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Fish Disease Leaflet

The *Fish Disease Leaflet* series, issued by the National Fish Health Research Laboratory, National Fisheries Research Center–Leetown, U.S. Fish and Wildlife Service, evolved from the more generalized *Fishery Leaflet* series to meet the needs of hatchery personnel and of fish health instructors in providing specific and timely information on fish diseases. Each *Fish Disease Leaflet* discusses a particular disease or a combination of related diseases, and gives a brief history of the disease, its etiology, clinical signs, diagnosis, geographic range, occurrence, and methods of control. As new information becomes available, the *Fish Disease Leaflets* are revised or new ones are issued; they are distributed by Technical Information Services, National Fisheries Research Center–Leetown, Box 700, Kearneysville, West Virginia 25430.

1. WOLF, K. 1966. Infectious pancreatic necrosis (IPN) of salmonid fishes. (Supersedes *Fishery Leaflet* 453, 1958.) 4 pp.
2. MEYER, F. P. 1974. Parasites of freshwater fishes; II, Protozoa; 3, *Ichthyophthirius multifiliis*. (Issued 1966; revised 1969 and 1974.) 5 pp.
3. BOWEN, J. T., AND R. E. PUTZ. 1966. Parasites of freshwater fish; IV, Miscellaneous; 3, Parasitic copepod *Argulus*. 4 pp.
4. BOWEN, J. T. 1966. Parasites of freshwater fish; IV, Miscellaneous; 4, Parasitic copepods *Ergasilus, Achtheres*, and *Salmincola*. 4 pp.
5. MEYER, F. P. 1966. Parasites of freshwater fishes; IV, Miscellaneous; 6, Parasites of catfishes. 7 pp.
6. WOLF, K. 1966. Viral hemorrhagic septicemia of rainbow trout. (Revised 1972; reprinted 1981 and 1984.) 4 pp.
7. PARISOT, T. J., AND J. W. WOOD. 1966. Fish mycobacteriosis (tuberculosis). (Issued 1966; revised 1970.) 2 pp.
8. WOLF, K. 1966. Bacterial kidney disease of salmonid fishes. (Reprinted 1970; supersedes *Fishery Leaflet* 566, 1964.) 4 pp.
9. HOFFMAN, G. L., S. F. SNIESZKO, AND K. WOLF. 1968. Approved procedure for determining absence of viral hemorrhagic septicemia and whirling disease in certain fish and fish products. (Reissued 1970; reprinted 1981.) 7 pp.
10. [Not issued]
11. SNIESZKO, S. F., AND G. L. BULLOCK. 1968. Freshwater fish diseases caused by bacteria belonging to the genera *Aeromonas* and *Pseudomonas*. (Supersedes *Fishery Leaflet* 459, 1958; revised 1962.) 7 pp.
12. PUTZ, R. E., AND J. T. BOWEN. 1968. Parasites of freshwater fishes; IV, Miscellaneous; The anchor worm (*Lernaea cyprinacea*) and related species. (Supersedes *Fishery Leaflet* 575, 1964.) 4 pp.
13. WOLF, K. 1968. Lymphocystis disease of fish. (Supersedes *Fishery Leaflet* 565, 1964.) 4 pp.
14. WOLF, K. 1969. Virus disease of sockeye salmon. (Supersedes *Fishery Leaflet* 454, 1958.) 3 pp.
15. WOLF, K. 1969. Blue-sac disease of fish (also known as dropsy, yolk sac disease, and *Hydrocoele embryonalis*). (Supersedes *Fishery Leaflet* 455; revised 1963.) 4 pp.
16. SNIESZKO, S. F., AND A. J. ROSS. 1969. Columnaris disease of fishes. (This leaflet was issued in November 1969 and is a revision of *Fish Disease Leaflet* 16 of February 1969; supersedes *Fishery Leaflet* 461, 1958.) 4 pp.
17. SNIESZKO, S. F. 1969. Fish furunculosis. (Supersedes *Fishery Leaflet* 467, 1958.) 4 pp.
18. PLUMB, J. A. 1972. Channel catfish virus disease. (Revision of *Fish Disease Leaflet* 18, 1969, by Wellborn, Fijan, and Naftel.) 4 pp.
19. SNIESZKO, S. F. 1970. Bacterial gill disease of freshwater fishes. (Supersedes *Fishery Leaflet* 464, 1958.) 4 pp.
20. PUTZ, R. E. 1969. Parasites of freshwater fishes; II, Protozoa; 1, Microsporida of fishes. (Supersedes *Fishery Leaflet* 571; revised November 1969.) 4 pp.
21. HOFFMAN, G. L. 1969. Parasites of freshwater fish; I, Fungi; 1, Fungi (*Saprolegnia* and relatives) of fish and fish eggs. (Supersedes *Fishery Leaflet* 564, 1963; reprinted 1981.) 6 pp.
22. WOLF, K. 1970. White-spot disease of fish eggs and fry. (Supersedes *Fishery Leaflet* 456, 1958.) 3 pp.

23. SNIESZKO, S. F. 1970. Nutritional (dietary) gill disease and other less known gill diseases of freshwater fishes. (Supersedes *Fishery Leaflet* 463, 1958.) 2 pp.

24. PIPER, R. G. 1970. Ulcer disease in trout. (Supersedes *Fishery Leaflet* 466.) 3 pp.

25. BULLOCK, G. L., AND S. F. SNIESZKO. 1970. Fin rot, coldwater disease, and peduncle disease of salmonid fishes. (Supersedes *Fishery Leaflet* 462, 1958; reprinted 1981, 1984.) 3 pp.

26. SNIESZKO, S. F., F. T. WRIGHT, G. L. HOFFMAN, AND K. WOLF. 1970. Selected fish disease publications in English. (Supersedes *Fishery Leaflet* 570, 1964.) 7 pp.

27. AMEND, D. F., AND G. WEDEMEYER. 1970. Approved procedure for determining absence of infectious pancreatic necrosis (IPN) virus in certain fish and fish products. 4 pp.

28. HOFFMAN, G. L. 1970. Control and treatment of parasitic diseases of freshwater fishes. (Supersedes *Fishery Leaflet* 486, 1959.) 7 pp.

29. ROSS, A. J. 1970. Vibriosis in fish. 3 pp.

30. PARISOT, T. J. 1970. Sacramento River chinook disease (SRCD). (Supersedes *Fishery Leaflet* 562, 1963.) 2 pp.

31. AMEND, D. F. 1970. Approved procedure for determining absence of infectious hematopoietic necrosis (IHN) in salmonid fishes. (Reprinted 1981.) 4 pp.

32. HERMAN, R. L. 1971. Visceral granuloma and nephrocalcinosis. 2 pp.

33. WRIGHT, F. T. 1971. List of reference sources for students of fish diseases. (Supersedes *Fishery Leaflet* 570, 1964; and *Fish Disease Leaflet* 26, 1970.) 11 pp.

34. WOLF, K. 1971. Soft-egg disease of fishes. (Supersedes *Fishery Leaflet* 457, 1958.) 1 p.

35. WOLF, K., AND M. C. QUIMBY. 1973. Fish virology: procedures and preparation of materials for plaquing fish viruses in normal atmosphere. 13 pp.

