ISSUES AND RESPONSES 5

This section was written with the lay (nontechnical) public in mind with minimal use of technical terminology. It includes its own references for reproduction and distribution to the public independent of the remainder of the manual. The Fish Management Chemicals Subcommittee intends to update this information annually for access on the American Fisheries Society Web site.

5.1 GENERAL INFORMATION

Q. What is rotenone?

A. Rotenone is a naturally occurring substance derived from the roots of tropical plants in the bean family Leguminosae including jewel vine *Derris* spp. and lacepod *Lonchocarpus* spp. Rotenone is very insoluble in water, and other materials can be added to disperse it throughout the water column in deep lakes and flowing waters. Rotenone is used either as a powder from ground-up plant roots (e.g., Pro-Noxfish®) or extracted from the roots and formulated as a liquid (e.g., Nusyn-Noxfish® and Noxfish®). The liquid formulations contain dispersants and emulsifiers (primarily naphthalene, methylnaphthalenes, and xylenes) that add little, if any, toxicity but disperse the rotenone throughout the water.

Q. How does rotenone work?

A. Rotenone does not suffocate fish or interfere with the uptake of oxygen in the blood as was long believed. Instead, it inhibits a biochemical 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 (Oberg 1967a, 1967b).

Q. Why is rotenone used in fish management?

A. Use of rotenone enables fisheries managers to eradicate entire populations and communities of fishes with minimum impact to nontarget wildlife. Following treatment, the desired population of fish is then reestablished in the water body. Although other approaches are useful as

control measures, these are only partially effective in eradicating fish. Use of rotenone is the only sampling method that allows for an accurate estimation of standing crop (biomass of a population) of diverse fishes in large water bodies.

Q. Is rotenone a selective pesticide?

A. Although rotenone has some toxicity to all oxygen-breathing animals, it is selective to fish and other gill-breathing organisms at the concentrations used by fish biologists. In general, most common aquatic invertebrates are less sensitive than fish to rotenone. Some of the zooplankton (cladocerans and copepods) are equally sensitive; however, these do have life history stages that can survive the treatment. Snails and clams are quite tolerant. Shad, pike, trout, and salmon are among the most sensitive fish. Sunfish are less sensitive, and catfish are among the most tolerant (Marking and Bills 1976; Chandler and Marking 1982).

5.2 PUBLIC HEALTH

Q. Are there any public health effects from the use of rotenone?

A. Millions of dollars have been spent on research to determine the safety of rotenone before approval of use from the U.S. Environmental Protection Agency (USEPA). Much of this research has been directed toward potential effects on public health. This research has established that rotenone does not cause birth defects (Hazleton Raltech Laboratories 1982), reproductive dysfunction (Spencer and Sing 1982), gene mutations (Biotech Research 1981; Goethem et al. 1981; NAS 1983), or cancer (USEPA 1981b; Tisdel 1985). When used according to label instructions for the control of fish, rotenone poses little, if any, hazard to public health. The USEPA (1981b, 1989b) has concluded that the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans and the environment.

Q. What is a lifetime safe exposure level for rotenone?

A. The National Academy of Science (NAS 1983) has suggested a Suggested No-Adverse Response Level (SNARL) for rotenone in drinking water of 0.014 milligrams (mg) rotenone per liter of water (14 parts per billion [ppb]). The California Department of Health Services (memorandum from P. Berteau, California Department of Health Services, to B. Finlayson, California Department of Fish and Game, 26 June 1984) has suggested an Action Level (level of concern) for rotenone in drinking water of 0.004 mg rotenone per liter of water (4 ppb). These proposed life-time, allowable levels for drinking water are based on applying a 1,000-fold safety factor to the chronic feeding study of Ellis et al. (1980). These levels assume a lifetime of exposure to rotenone. For comparison, most rotenone treatments are done within the range of 0.025–0.25 mg rotenone per liter of water (25–250 ppb), and rotenone generally persists for no longer than a few weeks. In addition, rotenone treatments are only infrequently applied to any body of water.

