United States Department of Agriculture

Natural Resources Conservation Service

6200 Jefferson NE Albuquerque, NM 87109-3734

September 12, 1995

BIOLOGICAL TECHNICAL NOTE NO. NM-29 (REVISED 9/95)

SUBJECT: ECS - AQUATIC WEED CONTROL

Purpose: To provide the current information for control of aquatic plants.

Effective Date: When received.

Attached are three publications on aquatic vegetation management and control. These publications will update Biology Technical Note #29 to include current information and contacts for the control of aquatic plants.

The following publications are included:

1. *Aquatic Vegetation Management and Control.*
2. *How to Identify and Control Water Weeds and Algae.*
3. *Guide to Drug, Vaccine, and Pesticide Use in Aquaculture.*

Remove pages numbered 97, 98, 99, 100, and 101 of Technical Note #29 and insert the attached three publications.

Do Not Remove "New Mexico Department of Game and Fish Policy Concerning the Use of Grass Carp" section of this technical note.

ROSENDO TREVINO III
State Conservationist

Attachments

Dist:
AC
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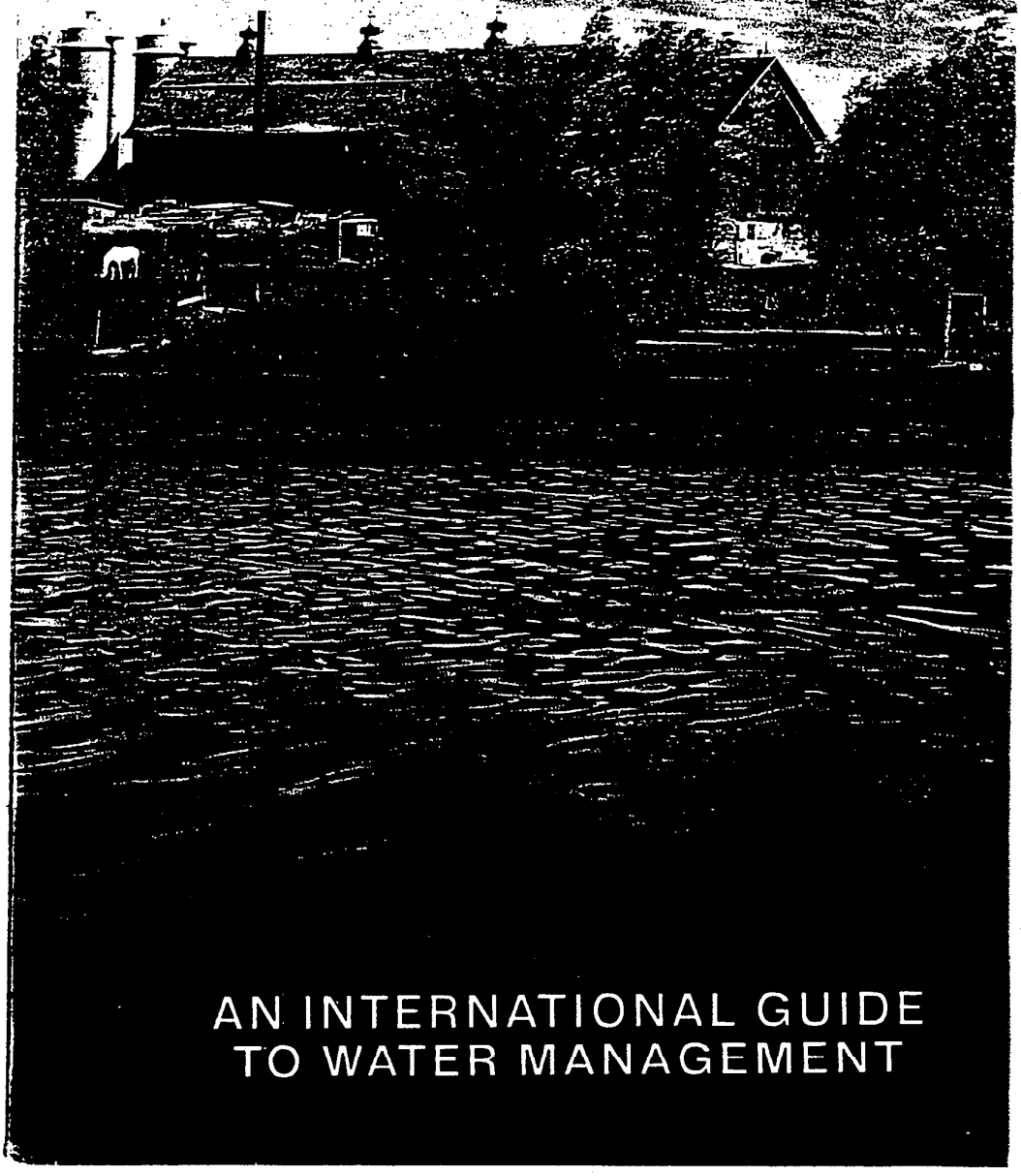
4th Edition