36. SNIESZKO, S. F. 1974. Nutritional (dietary) gill disease and other less known gill diseases of freshwater fishes. (Revision of *Fish Disease Leaflet* 23, 1970; supersedes *Fishery Leaflet* 463, 1958; reprinted 1981.) 2 pp.

37. WOLF, K. 1974. Rhabdovirus disease of northern pike fry. 4 pp.

38. WEDEMEYER, G. A., AND J. W. WOOD. 1974. Stress as a predisposing factor in fish diseases. (Reprinted 1981 and 1984.) 8 pp.

39. AMEND, D. F. 1974. Infectious hematopoietic necrosis (IHN) virus disease. (Supersedes *Fishery Leaflet* 454, 1958; *Fish Disease Leaflet* 14, 1969; and *Fish Disease Leaflet* 30, 1970.) 6 pp.

40. SNIESZKO, S. F., AND G. L. BULLOCK. 1974. Diseases of freshwater fishes caused by bacteria of the genera *Aeromonas, Pseudomonas*, and *Vibrio*. (Supersedes *Fishery Leaflet* 459, 1958 and 1962; and *Fish Disease Leaflet* 11, 1968.) 10 pp.

41. BULLOCK, G. L., H. M. STUCKEY, AND K. WOLF. 1975. Bacterial kidney disease of salmonid fishes. 7 pp.

42. BULLOCK, G. L., AND S. F. SNIESZKO. 1975. Hagerman redmouth, a disease of salmonids caused by a member of the Enterobacteriaceae. 5 pp.

43. SNIESZKO, S. F., AND G. L. BULLOCK. 1975. Fish furunculosis. (Supersedes *Fish Disease Leaflet* 17, 1969; and *Fishery Leaflet* 467, 1958.) 10 pp.

44. WOLF, K., T. SANO, AND T. KIMURA. 1975. Herpesvirus disease of salmonids. 8 pp.

45. SNIESZKO, S. F., AND G. L. BULLOCK. 1976. Columnaris disease of fishes. (Supersedes *Fishery Leaflet* 461, 1958; and *Fish Disease Leaflet* 16, 1969.) 10 pp.

46. HOFFMAN, G. L. 1976. Parasites of freshwater fishes. IV. Miscellaneous. The anchor parasite (*Lernaea elegans*) and related species. (Supersedes *Fishery Leaflet* 575, 1964; and *Fish Disease Leaflet* 12, 1968; reprinted 1981.) 8 pp.

47. HOFFMAN, G. L. 1976. Whirling disease of trout. (Revision of *Fishery Leaflet* 508, 1962.) 10 pp.

48. HOFFMAN, G. L. 1977. Copepod parasites of freshwater fish: *Ergasilus, Achtheres*, and *Salmincola*. (Supersedes *Fish Disease Leaflet* 4, 1966.) 10 pp.

49. HOFFMAN, G. L. 1977. *Argulus*, a Branchiuran parasite of freshwater fishes. (Supersedes *Fish Disease Leaflet* 3, 1966, 1969, and 1974.) 9 pp.

50. BULLOCK, G. L. 1977. Vibriosis in fish. (Supersedes *Fish Disease Leaflet* 29, 1970.) 11 pp.

51. AHNE, W., AND K. WOLF. 1977. Spring viremia of carp. 11 pp.

52. PLUMB, J. A. 1977. Channel catfish virus disease. (Supersedes *Fish Disease Leaflet* 18, 1969 and 1972.) 8 pp.

53. MANN, J. A. 1978. Diseases and parasites of fishes: an annotated bibliography of books and symposia, 1904-1977. Supersedes *Fishery Leaflet* 570, 1964; *Fish Disease Leaflet* 26, 1970; and *Fish Disease Leaflet* 33, 1971.) 28 pp.

54. BULLOCK, G. L. 1978. Pasteurellosis of fishes. 7 pp.

55. SNIESZKO, S. F. 1978. Mycobacteriosis (tuberculosis) of fishes. (Supersedes *Fish Disease Leaflet* 7, 1966 and 1970.) 9 pp.

56. LEWIS, D. H., AND L. R. UDEY. 1978. Meningitis in fish caused by an asporogenous anaerobic bacterium. 5 pp.

57. BULLOCK, G. L., AND S. F. SNIESZKO. 1979. Enteric redmouth disease of salmonids. (Supersedes *Fish Disease Leaflet* 42, 1975.) 7 pp.

58. JOHNSON, K. A., J. E. SANDERS, AND J. L. FRYER. 1979. *Ceratomyxa shasta* in salmonids. (Also published as *Oregon Agricultural Experiment Station Technical Paper* 5130.) 11 pp.

59. MITCHELL, A. J., AND G. L. HOFFMAN. 1980. Important tapeworms of North American freshwater fishes. 18 pp.

60. BULLOCK, G. L. 1980. Bacterial kidney disease of salmonid fishes caused by *Renibacterium salmoninarum*. (Supersedes *Fish Disease Leaflet* 41, 1975.) 10 pp.

61. [Not issued]

62. SNIESZKO, S. F. 1981. Bacterial gill disease of freshwater fishes. (Supersedes *Fishery Leaflet* 464, 1958 and 1970; and *Fish Disease Leaflet* 19, 1970.) 11 pp.

63. BULLOCK, G. L. 1981. Streptococcal infections of fishes. 7 pp.

64. HERMAN, R. L. 1981. Visceral granuloma and nephrocalcinosis. (Supersedes *Fish Disease Leaflet* 32, 1971.) 3 pp.

65. MCALLISTER, P. E. 1983. Infectious pancreatic necrosis (IPN) of salmonid fishes. (Supersedes *Fishery Leaflet* 453, 1958; and *Fish Disease Leaflet* 1, 1966.) 12 pp.

66. BULLOCK, G. L., R. C. CIPRIANO, AND S. F. SNIESZKO. 1983. Furunculosis and other diseases caused by *Aeromonas salmonicida*. (Supersedes *Fishery Leaflet* 467, 1958; *Fish Disease Leaflet* 17, 1969; and *Fish Disease Leaflet* 43, 1975.) 29 pp.

67. BULLOCK, G. L. 1984. Enteric redmouth disease of salmonids. (Supersedes *Fish Disease Leaflet* 57, 1979; and *Fish Disease Leaflet* 42, 1975.) 14 pp.

68. CIPRIANO, R. C., G. L. BULLOCK, AND S. W. PYLE. 1984. *Aeromonas hydrophila* and motile aeromonad septicemias of fish. (Supersedes *Fishery Leaflet* 459, 1958 and 1962; *Fish Disease Leaflet* 11, 1968; and *Fish Disease Leaflet* 40, 1976.) 23 pp.