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

A. The hazard associated with drinking water containing rotenone is very small because of the low concentration of rotenone used in the treatment (0.025–0.25 mg of rotenone per liter of water [25–250 ppb]) and the rapid breakdown of rotenone. Estimates on a single lethal dose to humans are 300–500 mg of rotenone per kilogram of body weight (Gleason et al. 1969). Hence, a 160-pound person would have to drink over 87,000 liters (23,000 gallons) of water treated at 0.25 mg of rotenone per liter of water (highest allowable treatment rate for fish management) at one sitting to receive a lethal dose; similarly, it is extremely unlikely that a 10-kilogram child would drink over 5,400 liters of water. An intake of 0.7 mg of rotenone per kilogram of body weight per day is considered safe (Haley 1978), far greater than the expected exposure resulting from the maximum fish management treatment rate of 0.25 mg of rotenone per liter of water.

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

A. Tolerances for rotenone in potable and irrigation water have not been established by USEPA, even though the studies required for setting tolerances have been completed. This does not mean that rotenone concentrations in drinking or irrigation waters will create problems, it just means that the USEPA has not established rotenone tolerances at the time of writing these guidelines. As a result, water containing residues of rotenone cannot be legally allowed for use as a domestic water source or on crops. During the treatment and for the period of time that rotenone residues are present, alternative water sources must be used for domestic and irrigation uses. Depending on initial rotenone concentration and environmental factors (e.g., temperature), this period can vary from 1 to 8 weeks (CDFG 1994; Finlayson and J. Harrington, unpublished data, presented at Chemical Rehabilitation Projects Symposium, Bozeman, Montana, 1991).

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

A. The USEPA (1981b, 1989b) has concluded that the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans and the environment. The California Environmental Protection Agency found that adverse impacts from properly conducted, legal uses of liquid rotenone formulations in prescribed fish management projects were nonexistent or within acceptable levels (memorandum from J. Wells, California Department of Pesticide Regulation, to Finlayson, 3 August 1993). Liquid rotenone contains the carcinogen trichloroethylene (TCE). However, the TCE concentration in water immediately following treatment (less than 0.005 mg TCE per liter of water [5 ppb]) is within the level permissible in drinking water (0.005 mg TCE per liter of water; USEPA 1980b). None of the other materials including xylenes, naphtha-

lene, piperonyl butoxide, and methylnaphthalenes exceed any water quality criteria or guidelines (based on lifetime exposure) set by the USEPA (1980a, 1981a, 1993). Many of these materials in the liquid rotenone formulations (trichloroethylene, naphthalene, and xylene) are the same as those found in fuel oil and are present in waters everywhere because of the frequent use of outboard motors.

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

A. No public health effects from rotenone use as a piscicide have been reported. The use of the powder Pro-Noxfish® and the liquid formulation Nusyn-Noxfish® have been monitored for airborne drift into adjacent areas. Airborne rotenone concentrations immediately adjacent to the treatment site, monitored in California during a treatment in 1997, varied from a high of 0.02 ppb rotenone (0.00053 mg of rotenone per cubic meter) immediately after application to nondetectable levels two weeks later (CARB 1997). The highest levels were approximately 1,000-fold lower than the estimated no observed effect level (NOEL) of 0.43 mg of rotenone per cubic meter of air for a 24-hour period estimated by the California Office of Environmental Health and Hazard Assessment and the California Department of Pesticide Regulation (CARB 1997). In the same monitoring program, TCE was detected only once at a trace amount in air at one spillway. The heavier hydrocarbons (naphthalene and methylnaphthalene) were found at 281 ppb (1.74 mg per cubic meter) in air immediately after treatment and diminished to 1.61 ppb (0.010 mg per cubic meter) in air within two weeks. Individuals can normally detect naphthalene and methylnaphthalene at levels between 40 and 84 ppb in the air. The highest levels of all materials in the 1997 monitoring program were found at a dam spillway because of water turbulence. The highest levels were determined not to be responsible for any health effects (CDPR 1998).

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

A. The USEPA (1981b) concluded that there was no reason to restrict the use of rotenone in waters intended for irrigation, livestock (with the possible exception of swine) consumption, and recreational swimming use. The USEPA (1990) ruled that a reentry interval was not needed for persons who swim in waters treated with rotenone based on an assessment of the toxicology data (e.g., skin, oral water intake) and exposure level. The reentry statement on the product labels—"do not swim in rotenone-treated water until the application has been completed and all the pesticide has been thoroughly mixed into the water according to labeling instructions"—indicates the safety of rotenone use for fish control. The reason for this slight waiting period is esthetic.

