ADDITIONAL INFORMATION

Q. How can more information be obtained on the fishery uses of rotenone and its effects on the environment?

A. An excellent source of information is the *Rotenone Use in Fisheries Management: Administrative and Technical Guidelines Manual* published by the American Fisheries Society. It is available on its website at www.fisheries.org/rotenone. The manual will be updated periodically as new information becomes available.

SUMMARY

Rotenone is an important fisheries management tool that has been used successfully for almost 70 years in the United States and Canada. Its use is carefully regulated to protect the safety and well being of the public and the environment. Most rotenone projects are supported by specific management plans that define the objectives and expected results. Although there may be some short-term losses of fishing opportunities when rotenone is used, the benefits greatly outweigh the losses because the use of rotenone restores balance to the fish community.

PHOTO: Roger Bloom, California Department of Fish and Game

Fly casting for Lahontan cutthroat trout on the Upper Truckee River, Sierra Nevada Mountains, California. This catch-and-release fishery allows the unique opportunity for anglers to catch and appreciate these rare and beautiful trout.

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