69. WOLF, K., AND M. E. MARKIW. 1985 Salmonid whirling disease. (Supersedes *Fish Disease Leaflet* 47, 1976.) 12 pp.

Investigations in Fish Control

Investigations in Fish Control **contains technical reports about fish control research conducted at the National Fisheries Research Center–LaCrosse, Wisconsin. This series continues a series formerly included in the *Resource Publication* series. Publications are typeset and have a standard size of 20 × 26 cm (7 7/8 × 10 1/4 in.); length varies. Intended audiences are research scientists and technically trained management personnel. The series was first issued in 1964. Copies are available from the National Fisheries Research Center–LaCrosse, Office of Technical Information, P.O. Box 818, LaCrosse, Wisconsin 54601.**

1. LENNON, R. E., AND C. R. WALKER. 1964. Laboratories and methods for screening fish-control chemicals. 15 pp.

   Describes the physical and technical facilities and procedures of the Fish Control Laboratories at LaCrosse, Wisconsin, and Warm Springs, Georgia. Describes three levels of screening of chemicals for use in fishery management.

2. WALKER, C. R., R. E. LENNON, AND B. L. BERGER. 1964. Preliminary observations on the toxicity of antimycin A to fish and other aquatic animals. 18 pp.

   Preliminary tests were made to evaluate the effects of antimycin A at concentrations of 0.01 to 120 ppb on 24 freshwater fish species in the laboratory and 25 species in outdoor pools. Responses of a select group of other animals and aquatic plants are discussed.

3. HENEGAR, D. L. 1966. Minimum lethal levels of toxaphene as a piscicide in North Dakota lakes. 16 pp. [Also issued as *Resource Publication* 7]

   To determine the minimum levels of toxaphene lethal to fishes in prairie lakes and reservoirs, 16 North Dakota lakes—ranging from 6.3 to 915 acres—were treated in 1959 and 1960 with concentrations of toxaphene ranging from 0.005 to 0.035 ppm. Physical and chemical studies were made of each area, hydrological maps were prepared, and test netting was carried out before and after treatment.

4. NEEDHAM, R. G. 1966. Effects of toxaphene on plankton and aquatic invertebrates in North Dakota lakes. 16 pp. [Also issued as *Resource Publication* 8]

   The effects of low concentrations of toxaphene on plankton and larger invertebrates were studied in four North Dakota lakes (a fifth lake, untreated, was a control). *Brachionus, Keratella, Trichocerca, Asplanchna, Polyarthra, Conochiloides, Daphnia, Ceriodaphnia, Bosmina,* and *Cyclops* were dominant zooplankters.

5. WARNICK, D. C. 1966. Growth rates of yellow perch in two North Dakota lakes after population reduction with toxaphene. 9 pp. [Also issued as *Resource Publication* 9]

   Growth rates of yellow perch (*Perca flavescens*) that survived a toxaphene treatment in Brush and Long lakes in North Dakota were calculated by the scale method for the 1960 and 1961 growing seasons.

6. MAHDI, M. A. 1966. Mortality of some species of fish to toxaphene at three temperatures. 10 pp. [Also issued as *Resource Publication* 10]

   Lethal concentrations of toxaphene were determined for the central stoneroller (*Campostoma anomalum*), golden shiner (*Notemigonus crysoleucas*), goldfish (*Carassius auratus*), black bullhead (*Ictalurus melas*), and bluntnose minnow (*Pimephales notatus*) in water at 53, 63, and 73 °F. Rainbow trout (*Salmo gairdneri*) were tested at 53 °F. The TL_m and LD50 were obtained by graphic methods. For comparison a normit method was used with the bluntnose minnow data.

7. GAYLORD, W. E., AND B. R. SMITH. 1966. Treatment of East Bay, Alger County, Michigan, with toxaphene for control of sea lampreys. 7 pp. [Also issued as *Resource Publication* 11]

   An experiment was conducted to determine whether toxaphene could be used to eradicate lake-dwelling sea lampreys (*Petromyzon marinus*) and to determine its effect on fish populations. In East Bay, a 78-acre lake on the Sucker River, Alger County, Michigan, an estimated concentration of 100 ppb was maintained for 14 days.

8. MEEHAN, W. R., AND W. L. SHERIDAN. 1966. Effects of toxaphene on fishes and bottom fauna of Big Kitoi Creek, Afognak Island, Alaska. 9 pp. [Also issued as *Resource Publication* 12]

   Big Kitoi Creek, on Afognak Island, Alaska, was treated with toxaphene in July 1961 to remove sculpins (*Cottus aleuticus*) predaceous on pink salmon fry (*Oncorhynchus gorbuscha*). Dispersion

and penetration of toxaphene into the streambed were determined, as well as time required for detoxification. Numbers, weight, recruitment, and species composition of bottom fauna, insects, and other invertebrate groups were also monitored.

9. WALKER, C. R., R. J. STARKEY, AND L. L. MARKING. 1966. Relation of chemical structure to fish toxicity in nitrosalicylanilides and related compounds. 12 pp. [Also issued as *Resource Publication* 13]

   Relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout (*Salmo gairdneri*) and goldfish (*Carassius auratus*) were evaluated in standard, static bioassays. Single and multiple substitutions of alkyl-, nitro-, and halo-groups were tested.

10. MARKING, L. L. 1966. Evaluation of *p,p'*-DDT as a reference toxicant in bioassays. 10 pp. [Also issued as *Resource Publication* 14]

    p,p'-DDT was tested as a reference standard toxicant against 19 species of freshwater fish, including 39 lots from 10 sources. The rapidity, nonselectivity, and consistency of its toxicity to fish were evaluated in 96-h static bioassays.

11. SCHOETTGER, R. A., AND A. M. JULIN. 1966. Evaluation of an electronic method of measuring hematocrits of fish. 11 pp. [Also issued as *Resource Publication* 15]

    Investigates 1) the comparability of YSI (Yellow Springs Instrument Company) electronic and centrifuge methods for measuring hematocrits in fish, 2) the reproducibility of electronic hematocrits, and 3) some physiological variables in fish blood that could influence conductivity—specifically, electrolyte and protein concentrations.

12. MARKING, L. L. 1967. Toxicity of MS-222 to selected fishes. 10 pp. [Also issued as *Resource Publication* 18]

    Toxicity of MS-222 to rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*), and walleye (*Stizostedion vitreum*) of various sizes was determined in 15-, 30-, and 60-min and 24-, 48-, and 96-h static bioassays at selected temperatures. Safety indexes were calculated on the basis of brief exposures.

13. SCHOETTGER, R. A., AND A. M. JULIN. 1967. Efficacy of MS-222 as an anesthetic on four salmonids. 15 pp. [Also issued as *Resource Publication* 19]

    MS-222 was tested for its efficacy as an anesthetic for rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), and lake trout (*S. namaycush*). Effects were noted at various temperatures, exposure times, dosages, pH values, and water hardness levels. Differences between larger and smaller fish were identified.

14. WALKER, C. R., AND R. A. SCHOETTGER. 1967. Method for determining MS-222 residues in fish. 10 pp. [Also issued as *Resource Publication* 20]

    Investigates applicability of a modified Bratton–Marshall method for detecting MS-222 in fish tissues.