Q. Are people at risk from consuming fish stocked into a recently treated water body?

A. Fish are not stocked into a treated area until all of the toxic effects are gone and rotenone has dissipated. Hence, stocked fish cannot accumulate residues of rotenone from the water. Residues of rotenone in tolerant fish that survive a rotenone treatment won't last for more than sev-

eral days because the bioaccumulation potential for rotenone is low and the half-life of rotenone in fish is about 1 day (Gingerich and Rach 1985; Gingerich 1986).

Q. Is there any risk to people from consuming fish that have been killed from rotenone?

A. The USEPA has not established guidelines for consuming fish killed with rotenone. Therefore, agencies cannot condone this practice. Additionally, there is a valid concern of risk of salmonella and other bacteriological poisoning from consuming fish that have been dead for a period of time. 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.

5.3 ENVIRONMENTAL QUALITY

Q. Do dead and decaying fish pose any problems to the recovery of fishing?

A. Most dead fish will sink to the bottom of the treated body of water in several days, decompose, and release nutrients back into the water. These nutrients will directly stimulate phytoplankton and indirectly stimulate insect and zooplankton production. These organisms are a good food base for fish.

Q. Can the toxic effects of rotenone to fish and other aquatic life be neutralized?

A. In lakes or rivers, if biologists want to neutralize the effects of rotenone, potassium permanganate, an oxidizing agent, can be used. This is added to the water at a minimum 1:1 ratio with the concentration of rotenone applied plus sufficient additional permanganate to satisfy the oxygen demand caused by organic matter that may be present in the treated water. Neutralization of rotenone with permanganate may be impaired at water temperatures of 50°F (10°C) or less (CDFG 1994; AgrEvo, no date).

Q. What is the "pesticide" smell sometimes associated with the use of rotenone?

A. The aromatic smell (like the smell of mothballs) associated with the use of liquid rotenone formulations is likely airborne concentrations (greater than 40 ppb) of naphthalene and methylnaphthalene (CDPR 1998). This smell may last for several days, depending on air and water temperatures and wind direction. These relatively "heavy" organic compounds tend to sink (remain close to the ground) and move downwind. The California Department of Pesticide Regulation (CDPR 1998) found no health effects from this smell despite complaints.

Q. How long does rotenone persist?

A. The time for natural degradation (neutralization) of rotenone by hydrolysis is governed primarily by temperature. Studies in standing, ice-free waters in California show that rotenone completely degrades within

1 to 8 weeks within the temperature range of 10–20°C (CDFG 1994; Siepmann and Finlayson 1999; Finlayson and Harrington, unpublished); the estimated half-life values for California waters vary from 7.8 to 1.5 days, respectively. Other studies indicate half-life values of 13.9 hours to 10.3 days for water temperatures of 24°C and 5°C, respectively (Gilderhus et al. 1986, 1988). Rotenone dissipates in flowing waters relatively quickly (less than 24 hours) due to dilution and increased rates of hydrolysis (Borriston Laboratories 1983) and photolysis (Cheng et al. 1972; Biospherics 1982). Although rotenone can be found in lake sediments, the levels approximate those found in water, and breakdown of rotenone lags one to two weeks behind water levels. It is uncommon to find rotenone in stream sediments (CDFG 1994).

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

A. Researchers in California have found other organic compounds associated with the use of the liquid formulation Nusyn-Noxfish® (CDFG 1994; Siepmann and Finlayson 1999; Finlayson and Harrington, unpublished). These include the volatile organic compounds (VOC) [xylene, trichlorethylene (TCE), toluene, and trimethylbenzene] and the semivolatile organic compounds (semiVOC) [piperonyl butoxide (PBO), naphthalene, 1-methyl naphthalene, and 2-methyl naphthalene] (Table 5.1). With the exception of PBO, the other organic compounds disappear before rotenone dissipates, typically within 1 to 3 weeks. Piperonyl butoxide, which is the other active ingredient (synergist) in Nusyn-Noxfish®, is relatively stable; photolysis does not contribute significantly to its degradation (Friedman and Epstein 1970). Piperonyl butoxide has persisted in deep lake waters at low temperatures (below 10°C) for approximately nine months. The VOC's do not accumulate in the sediment, and only naphthalene and the methyl naphthalenes temporarily (less than 8 weeks) accumulate in the sediments (CDFG 1994; Siepmann and Finlayson 1999; Finlayson and Harrington, unpublished).