$69

HOW TO IDENTIFY AND CONTROL WATER WEEDS and ALGAE



AN INTERNATIONAL GUIDE
TO WATER MANAGEMENT

AQUATIC PLANT CONTROL METHODS

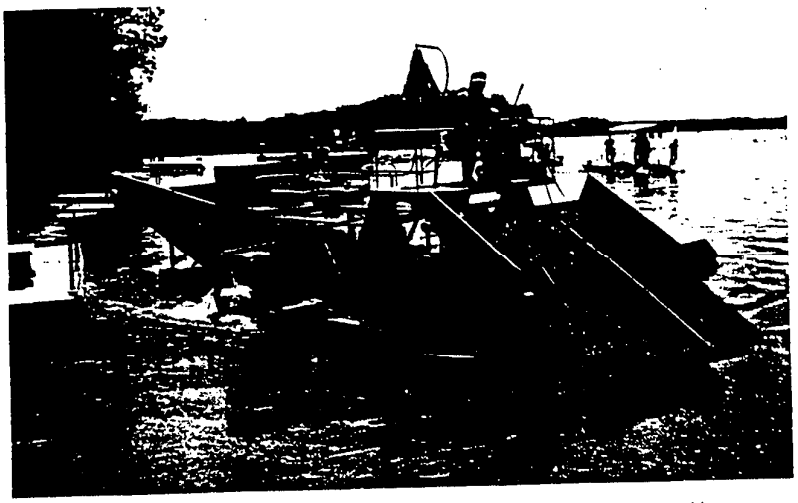
Waters clogged with aquatic vegetation are usually rendered useless for their intended purposes. Correctional methods are available, but before choosing a technique, consider the following interrelated factors:

1. **What is the intended use of the water?**
   It is usually not necessary to **eliminate** all the growth, but rather to **control** vegetation creating a nuisance. The degree of aquatic plant control is determined by water use.
2. **How safe is the method?**
   This should not only include human hazards, but also the environmental impacts. Seemingly harmless alterations in the aquatic environment can sometimes result in severe ecological damage such as loss of all fish and plant life.
3. **How effective is the method?**
   The various control methods offer varying degrees of effectiveness. Assess how long it will take to obtain control and how long control will last.
4. **What method is least costly?**
   This question must be judged on a long-term basis. Capital investment and labor must be included in these costs. Safety and effectiveness are also factors to be evaluated.

The following methods have been used as aquatic nuisance control techniques. The advantages and disadvantages of each are discussed.

PHYSICAL REMOVAL

Hand harvesting of aquatic vegetation by pulling, raking, cutting, or digging can be accomplished in small shoreline areas. Specialized rakes and cutters have been designed to increase efficiency. Neighborhood youth groups might want to designate a lake or pond "clean-up day" as one of their community projects. Be aware, however, that working underwater is a cumbersome and tiring task, and regrowth from seeds and remaining underground plant parts can be expected.



Fragmented plants, limited maneuverbility and high cost are some of the problems associated with mechanical weed harvesting.

MECHANICAL REMOVAL

Specialized mechanical equipment has been developed for both cutting and harvesting (removing) aquatic weed growth. Units range in size from toothed blades which attach to a rowboat up to large harvesters equipped with retrieval and unloading conveyors.