15. WALKER, C. R., AND R. A. SCHOETTGER. 1967. Residues of MS-222 in four salmonids following anesthesia. 11 pp. [Also issued as *Resource Publication* 21]

    Residues of MS-222 (tricaine methanesulfonate) in the blood, muscle, liver, and kidney of rainbow trout (*Salmo gairdneri*) and in the muscle of brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), and lake trout (*S. namaycush*), were measured by a modified Bratton–Marshall colorimetric method. Temperatures were 7, 12, and 17°C in waters with total hardnesses of 10 to 180 ppm.

16. SCHOETTGER, R. A. 1967. Annotated bibliography on MS-222. 15 pp. [Also issued as *Resource Publication* 22]

    Contains 86 references, most of them annotated, on uses of MS-222 on cold-blooded animals including fish and amphibians.

17. SCHOETTGER, R. A., C. R. WALKER, AND L. L. MARKING. 1967. MS-222 as an anesthetic for channel catfish: its toxicity, efficacy, and muscle residues. 14 pp. [Also issued as *Resource Publication* 33]

    The influences of duration of exposure of MS-222, size of fish, temperature, and water quality on toxicity, efficacy, and residues are discussed for channel catfish (*Ictalurus punctatus*).

18. WILLFORD, W. A. 1966. Toxicity of 22 therapeutic compounds to six fishes. 10 pp. [Also issued as *Resource Publication* 35]

    Twenty-two therapeutic chemicals (18 parasiticides and 4 oral bacteriostats) were tested by bioassays for toxicity to fish. Tests were in 24- and 48-h static bioassays on rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), and bluegill (*Lepomis macrochirus*) at 12°C, and channel catfish (*Ictalurus punctatus*) at 17°C.

19. MARKING, L. L., AND J. W. HOGAN. 1967. Toxicity of Bayer 73 to fish. 13 pp. [Also issued as *Resource Publication* 36]

    Provides and discusses results of study on Bayer 73, a molluscicide sold commercially as Bayluscide, and its toxicity to 18 freshwater fish species. Various temperatures, water qualities and pH's were tested. Discusses biodegradability, efficacy,

and relative safety of Bayer 73 in conjunction with its usefulness as a general fish toxicant.

20. WILLFORD, W. A. 1967. Toxicity of dimethyl sulfoxide (DMSO) to fish. 8 pp. [Also issued as *Resource Publication* 37]

    Toxicities of dimethyl sulfoxide (DMSO) to rainbow trout (*Salmo gairdneri*), brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), carp (*Cyprinus carpio*), black bullhead (*Ictalurus melas*), channel catfish (*Ictalurus punctatus*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), and yellow perch were determined in 24-, 48-, and 96-hour static bioassays at 12°C. Toxicity was low, around 30 ppt.

21. HESSELBERG, R. J., AND R. M. BURRESS. 1967. Labor-saving devices for bioassay laboratories. 8 pp. [Also issued as *Resource Publication* 38]

    Three inexpensive pieces of labor-saving apparatus for bioassay laboratory use are described and illustrated. Construction features, material costs, and use of a jar rinser, automatic liquid measuring vessel, and jar emptier are discussed.

22. SCHOETTGER, R. A., AND A. M. JULIN. 1969. Efficacy of quinaldine as an anesthetic for seven species of fish. 10 pp.

    Quinaldine was tested as an anesthetic for rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), channel catfish (*Ictalurus punctatus*), bluegill (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*). The influences of pH, temperature, water hardness, age of quinaldine solutions, and repeated exposures on the efficacy of quinaldine are discussed.

23. MARKING, L. L. 1969. Toxicity of quinaldine to selected fishes. 10 pp.

    Quinaldine was tested as an anesthetic for various sizes of nine fish species in 15-, 30-, and 60-min and 3-, 6-, 24-, 48-, and 96-h static bioassays. The influences of temperature, pH, and water hardness on the efficacy of quinaldine are discussed.

24. LOCKE, D. O. 1969. Quinaldine as an anesthetic for brook trout, lake trout, and Atlantic salmon. 5 pp.

    Quinaldine (2-methylquinoline) was tested as an anesthetic for Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), and lake trout (*S. namaycush*) at various water temperatures and hardness.

25. BURRESS, R. M., AND C. W. LUHNING. 1969. Field trials of antimycin as a selective toxicant in channel catfish ponds. 12 pp.

26. BERGER, B. L., R. E. LENNON, AND J. W. HOGAN. 1969. Laboratory studies on antimycin A as a fish toxicant. 21 pp.

    Liquid and sand formulations of antimycin A were tested in laboratory waters of various temperatures, hardnesses, pH values, and turbidities against 31 species of freshwater fish of various sizes and life stages.

27. GILDERHUS, P. A., B. L. BERGER, AND R. E. LENNON. 1969. Field trials of antimycin A as a fish toxicant. 21 pp.

    Antimycin A was subjected to field trials as a fish toxicant in 20 ponds and lakes and 5 streams in the East, Midwest, and West of the United States. The formulations of toxicant included three on sand grains, which are designed to release antimycin uniformly within certain depths, and one formulation in a liquid. The influences of pH and water temperature on the efficacy of antimycin A were examined; effects on other aquatic animals were noted.

28. BURRESS, R. M., AND C. W. LUHNING. 1969. Use of antimycin for selective thinning of sunfish populations in ponds. 10 pp.

    Selective removal of bluegills (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), and redbreast sunfish (*L. auritus*) was tested in six soft-water ponds in west-central Georgia by applications of 0.4, 0.6, 0.8, and 1.0 ppb of antimycin in the Fintrol-5 formulation. The influences of season, weather conditions, and water temperature on the efficacy of antimycin are described.

29. HOWLAND, R. M., AND R. A. SCHOETTGER. 1969. Efficacy of methylpentynol as an anesthetic on four salmonids. 11 p.

    Determines the effective concentrations of methylpentynol for anesthetizing rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), and lake trout (*S. namaycush*). The effects of water hardness, pH, water temperature, and repeated dosages on rate of anesthesia are described.

30. MARKING, L. L. 1969. Toxicity of methylpentynol to selected fishes. 7 pp.

    Methylpentynol was tested in 96-h bioassays for its toxicity to rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), northern pike (*Esox lucius*), channel catfish (*Ictalurus punctatus*), bluegills (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and walleyes (*Stizostedion vitreum*).

31. SVENDSEN, G. E. 1969. Annotated bibliography on methylpentynol. 7 pp.

    Provides references on fishery uses, biochemistry, physiology, and methods of analysis of methylpentynol.

32. HOGAN, J. W. 1969. Toxicity of Hyamine 3500 to fish. 9 pp.

    The toxicity of Hyamine 3500 to 3 species of trout and 11 species of warmwater fish was determined in static bioassays. Twenty-nine lots of fish from nine sources were used in water at various levels of pH, temperature and total hardness.

33. LANE, T. H., AND H. M. JACKSON. 1969. Voidance time for 23 species of fish. 9 pp.

    Reports on voidance time (time required for food residues to pass through the alimentary canal) observations on fingerlings of 23 species of bioassay fish.

34. HOWLAND, R. M. 1969. Laboratory studies on possible fish-collecting aids with some toxicities for the isomers of cresol. 10 pp.