Table 5.1. Persistence of rotenone and other organic compounds in water and sediment impoundments treated with 2 ppm rotenone formulation.

Compound	Initial water concentration (parts per billion)	Water persistence	Initial sediment concentration (parts per billion)	Sediment persistence
Rotenone	50	<8 weeks	522	<8 weeks
Trichloroethylene	1.4	<2 weeks	ND*	
Xylene	3.4	<2 weeks	ND	
Trimethylbenzene	0.68	<2 weeks	ND	
Naphthalene	140	<3 weeks	146	<8 weeks
1-m-naphthalene	150	<3 weeks	150	<4 weeks
2-m-naphthalene	340	<3 weeks	310	<4 weeks
Toluene	1.2	<2 weeks	ND	
Piperonyl Butoxide	30	<9 months	ND	

*ND=below detection limits

Q. Does the synergist piperonyl butoxide used in some formulations pose an environmental risk?

A. No, piperonyl butoxide has little toxicity to fish and wildlife and is not a risk to humans at the concentrations used in fish management (Roussel Bio Corporation, no date).

Q. Is rotenone likely to enter groundwater and pollute water supplies?

A. The ability of rotenone to move through soil is low to slight. Rotenone moves only 2 cm (<1 inch) in most types of soils. An exception would be in sandy soils where the movement is about 8 cm (slightly more than 3 inches). Rotenone is strongly bound to organic matter in soil so it is unlikely that rotenone would enter groundwater (Dawson et al. 1991). The other compounds in the liquid formulation Nusyn-Noxfish® have not been detected in groundwaters (CDFG 1994; Siepmann and Finlayson 1999; Finlayson and Harrington, unpublished).

Q. Are there any degradation products from rotenone that can cause environmental problems?

A. The metabolite of rotenone, rotenolone, persists longer than rotenone, especially in cold, alpine lakes (Finlayson and Harrington, unpublished). Rotenolone has been detected for as long as 6 weeks in cool water temperatures (<10°C) at high elevations (>8,000 feet). In part, this situation occurs because rotenone may be more susceptible to photolysis than rotenolone. However, studies have indicated that rotenolone is approximately one-tenth as lethal as rotenone (CDFG 1991a). In those rare cases of rotenolone persistence, fish stocking would be delayed until both rotenone and rotenolone residues have declined to nondetectable (<2 ppb) levels to err on the side of safety.

5.4 FISH AND WILDLIFE

Q. Does rotenone affect all aquatic animals the same?

A. No. Fish are more susceptible. 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) and thus, digestive enzymes cannot neutralize it. Contrary to common belief, the other ingredients in Noxfish® and Nusyn-Noxfish® impart no toxicity to fish, insects, birds, or mammals (CDFG 1994). Rotenone residues in dead fish are generally very low (<0.1 ppm), unstable like those in water, and not readily absorbed through the gut of the animal eating fish.

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

A. For the reasons listed above, birds and mammals that eat dead fish and drink treated water will not be affected. A bird weighing ¼ pound would have to consume 100 quarts of treated water or more than 40

pounds of fish and invertebrates within 24 hours to receive a lethal dose. This same bird would normally consume 0.2 ounces of water and 0.32 ounces of food daily; thus, a safety factor of 1,000- to 10,000-fold exists for birds and mammals. No latent or continuing toxicity is expected since under normal conditions rotenone will not persist for more than a few weeks (CDFG 1994).