Harvesting facilitates removal of a certain amount of nutrients and organic material from the lake in the form of plant tissue. Unless done intensively, noticeable reduction of nutrient concentrations and sediment build-up will not occur.

Harvesters are sometimes utilized for off-shore weed removal, supplementing a chemical treatment program along hard to reach shoreline areas. Another effective approach involves harvesting a week or so prior to chemical treatment. This enhances chemical effectiveness since many plants are quite vulnerable in their active "regrowth" stage.

When harvesting, remove all plant fragments to avoid their re-establishment throughout the lake. Harvested weeds should not be left on shore to dry. Fresh weeds are quite bulky, so hauling could be costly. Gardeners and farmers sometimes utilize them for mulch materials.

Drawbacks to harvesting must be considered. Initial investment is high plus maintenance is expensive. Mobility and effectiveness are limited around developed shorelines and over uneven bottoms. Hedgerows of weeds, left several feet below the water, can branch out and regrow at greater densities. Several cuttings will be required per season. Fragmented plants can establish themselves in new areas. Harvesting is ineffective in removing algae and duckweed. Cutting bars can disturb valuable spawning areas.

HABITAT MANIPULATION

Bottom Barriers made of plastic, rubber, fiberglass screen or nylon are available for placement in beach or shoreline areas or small ponds. They are intended to inhibit or prevent rooted growth within selective areas. They are best installed during pond construction, drawdown, or during periods when growth is not present. Algae and free-floating vegetation is unaffected. Build-up of even slight amounts of sediment on the liner will provide substrate for new growth.

Shading water areas with black plastic sheeting, soluble dyes, artificial structures, or overhanging shoreline vegetation has been attempted to inhibit aquatic plant growth. Sheeting makes the water inaccessible for a period of several weeks. Dye concentrations, constantly diluted by rainfall and inflowing water, require frequent additions during the growing season. Dyes are also ineffective on surface growth and in waters less than 2 feet deep. Man-made structures and bank vegetation serve only to partially limit light penetration. Shade tolerant aquatic species will still develop.

Drawdown or periodic lowering of water levels to expose bottom sediments, where physically possible, is an effective tool for controlling some aquatic weed species. Desiccation (drying-out) of underwater weeds and compaction of bottom mud results. Freezing of the ground during drawdown will also kill the roots and underground stems of certain aquatic plants. Encroachment by emergent shoreline plants, seed survival, and destruction of fish habitat can present a problem if drawdown is improperly timed.

This lake was drawn down for dredging purposes. Such drastic measures may destroy fish populations and habitat plus make way for encroachment by emergent plants.

A dragline equipped with a clam bucket can deepen shoreline areas around ponds. Be sure to remove dredge spoils from the area to prevent them from washing back into the water.

Dilution or flushing a water body with fresh water from a nutrient-free source can aid in lowering nutrient concentrations. As a result, some aquatic plant growth will be reduced. Rooted aquatic plants utilizing nutrients contained in bottom sediments will remain unaffected.

Dredging has the benefit of removing existing rooted plants and nutrient rich sediments plus increasing water depths. If the bottom is properly contoured, underwater weed growth can be reduced or eliminated. Draglines with clam buckets are used for small pond work. Large hydraulic dredges are employed on large bodies of water. Disposal of spoils presents the biggest problem since water contained in the saturated muck should be prevented from re-entering the watershed. As a result, dredging is very costly.

Fertilization of ponds to produce planktonic algae blooms which shade out rooted vegetation and increase fish production is a method commonly used by commercial catfish farmers in the South. Most ponds, however, are fertile enough to support an abundance of life. The addition of more nutrients can compound existing problems by stimulating additional noxious weed and algae growth. Blooms detract from the recreational and aesthetic value of the pond and can create taste and odor problems.

BIOLOGICAL CONTROLS

Plant consumers (herbivores), plant pathogens (diseases) and competitive species are under study as "natural" approaches to controlling noxious vegetation. While some have shown promise, the introduction of exotic organisms carries with it unknown, long-term ecological consequences.