    The relative merits of quinaldine (2 methylquinoline), McNeil-JR-7464 (dl-1-(l-phenyl-ethyl)-5-(propoxy-carbonyl)-imidazole hydrochloride), and three isomers of cresol (p-methylphenol, o-methylphenol, and m-methylphenol) as collecting agents were determined in a lotic system under laboratory conditions at 12°C. The toxicity of the three cresol isomers to rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), and brook trout (*Salvelinus fontinalis*) was measured in bioassays conducted in standard constituted water, and LC50 values were calculated for exposures of 6, 24, 48, and 96 h. The toxicity of *para*-cresol was also established for common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), black bullhead (*Ictalurus melas*), channel catfish (*I. punctatus*), bluegill (*Lepomis macrochirus*), and yellow perch (*Perca flavenscens*).

35. SCHOETTGER, R. A. 1970. Toxicity of Thiodan in several fish and aquatic invertebrates. 31 pp.

    Thiodan, a chlorinated hydrocarbon insecticide, was tested on rainbow trout (*Salmo gairdneri*) and their fertilized eggs, western white suckers (*Catostomus commersoni*), *Daphnia magna*, and damselfly naiads. Toxicity was influenced by temperature, length of exposure, and alkaline pH. Deposition and metabolism of Thiodan residues in western white suckers, northern creek chubs (*Semotilus atromaculatus*), and goldfish (*Carassius auratus*) were traced with the aid of carbon-14 labeled Thiodan, and chemical analyses of Thiodan in tissues. A possible metabolic pathway for Thiodan degradation is discussed.

36. MARKING, L. L. 1970. A method for rating chemicals for potency against fish and other organisms. 8 pp.

    A potency rating is presented by which the toxicity of chemicals to organisms can be assessed with a minimum of data from preliminary bioassays. This method permits effective and rapid evaluation of toxicity when data from preliminary tests are inadequate for statistical analysis.

37. MARKING, L. L., AND W. A. WILLFORD. 1970. Comparative toxicity of 29 nitrosalicylanilides and related compounds to eight species of fish. 11 pp.

    The relative potencies of 29 nitrosalicylanilides and related structures against rainbow trout (*Salmo gairdneri*), goldfish (*Carassius auratus*), common carp (*Cyprinus carpio*), fathead minnows (*Pimephales promelas*), black bullheads (*Ictalurus melas*) green sunfish (*Lepomis cyanellus*), bluegills (*L. macrochirus*), and yellow perch (*Perca flavescens*) were determined in 96-h static bioassays. They varied depending on the type and position of substitutions.

38. MARKING, L. L., E. L. KING, C. R. WALKER, AND J. H. HOWELL. 1970. Toxicity of 33NCS to freshwater fish and sea lampreys. 16 pp.

    The chemical 33NCS (3′-chloro-3-nitrosalicylanilide) was evaluated as a fish control agent and as a larvicide for sea lampreys (*Petromyzon marinus*) at the Fish Control Laboratories of the Bureau of Sport Fisheries and Wildlife and the Hammond Bay Biological Station of the Bureau of Commercial Fisheries. Toxicity was shown to be strongly influenced by variations in water quality.

39. SCHOETTGER, R. A., AND G. E. SVENDSEN. 1970. Effects of antimycin A on tissue respiration of rainbow trout and channel catfish. 10 pp.

    The effects of antimycin A on respiration of the liver, kidneys, brain, and gills of rainbow trout (*Salmo gairdneri*) and channel catfish (*Ictalurus punctatus*) were measured in vivo and in vitro.

40. LENNON, R. E., AND B. L. BERGER. 1970. A resume on field applications of antimycin A to control fish. 19 pp.

    Investigates the toxicity of antimycin A in waters of various salt contents, pH's, and temperatures. A liquid formulation was used in most laboratory trials and in streams. Dry formulations were tested in the laboratory and in lakes and ponds. Discusses nonrepellency of antimycin and its use in partial reclamations and as a selective toxicant.

41. ALLEN, J. L., C. W. LUHNING, AND P. D. HARMAN. 1970. Identification of MS-222 residues in selected fish tissues by thin layer chromatography. 7 pp.

    Thin-layer chromatography was used to identify MS-222 in the presence of background primary aromatic amines in fish muscle, brain, and blood. This method, in which the Bratton–Marshall reaction is used to visualize the spots, gave both the specificity of the Bratton–Marshall reaction for primary aromatic amines and the R_f of MS-222 as tools for identification of the residues.

42. HUNN, J. B. 1970. Dynamics of MS-222 in the blood and brain of freshwater fishes during anesthesia. 8 pp.

    Measures the rate of uptake of MS-222 in the blood and brain of 11 freshwater species during induction of anesthesia.

43. WILLFORD, W. A. 1970. Effect of MS-222 on electrolyte and water content in the brain of rainbow trout. 7 pp.

    Rainbow trout (*Salmo gairdneri*) were exposed to 100 m/L solutions of MS-222 for 1-, 2-, 4-, and 10-min intervals; their brains were analyzed for sodium, potassium, calcium, magnesium, zinc, iron, and water content.

44. SCHNICK, R. A. 1972. A review of literature on TFM (3-trifluoromethyl-4-nitrophenol) as a lamprey larvicide. 31 pp.

45. ALLEN, J. L., C. W. LUHNING, AND P. D. HARMAN. 1972. Residues of MS-222 in northern pike, muskellunge, and walleye. 8 pp.

    Residues of MS-222 (tricaine methanesulfonate) in muscle tissue of northern pike (*Esox lucius*), muskellunge (*E. masquinongy*), and walleye (*Stizostedion vitreum*) following anesthesia were measured by a modified Bratton–Marshall colorimetric method and confirmed by thin-layer chromatography.

46. MARKING, L. L. 1972. Methods of estimating the half-life of biological activity of toxic chemicals in water. 9 pp.

    Methods presented require determination of LC50 values for organisms in aged solutions containing unknown residual concentrations, and concurrent tests of solutions containing known concentrations. Half-life of biological activity is determined by plotting the percent concentrations remaining in aged solutions, or deactivation indices against aging time on cyclic semilogarithmic graph paper.

47. ALLEN, J. L., AND J. B. SILLS. 1973. Preparation and properties of quinaldine sulfate, an improved fish anesthetic. 7 pp.

48. MARKING, L. L., AND V. K. DAWSON. 1973. Toxicity of quinaldine sulfate to fish. 8 pp.

    Acute toxicities of quinaldine sulfate ($QdSO_4$) were determined against selected species of coldwater and warmwater fishes. The LC50's were derived for 3-, 6-, 24-, and 96-h exposures in bioassays with different temperatures, hardnesses, and pH's.

49. GILDERHUS, P. A., B. L. BERGER, J. B. SILLS, AND P. D. HARMAN. 1973. The efficacy of a quinaldine sulfate as an anesthetic for freshwater fish. 9 pp.

    Quinaldine sulfate ($QdSO_4$) was tested for its efficacy on 15 freshwater fish species. The influences of water hardness, water temperature, and pH on efficacy were noted.

50. SILLS, J. B., J. L. ALLEN, P. D. HARMAN, AND C. W. LUHNING. 1973. Residue of quinaldine in ten species of fish following anesthesia with quinaldine sulfate. 9 pp.