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

A. During recent treatments in California, fish-eating birds (i.e., herons and sea gulls) and mammals (i.e., raccoons) were found foraging on dying and recently dead fish for several days following treatment (CDFG 1994). Following this abundance of dead fish, a temporary reduction in food supplies for fish- or invertebrate-eating birds and mammals will result until the fish and invertebrates are restored. There is no indication that this temporary reduction results in any significant impacts to most bird or mammal populations because most animals can utilize other water bodies and sources for food. However, the temporary loss in food resources for sensitive animals during mating may cause unavoidable impacts. California has 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 (CDFG 1991b). Likewise, Michigan has mitigated the impacts to loons by delaying treatments until chicks have fledged.

Q. Is it safe for livestock to drink from rotenone-treated waters?

A. Rotenone was used for many years to control grubs on the backs of dairy and beef cattle. The USEPA (1981b) has stated that there is no need to restrict livestock consumption of treated waters. However, swine are more sensitive to rotenone than cattle (Thomson 1985).

5.5 REFERENCES

AgrEvo. No date. Nusyn-Noxfish stream and river monograph. AgrEvo Environmental Health, Montvale, New Jersey.

Biospherics. 1982. Aqueous photodegradation of ^{14}C-rotenone. Report to U.S. Geological Service, Upper Midwest Environmental Sciences Center (U.S. Fish and Wildlife Service Study 14-16-990-81-042), La Crosse, Wisconsin.

Biotech Research. 1981. Analytical studies for detection of chromosomal aberrations in fruit flies, rats, mice and horse bean. Report to U.S. Geological Service, Upper Midwest Environmental Sciences Center (U.S. Fish and Wildlife Service Study 14-16-990-80-54), La Crosse, Wisconsin.

Borriston Laboratories. 1983. Hydrolysis of ^{14}C-rotenone. Report to U.S. Geological Service, Upper Midwest Environmental Sciences Center (U.S. Fish and Wildlife Service Study), La Crosse, Wisconsin.

CARB (California Air Resources Board). 1997. Lake Davis fish kill emergency response—final report. CARB, Sacramento.

CDFG (California Department of Fish and Game). 1991a. Pesticide investigations unit, aquatic toxicology laboratory 1990 annual progress report. CDFG, Environmental Services Division, Sacramento.

CDFG (California Department of Fish and Game). 1991b. Northern pike eradication project - draft subsequent environmental impact report. CDFG, Inland Fisheries Division, Sacramento.

CDFG (California Department of Fish and Game). 1994. Rotenone use for fisheries management - final programmatic environmental impact report (SCH 92073015). CDFG, Environmental Services Division, Sacramento.

CDPR (California Department of Pesticide Regulation). 1998. A report on the illnesses related to the application of rotenone to Lake Davis. CDPR, Worker Health and Safety Branch, Report HS-1772, Sacramento.

Chandler, J., and L. Marking. 1982. Toxicity of rotenone to selected aquatic invertebrates and frog larvae. Progressive Fish-Culturist 44:78-80.

Cheng, H., I. Yamamoto, and J. Casida. 1972. Rotenone photodecomposition. Journal of Agricultural Food Chemistry 20:850-856.

Dawson, V. K., W. H. Gingerich, R. A. Davis, and P. A. Gilderhus. 1991. Rotenone persistence in freshwater ponds: effects of temperature and sediment adsorption. North American Journal of Fisheries Management 11:226-231.

Ellis, H., and six coauthors. 1980. Subchronic oral dosing study for safety evaluation of rotenone using dogs. Report to U.S. Geological Service, Upper Midwest Environmental Sciences Center (U.S. Fish and Wildlife Service Study 14-16-009-79-115), La Crosse, Wisconsin.

Friedman, M. A., and S. S. Epstein. 1970. Stability of piperonyl butoxide. Toxicology and Applied Pharmacology 17: 810-812.

Gilderhus, P. A., J. L. Allen, and V. K. Dawson. 1986. Persistence of rotenone in ponds at different temperatures. North American Journal of Fisheries Management 6:126-130.

Gilderhus, P. A., V. K. Dawson, and J. L. Allen. 1988. Deposition and persistence of rotenone in shallow ponds during cold and warm seasons. U.S. Fish and Wildlife Service, Investigations in Fish Control 95.

Gingerich, W. 1986. Tissue distribution and elimination of rotenone in rainbow trout. Aquatic Toxicology 8:27-40.