Plant-eating fish, such as the **grass carp** or **white amur** *(Ctenopharygodon idella Val.)* have been stocked in lakes, ponds and canals to consume aquatic vegetation. Although banned in most states, sterile (triploid) stocks may be introduced in some areas. Long-term effects upon native fish and plant populations are still unpredictable. Questions exist on suitable stocking rates, competition with gamefish and potential for habitat destruction. Feeding by these fish is initially selective. However, as sources of preferred plants become scarce, feeding will continue on other types of growth. This can lead to the eradication of all rooted vegetation, the habitat required by desired gamefish species. Furthermore, the short intestine of these fish results in incomplete digestion of plant materials and rapid recycling of nutrients. Algae blooms, not controlled by these fish, can result.

Similarly, **Tilapia** have been stocked in waters to feed upon algae. These fish are highly successful at reproducing in warm waters and have been known to overpopulate. They are sensitive to cold water and do not survive if water temperatures fall below 50° F (10° C). They are not a preferred sport species and are of questionable quality for food.

Insects have been introduced with some success to selectively feed upon aquatic plant populations. Adults and/or larvae of certain moths and weevils, taken from their native areas, have been introduced where exotic plant populations have become established. Some success has been achieved in controlling Water Hyacinth and Alligatorweed. Extreme caution must be taken to ensure these insects will not feed upon native plants nor agricultural crops.

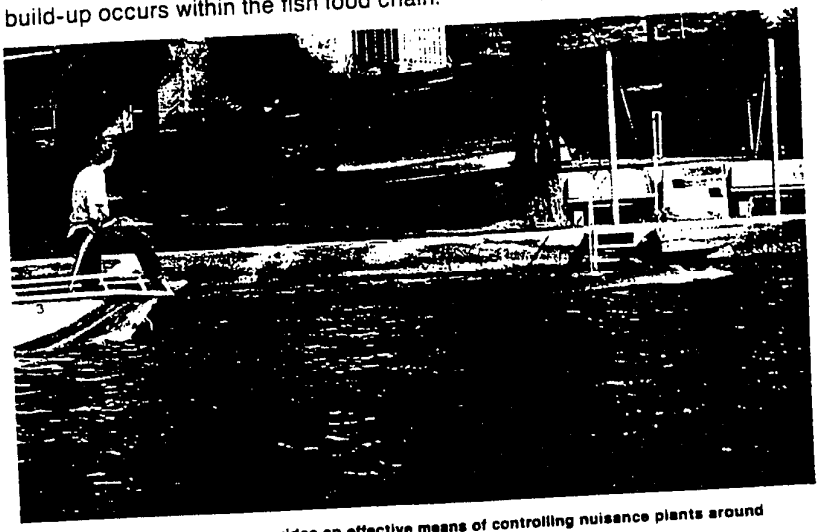
Competitive plant species, introduced in some areas in an attempt to overtake existing noxious species, has had limited success. Without control over numerous environmental factors, it is difficult, if not impossible, for man to dictate what should grow where within the aquatic environment. "Aquatic gardening", unlike terrestrial farming, contains too many uncontrolled variables.

Plant diseases or pathogens such as bacteria, viruses, fungi and other microorganisms which host upon aquatic plants are being examined as selective control agents. Isolation and culturing of these organisms must be perfected and their effects upon native aquatic plants, terrestrial species and animals must be carefully looked at before they are "seeded" into new environments.

NOTE: State, Federal and International regulations prohibit and/or regulate the transportation and introduction of exotic organisms discussed above. Consult your local authorities.

CHEMICAL CONTROL

The use of chemicals is the most common and versatile management strategy for controlling nuisance aquatic plant populations. Chemicals offer longer lasting control than mechanical methods; involve minimal labor and equipment; provide flexibility and predictability; plus, ultimately cost less. From the range of products available, spot control within particular areas or selective control of specific plant species can be achieved. Applications can be made to sites that cannot or might not be reached by other methods. Algaecides and aquatic herbicides will not disrupt the ecological balance and in many cases can be used to restore some balance to a system. Ingredients are non-persistent. They will degrade or become deactivated within a relatively short period of time, after controlling target plants. Therefore, no build-up occurs within the fish food chain.



Chemical treatment provides an effective means of controlling nuisance plants around docks and piers.