    The concentration and persistence of residues of the anesthetic quinaldine in five species each of coldwater and warmwater fishes were measured following treatment with the new formulation quinaldine sulfate. Quinaldine accumulated in relation to increasing temperature, treatment concentration, and length of exposure.

51. LUHNING, C. W. 1973. Methods for simultaneous determination and identification of MS-222 and metabolites in fish tissues. 10 pp.

    The analytical method described detects residues of MS-222 and its metabolites: acetylated MS-222, *m*-aminobenzoic acid, and *m*-acetylaminobenzoic acid. The thin-layer chromatographic procedures are done simultaneously with analytical procedures.

52. LUHNING, C. W. 1973. Residues of MS-222, benzocaine, and their metabolites in striped bass following anesthesia. 11 pp.

    Striped bass (*Morone saxatilis*) were anesthetized in a 100 mg/L solution of MS-222 at 17.5°C. Other striped bass were anesthetized with benzocaine. Residues were measured following anesthesia by a modified Bratton–Marshall colorimetric method and confirmed by thin-layer chromatography.

53. DAWSON, V. K., AND L. L. MARKING. 1973. Toxicity of mixtures of quinaldine sulfate and MS-222 to fish. 11 pp.

    Acute toxicities of mixtures of two fish anesthetics (quinaldine sulfate and MS-222) to coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), bluegill (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*) of various sizes were determined in 15-, 30-, and 60-min and 24-, 48-, and 96-h static toxicity tests. The effects of various temperatures, water hardnesses, and pH's on the mixture's toxicity were evaluated.

54. GILDERHUS, P. A., B. L. BERGER, J. B. SILLS, AND P. D. HARMAN. 1973. The efficacy of quinaldine sulfate: MS-222 mixtures for the anesthetization of freshwater fish. 9 pp.

    Combinations of quinaldine sulfate ($QdSO_4$) and MS-222 were tested for their efficacy in anesthetizing 14 freshwater fish species. The effects of various pH's and water hardnesses on the efficacy were evaluated.

55. SILLS, J. B., J. L. ALLEN, P. D. HARMAN, AND C. W. LUHNING. 1973. Residues of quinaldine and MS-222 in fish following anesthesia with mixtures of quinaldine sulfate: MS-222. 12 pp.

    Residues of quinaldine and MS-222 in 10 species of fish exposed to mixtures of quinaldine and MS-222 were determined using gas chromatography and spectrophotometry for quinaldine and colorimetry for MS-222. Mean concentrations varied with concentration, temperature, length of exposure, and species.

56. MAKI, A. W., L. D. GEISSEL, AND H. E. JOHNSON. 1975. Toxicity of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) to 10 species of algae. 17 pp.

    The toxicity of analytical and field grades of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) to unialgal cultures of four green algae, four blue-green algae, and two species of diatoms was examined in 96-h toxicity tests. Growth was measured by daily optical density readings, cell counts of nonfilamentous species, and a gravimetric determination of maximum standing crop at the end of the tests.

57. KAWATSKI, J. A., M. M. LEDVINA, AND C. R. HANSEN, JR. 1975. Acute toxicities of 3-trifluoromethyl-4-nitrophenol (TFM) and 2',5-dichloro-4'-nitrosalicylanilide (Bayer 73) to larvae of the midge *Chironomus tentans*. 7 pp.

    The toxicants 3-trifluoromethyl-4-nitrophenol (TFM) and 2',5-dichloro-4'-nitrosalicylanilide (Bayer 73) were tested individually and together for toxicity to fourth instar *Chironomus tentans* in laboratory static tests at 22 ± 1 °C. Toxicity varied depending on water hardness.

58. FREMLING, C. R. 1975. Acute toxicity of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) to nymphs of mayflies (*Hexagenia* sp.). 8 pp.

    A recycling test apparatus and burrow-containing artificial substrates were used to determine the toxicity of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) against Hexagenia mayfly nymphs. Effects of pH, water hardness, and temperature on toxicity were evaluated.

59. SANDERS, H. O., AND D. F. WALSH. 1975. Toxicity and residue dynamics of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) in aquatic invertebrates. 9 pp.

    Six species of aquatic invertebrates including scud, *Gammarus pseudolimnaeus*, daphnid, *Daphnia magna*, crayfish, *Orconectes nais*, aquatic sowbug, *Asellus brevicaudus*, damselfly nymph, *Ischnura verticalis*, and a mayfly nymph, *Stenonema* sp. were exposed to TFM in toxicity tests in hard water at 21 °C.

60. MARKING, L. L., AND L. E. OLSON. 1975. Toxicity of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) to nontarget fish in static tests. 27 pp.

    The toxicity of purified, field grade, and reduced TFM to fish was determined in laboratory toxicity tests. The influence of water hardness, pH, and temperature on TFM toxicity was evaluated, and residual toxicity of TFM in water solutions was determined to evaluate the persistence of the toxicant under aerobic conditions.

61. MARKING, L. L., T. D. BILLS, AND J. H. CHANDLER. 1975. Toxicity of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) to nontarget fish in flow-through tests. 9 pp.

    Field grade 3-trifluoromethyl-4-nitrophenol (TFM) was tested for acute and chronic toxicity to 11 species of nontarget fish in 4- and 30-day exposures, respectively. The species used were coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), goldfish (*Carassius auratus*), golden shiner (*Notemigonus crysoleucas*), channel catfish (*Ictalurus punctatus*), bluegill (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), and yellow perch (*Perca flavescens*).

62. CHANDLER, J. H., JR., AND L. L. MARKING. 1975. Toxicity of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) to selected aquatic invertebrates and frog larvae. 7 pp.

    The lampricide 3-trifluoromethyl-4-nitrophenol (TFM) was tested against various groups of nontarget aquatic organisms. Invertebrates exposed were flatworms (*Catenula* sp.), annelids (*Tubifex tubifex*), daphnids (*Daphnia magna*), seed shrimps (*Cypridopsis* sp.), glass shrimp (*Palaemonetes kadiakensis*), mayfly nymphs (*Callibaetis* sp.), backswimmers (*Notonecta* sp.), mosquito larvae (*Culex* sp. and *Anopheles* sp.), bivalve mollusks (*Corbicula* sp., *Sphaerium* sp., *Elliptio* sp., and *Plectomerus* sp.) and snails (*Physa* sp., *Helisoma* sp., and *Pleurocera* sp.). Vertebrates exposed to TFM were larvae of gray tree frogs (*Hyla versicolor*), leopard frogs (*Rana pipiens*), and bullfrogs (*R. catesbeiana*).

63. DAWSON, V. K., K. B. CUMMING, AND P. A. GILDERHUS. 1975. Laboratory efficacy of 3-trifluoromethyl-4-nitrophenol (TFM) as a lampricide. 13 pp.

    The lampricidal activity of 3-trifluoromethyl-4-nitrophenol (TFM) was tested under controlled laboratory conditions to evaluate its response to different levels of pH, water hardness, and temperature, and to various sizes, developmental stages, and species of lampreys.