Gingerich, W., and J. Rach. 1985. Uptake, accumulation and depuration of ^{14}C-rotenone in bluegills (*Lepomis macrochirus*). Aquatic Toxicology 6:170-196.

Gleason, M., R. Gosselin, H. Hodge, and P. Smith. 1969. Clinical toxicology of commercial products. The William and Wilkins Company, Baltimore, Maryland.

Goethem, D., B. Barnhart, and S. Fotopoulos. 1981. Mutagenicity studies on rotenone. Report to U.S. Geological Service, Upper Midwest Environmental Sciences Center (U.S. Fish and Wildlife Service Study 14-16-009-80-076), La Crosse, Wisconsin.

Haley, T. 1978. A review of the literature of rotenone. Journal of Environmental Pathology and Toxicology 1:315-337.

Hazleton Raltech Laboratories. 1982. Teratology study with rotenone in rats. Report to U.S. Geological Service, Upper Midwest Environmental Sciences Center (U.S. Fish and Wildlife Service Study 81178), La Crosse, Wisconsin.

Marking, L., and T. Bills. 1976. Toxicity of rotenone to fish on standardized laboratory tests. U.S. Fish and Wildlife Service, Investigations in Fish Control, Bulletin 72.

NAS (National Academy of Science). 1983. Drinking water and health, volume 5. Safe Drinking Water Committee Board of Toxicology and Environmental Health Hazards, Commission on Life Sciences, National Research Council, National Academy Press, Washington, D.C.

Oberg, K. 1967a. On the principal way of attack of rotenone in fish. Archives for Zoology 18:217-220.

Oberg, K. 1967b. The reversibility of the respiration inhibition in gills and the ultrastructural changes in chloride cells from rotenone-poisoned marine teleost, *Gaduscallarius*. Experimental Cellular Research 45:590-602.

Roussel Bio Corporation. No date. Technical information sheet piperonyl butoxide insecticidal syngerist. Roussel Bio Corporation, Montvale, New Jersey.

Siepmann, S., and B. Finlayson. 1999. Chemical residues in water and sediment following rotenone application to Lake Davis, California. California Department of Fish and Game, Office of Spill Prevention and Response Administrative Report 99-2, Sacramento.

Spencer, F., and L. Sing. 1982. Reproductive responses to rotenone during decidualized pseudogestation and gestation in rats. Bulletin of Environmental Contamination and Toxicology 228:360-368.

Thomson, W. T. 1985. Agricultural chemicals, book 1: insecticides, acaracides and ovicides. Thomson Publications, Fresno, California.

Tisdel, M. 1985. Chronic toxicity study of rotenone in rats. Report to U.S. Geological Survey, Upper Midwest Environmental Sciences Center (U.S. Fish and Wildlife Service Study 6115-100), La Crosse, Wisconsin.

USEPA (U.S. Environmental Protection Agency). 1980a. Ambient water quality criteria for naphthalene. USEPA Document 440/5-80-059, Washington, D.C.

USEPA (U.S. Environmental Protection Agency). 1980b. Ambient water quality criteria trichloroethylene. USEPA Document 440/5-80-077, Washington, D.C.

USEPA (U.S. Environmental Protection Agency). 1981a. Advisory option for xylenes (dimethylbenzene). USEPA, Office of Drinking Water, Washington, D.C.

USEPA (U.S. Environmental Protection Agency). 1981b. Completion of pre-RPAR review of rotenone. USEPA, Office of Toxic Substances (June 22, 1981), Washington D.C.

USEPA (U.S. Environmental Protection Agency). 1989b. Guidance for the reregistration of pesticide products containing rotenone and associated resins as the active ingredient. USEPA Report 540/RS-89-039, Washington, D.C.

USEPA (U.S. Environmental Protection Agency). 1990. Rotenone re-entry statement for swimmers. USEPA Administrative 6704-Q, (January 17, 1990), Washington, D.C.

USEPA (U.S. Environmental Protection Agency). 1993. Water quality standards handbook. USEPA Report (EPA-823-B-93-002), Water Quality Standards Branch, Office of Science and Technology (September 1993), Washington, D.C.