Products currently allowed for use are somewhat limited due to the stringent government registration process. Millions of dollars and years of research have gone into testing these compounds on a broad spectrum of target and non-target organisms. Evaluations are made not only by the manufacturers themselves, but by universities, government agencies, private consultants and commercial applicators.

The registration process requires a battery of short-term (acute) and long-term (chronic) testing under a variety of environmental and laboratory conditions. Toxicity to rats, fish, aquatic invertebrates, desirable vegetation (crops, ornamental plants, turf, etc.) and other potentially exposed organisms must be determined. Screening tests and multiple generation studies on test animals are conducted to determine effects on cell function and growth, fetal development and pregnancy. Chemical residues and breakdown products are examined to trace the pathway of the compounds within the environment. Effects from altering water temperature, light intensities, water qualities and other factors are also investigated. Determinations are made as to the application rates and frequencies required to control the target aquatic plant species.

The outcome of this testing is the drafting of a product label designed to apply the product effectively and prevent product misuse. Specific directions are provided for handling - application - container storage and disposal - water use restrictions following application. Use instructions and precautionary wording are clearly stated on the label. Additional product data is available from the manufacturer providing additional insight into product toxicology, environmental effects and use.

Proper use of these products may entail temporary restrictions on use of water for swimming, fish consumption, drinking, irrigation or domestic use. These restrictions vary with the different chemicals used (see pg. 98). Local permits and/or licensing may be required on public waters. Varying water, weather and/or plant growth conditions could interfere with product effectiveness. With proper planning, timing, application and follow-up . . . safe, effective and economical control of nuisance aquatic plants can be achieved.

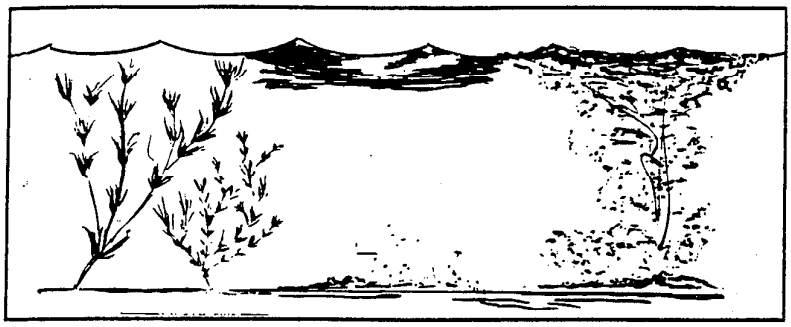
There are aquatic herbicides and algaecides available that are specifically labeled for use in lakes, ponds, irrigation and drainage systems, etc.

The following sections of this book provide the step-by-step procedures and information necessary to accomplish the above objectives:

CHEMICAL TREATMENT CONSIDERATIONS

1. **IDENTIFICATION**
   (See pages 20 - 66)
2. **TREATMENT AREA DETERMINATION**
   (See pages 67 - 68)
3. **CHEMICAL SELECTION**
   (See pages 69 - 70)
4. **EQUIPMENT SELECTION**
   (See pages 71 - 74)
5. **APPLICATION**
   (See pages 75 - 78)
6. **FOLLOW-UP**
   (See pages 79 - 80)

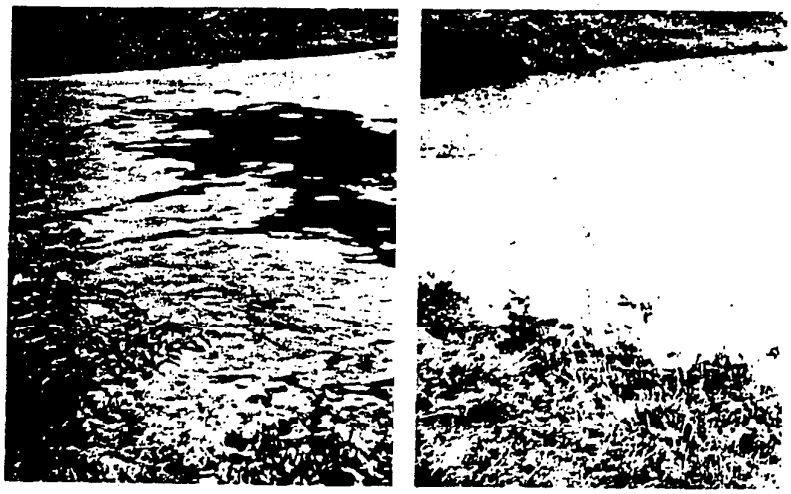
ALGAE



The algae are primitive plants closely related to the fungi. They exhibit no true leaves, stems or root systems and reproduce by means of spores, cell division or fragmentation. Some 17,400 species of algae have been identified and thousands more probably exist.