64. PIAVIS, G. V., AND J. H. HOWELL. 1975. Effects of 3-trifluoromethyl-4-nitrophenol (TFM) on developmental stages of the sea lamprey. 8 pp.

Developing sea lampreys (*Petromyzon marinus*) in stages 1 (zygote) through 17 (burrowing prolarva) were exposed for 24 h to a 10-mg/L (active ingredient) solution of 3-trifluoromethyl-4-nitrophenol (TFM) at 18°C. Embryonic development, incidence of abnormalities, and mortality in the experimentals were compared with those in unexposed controls.

65. SILLS, J. B., AND J. L. ALLEN. 1975. Accumulation and loss of residues of 3-trifluoromethyl-4-nitrophenol (TFM) in fish muscle tissue: laboratory studies. 10 pp.

    Residues of 3-trifluoromethyl-4-nitrophenol (TFM) in the muscle tissue of eight species of fish exposed under controlled conditions were determined by gas chromatography. The concentration of TFM residue varied depending on pH, temperature, hardness of test solutions, and TFM concentration.

66. GILDERHUS, P. A., J. B. SILLS, AND J. L. ALLEN. 1975. Residues of 3-trifluoromethyl-4-nitrophenol (TFM) in a stream ecosystem after treatment for control of sea lampreys. 7 pp.

    Samples of water, bottom soil, plants, invertebrates, and fish for residue analysis were collected from two stations on the East Au Gres River in Michigan before, during, and after treatment of the stream with 3-trifluoromethyl-4-nitrophenol (TFM) for control of sea lampreys (*Petromyzon marinus*).

67. MARKING, L. L., AND V. K. DAWSON. 1975. Method for assessment of toxicity or efficacy of mixtures of chemicals. 8 pp.

    Individual toxic contributions of poisons were summed and additive toxicity was defined by a linear index for two chemicals in combination. Examples were cited from literature and from laboratory tests to assess additive toxicity of selected chemical mixtures to fish.

68. BURRESS, R. M. 1975. Development and evaluation of on-site toxicity test procedures for fishery investigations. 8 pp.

    A simple, inexpensive procedure was developed for conducting on-site tests (bioassays) of the toxicity of various concentrations of antimycin on target and nontarget fishes in waters to be treated. Final modifications and evaluations of the method were made on the basis of treatments of ponds with antimycin in accordance with data derived from these on-site tests. The procedure described is adaptable for tests of many other chemical compounds commonly used by fishery workers.

69. BILLS, T. D., AND L. L. MARKING. 1976. Toxicity of 3-trifluoromethyl-4-nitrophenol (TFM), 2',5-dichloro-4'nitrosalicylanilide (Bayer 73), and a 98:2 mixture to fingerlings of seven fish species and to eggs and fry of coho salmon. 9 pp.

    The toxicity of the lampricides TFM and Bayer 73, and a 98:2 mixture of these compounds was determined for fingerlings of brown trout (*Salmo trutta*), rainbow trout (*S. gairdneri*), lake trout (*Salvelinus namaycush*), brook trout (*S. fontinalis*), channel catfish (*Ictalurus punctatus*), bluegill (*Lepomis macrochirus*), and yellow perch (*Perca flavescens*), and for eggs and fry of coho salmon (*Oncorhynchus kisutch*).

70. MAKI, A. W., AND H. E. JOHNSON. 1976. The freshwater mussel (*Anodonta* sp.) as an indicator of environmental levels of 3-trifluoromethyl-4-nitrophenol (TFM). 5 pp.

    After freshwater mussels (*Anodonta* sp.) were exposed to 8.68-mg/L solutions of 3-trifluoromethyl-4-nitrophenol (TFM; ^{14}C-TFM and analytical grade TFM) in a model stream for 24 h, the uptake and elimination rates of TFM residues for the foot, gill, and viscera were determined by radioassay.

71. BURRESS, R. M., P. A. GILDERHUS, AND K. B. CUMMING. 1976. Field tests of isobornyl thiocyanoacetate (Thanite) for live collection of fishes. 13 pp.

    Eight ponds containing 28 fish species were treated with isobornyl thiocyanoacetate (Thanite) to test its efficacy for live collection of fish.

72. MARKING, L. L., AND T. D. BILLS. 1976. Toxicity of rotenone to fish in standardized laboratory tests. 11 pp.

    The following treatments were evaluated: 1) the toxicity of rotenone to fish in standardized static and flow-through tests, 2) the toxicity of rotenone to newly fertilized trout eggs, 3) the residual toxicity of rotenone in water after selected periods of aging, 4) the efficiency of two compounds used to detoxify rotenone, and 5) the comparative toxicities of three rotenone formulations.

73. BILLS, T. D., L. L. MARKING, AND J. H. CHANDLER, JR. 1977. Formalin: its toxicity to nontarget aquatic organisms, persistence, and counteraction. 7 pp.

    The acute toxicity of formalin to selected fishes and aquatic invertebrates was determined in standardized laboratory tests. Also evaluated were: 1) the effects of water characteristics on toxicity, 2) the persistence of formalin in water, and 3) the feasibility of counteracting formalin by oxidation or reduction, or removal from the water with activated carbon.

74. MARKING, L. L., AND T. D. BILLS. 1977. Chlorine: its toxicity to fish and detoxification of antimycin. 5 pp.

    The effects of pH, temperature, and water hardness on the toxicity of chlorine were evaluated. Different concentrations of chlorine at different pH levels were tested for detoxification of antimycin.

75. BILLS, T. D., L. L. MARKING, AND J. H. CHANDLER, JR. 1977. Malachite green: its toxicity to aquatic organisms, persistence, and removal with activated carbon. 6 pp.

    Acute toxicity of malachite green was determined for nontarget fish species and aquatic invertebrates. The effects of pH, temperature, and water hardnesses on toxicity were evaluated. The persistence of malachite green in water and its possible removal from water with activated carbon were investigated.

76. MARKING, L. L., T. D. BILLS, AND J. H. CHANDLER, JR. 1977. Toxicity of Furanace to fish, aquatic invertebrates, and frog eggs and larvae. 6 pp.

    The toxicity of Furanace to fish, frog eggs and larvae, and aquatic invertebrates was determined in standardized laboratory tests and in use pattern exposures. Tests were also conducted in aged solutions of Furanace to determine its persistence in water. The effects of temperature, pH, and water hardness on toxicity were evaluated.

77. DAWSON, V. K., K. B. CUMMING, AND P. A. GILDERHUS. 1977. Efficacy of 3-trifluoromethyl-4-nitrophenol (TFM), 2',5-dichloro-4'-nitrosalicylanilide (Bayer 73), and a 98:2 mixture as lampricides in laboratory studies. 11 pp.

    The lampricidal effects of 3-trifluoromethyl-4-nitrophenol (TFM), 2',5-dichloro-4'-nitrosalicylanilide (Bayer 73), and a 98:2 mixture of the two (TFM:2B) were tested against larvae of the sea lamprey (*Petromyzon marinus*) under controlled laboratory conditions. The lampricides were tested in water at temperatures of 7, 12, and 17 °C; total hardnesses of 44, 170, and 300 mg/L as $CaCO_3$; and pH values of 6.5, 7.5, and 8.5. Burrowed and free-swimming larvae were tested, and the risk to nontarget organisms was evaluated.

78. SANDERS, H. O. 1977. Toxicity of the molluscicide Bayer 73 and residue dynamics of Bayer 2353 in aquatic invertebrates. 7 pp.

    The molluscicide Bayer 73 (2-aminoethanol salt of 2',5-dichloro-4'-nitrosalicylanilide), was tested against five species of crustaceans and two species of aquatic insects: daphnids (*Daphnia magna*), aquatic sowbugs (*Asellus brevicaudus*), scuds (*Gammarus pseudolimnaeus*), glass shrimp (*Palaemonetes kadiakensis*), crayfish (*Orconectes nais*), damselfly nymphs (*Ischnura verticalis*), and midge larvae (*Chironomus plumosus*). The rates of accumulation and elimination of radioactive residues were evaluated.

79. KAWATSKI, J. A., AND A. E. ZITTEL. 1977. Accumulation, elimination, and biotransformation of the lampricide 2',5-dichloro-4'-nitrosalicylanilide by *Chironomus tentans*. 8 pp.

80. HOUF, L. J., AND R. S. CAMPBELL. 1977. Effects of antimycin A and rotenone on macrobenthos in ponds. 29 pp.

    Samples of macrobenthos, collected over a 14-month period from nine 0.03-ha experimental ponds at the Fish-Pesticide Research Laboratory, Columbia, Missouri, were analyzed to determine the long- and short-term effects of antimycin A and rotenone. The effects on species diversity, emergence, seasonal dynamics, abundance, and relative members of taxa were evaluated.

81. JACOBI, G. Z., AND D. J. DEGAN. 1977. Aquatic macroinvertebrates in a small Wisconsin trout stream before, during, and 2 years after treatment with the fish toxicant antimycin. 24 pp.

    Benthos and benthic drift were sampled periodically in Seas Branch Creek (Vernon County, Wisconsin) for 5 months before and for 2 years after the stream was treated with antimycin, and over the same period in nearby untreated Maple Dale Creek.

82. SCHNICK, R. A., AND K. A. GRAVES. 1977. *Investigations in Fish Control*: index to numbers 1–72, 1964–76. 19 pp.

    Key words from *Investigations in Fish Control* are given, and issue titles, authors, and publication dates are listed.

83. MARKING, L. L., AND J. H. CHANDLER, JR. 1978. Survival of two species of freshwater clams, *Corbicula leana* and *Magnonaias boykiniana*, after exposure to antimycin. 5 pp.

    The Asiatic clam, *Corbicula leana* Prime, and a clam native to the southern United States, *Magnonaias boykiniana*, were exposed to antimycin at several concentrations for various periods and then placed in an untreated earthen pond for posttreatment observation.

84. DWYER, W. P., F. L. MAYER, J. L. ALLEN, AND D. R. BUCKLER. 1978. Chronic and simulated use-pattern exposures of brook trout (*Salvelinus fontinalis*) to 3-trifluoromethyl-4-nitrophenol (TFM). 6 pp.

    The effects of 3-trifluoromethyl-4-nitrophenol (TFM) on brook trout (*Salvelinus fontinalis*) were compared under conditions of continuous (chronic) exposure, and under conditions simulating those used in the application of TFM in tributary streams of the Great Lakes for control of the sea lamprey (*Petromyzon marinus*). Mortality, growth, and reproduction were measured.

85. SCHULTZ, D. P., AND P. D. HARMAN. 1978. Hydrolysis and photolysis of the lampricide 2',5-dichloro-4'-nitrosalicylanilide (Bayer 73). 5 pp.

    The hydrolysis of C-Bayer 2353, the non-salt form of Bayer 73, is investigated in water buffered at various pH's. The photolysis of C-Bayer 2353 on

thin-layer chromatographic plates, on glass slides, and in aqueous solutions is analyzed.

86. SCHNICK, R. A., AND F. P. MEYER. 1978. Registration of thirty-three fishery chemicals: status of research and estimated costs of required contract studies. 19 pp.

Information is given for each chemical, including its sponsor, current (1978) registration status, six research uses, costs of required contract studies, and prognosis for registration of use of each compound.

87. DAWSON, V. K., AND P. A. GILDERHUS. 1979. Ethyl-p-aminobenzoate (benzocaine): efficacy as an anesthetic for five species of freshwater fish. 5 pp.

Ethyl-*p*-aminobenzoate (benzocaine) was tested for its efficacy as an anesthetic for rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), northern pike (*Esox lucius*), carp (*Cyprinus carpio*), and largemouth bass (*Micropterus salmoides*). The toxicity of benzocaine to fish eggs was determined. The effects of pH, temperature, and water hardness on the efficacy of benzocaine were evaluated.

88. LAUNER, C. A., AND T. D. BILLS. 1979. Influences of selected environmental factors on the activity of a prospective fish toxicant, 2-(digeranyl-amino)-ethanol, in laboratory tests. 4 pp.

Fathead minnows (*Pimephales promelas*), brown trout (*Salmo trutta*), and rainbow trout (*S. gairdneri*) were used to assess the influences of temperature, pH, turbidity, ultraviolet light, and aquatic vegetation on the toxicity of an experimental fish toxicant, 2-(digeranylamino)-ethanol (GD-174). The feasibility of chemical counteraction by oxidation or reduction was also examined.

89. HUDSON, R. H. 1979. Toxicities of the lampricides 3-trifluoromethyl-4-nitrophenol (TFM) and the 2-aminoethanol salt of 2',5-dichloro-4'-nitrosalicylanilide (Bayer 73) to four bird species. 5 pp.

The acute oral toxicities of the lampricides 3-trifluoromethyl-4-nitrophenol (TFM) and the 2-aminoethanol salt of 2',5-dichloro-4'-nitrosalicylanilide (Bayer 73, Bayluscide) were determined in mallards (*Anas platyrhynchos*), ring-billed gulls (*Larus delawarensis*), northern bobwhites (*Colinus virginianus*), and California quail (*Callipepla californicus*). Both field grade and purified TFM were tested.

90. DAWSON, V. K., J. B. SILLS, AND C. W. LUHNING. 1982. Accumulation and loss of 2',5-dichloro-4'-nitrosalicylanilide (Bayer 73) by fish: laboratory studies. 5 pp.

Coho salmon (*Onchorynchus kisutch*), rainbow trout (*Salmo gairdneri*), channel catfish (*Ictalurus punctatus*), and largemouth bass (*Micropterus salmoides*) were exposed to Bayer 73. Concentration and persistence of the lampricide in muscle, plasma, and bile were measured.

91. BURRESS, R. M. 1982. Effects of synergized rotenone on nontarget organisms in ponds. 7 pp.

Synergized rotenone was applied to two shallow, 0.05-ha ponds. The effects on total numbers and diversity of benthic invertebrates, mortality of caged Asiatic clams (*Corbicula manilensis*), and mortality of larval leopard frogs (*Rana pipiens*) were noted.