These organisms have adapted to many different habitats and exhibit a wide range of characteristics. They can be found in many places from hot springs to glaciers, fresh water to salt water and sandy beaches to rice paddies.

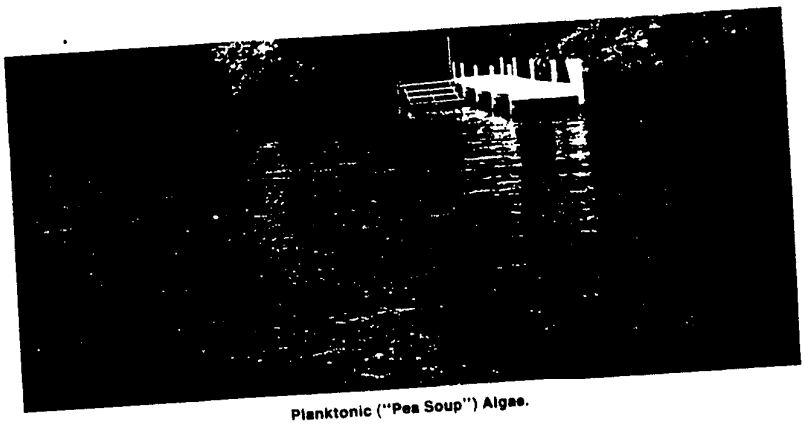
On the following pages nuisance algal growths are classified into 3 general categories: planktonic, filamentous, and attached-erect forms. The use of copper sulfate has not been recommended as research and field usage have shown a high potential for detrimental environmental effects. In certain waters copper sulfate is quite toxic to fish and other organisms. Overuse of this product is common due to its short-term effectiveness. This can result in copper build-up in the sediments leading to a sterile bottom (see Historical Perspective, page 5).



This pond experienced severe problems with filamentous algae (left). Periodic treatments with Cutrine®-Plus controls this growth (right).

TOXIC ALGAE

Death and sickness to pets, livestock, wildlife and even man have been attributed to the presence of certain algae, mostly blue-green bloom-forming species, in water supplies. Lethal substances produced by these algae are retained within the cell and released after death (endotoxin) or are secreted from living cells (exotoxin). Much is still left to be learned about the nature and origin of these substances. **It is important that water purification engineers, livestock raisers, wildlife specialists, pond owners and lake property owners are aware of this potential danger.** Many unattended farm ponds and other waters contain some of these toxic forms, posing a threat to human health and environment. Medical case histories, biologist reports and laboratory tests show some of the possible effects of toxic algae.



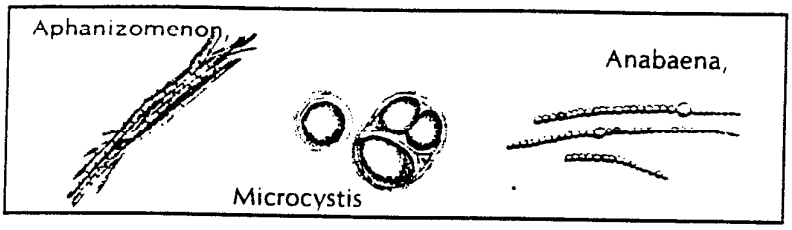
Planktonic ("Pea Soup") Algae.

HUMANS: A list compiled by the U.S. Department of the Interior Federal Water Pollution Control Administration summarizes medical case histories of algae poisonings for a 120 year period. Exposure to and ingestion of algae caused a variety of discomforts including: skin rashes, headaches, nausea, vomiting, diarrhea, fever, eye, nose and throat irritation and muscular pains.

WILDLIFE: Severe ecological disruptions attributed to overabundant toxic algal species have been reported. For example, an Iowa State biologist reporting on an algae bloom on Storm Lake recorded the loss of thousands of Franklin gulls, migratory waterfowl and fish.

LIVESTOCK: The California State Water Resources Control Board states in their Water Quality Criteria Handbook (Second Edition): "From many different parts of the world, including the United States, there have been reports of rapid deaths of a great variety of animals after drinking water containing high concentrations of blue-green algae such as **Microcystis, Aphanizomenon, Nostoc rivulare, Nodularia, Gleotrichia, Gomphosphaeria** and **Anabaena.** Fatal poisonings have occurred among cattle, pigs, sheep, dogs, horses, turkeys, ducks, geese and chickens, and also among experimental animals such as rabbits, rats, guinea pigs and mice. It is believed that such algae may be toxic to all warm-blooded animals."

PLANKTONIC ALGAE - Common genera: Anabaena, Chlorella, Pediastrum, Scenedesmus, Oocystis.



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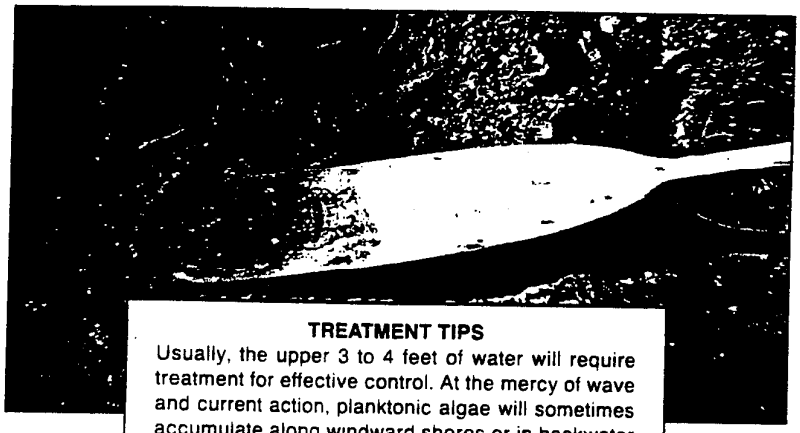


TREATMENT TIPS

Usually, the upper 3 to 4 feet of water will require treatment for effective control. At the mercy of wave and current action, planktonic algae will sometimes accumulate along windward shores or in backwater areas, thus reducing the size of the treatment area.

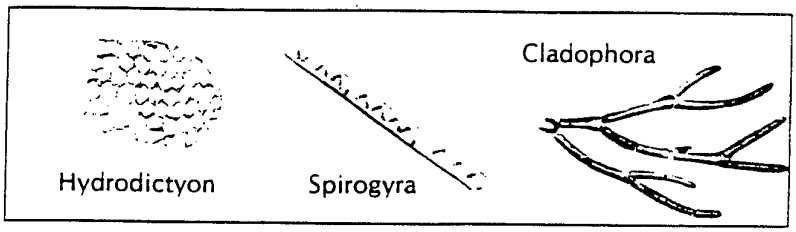
Description: Microscopic plants usually suspended in the upper few feet of water often reaching bloom proportions. Water appears pea soup green or brownish. Natural die-off may cause summerkill of fish due to oxygen depletion. Some species may be toxic to livestock, wildlife, or man (see page 22) or impart taste and odor problems (page 9).

Distribution: Worldwide.

NOTE - The above picture was taken at Lake Delavan (WI) which had been treated for many years with tons of copper sulfate. Build-up of copper precipitates in the sediments and shading by the algae bloom prohibited establishment of rooted plant growth which would have competed for nutrients. Fishing and recreation declined. Effective restoration measures, which included use of Cutrine® algaecide, have helped to re-establish desirable vegetation and restore recreational value.

Recommended Control Method: Apply 0.6 gallons of CUTRINE®-PLUS per acre-foot of water. Chemical should be diluted at least 20 to 1 to achieve uniform dispersion of algaecide in water. Several treatments may be required for seasonal control.

FILAMENTOUS ALGAE - Common genera: Spirogyra, Cladophora, Rhizoclonium, Mougeotia, Zygnema and Hydrodictyon.



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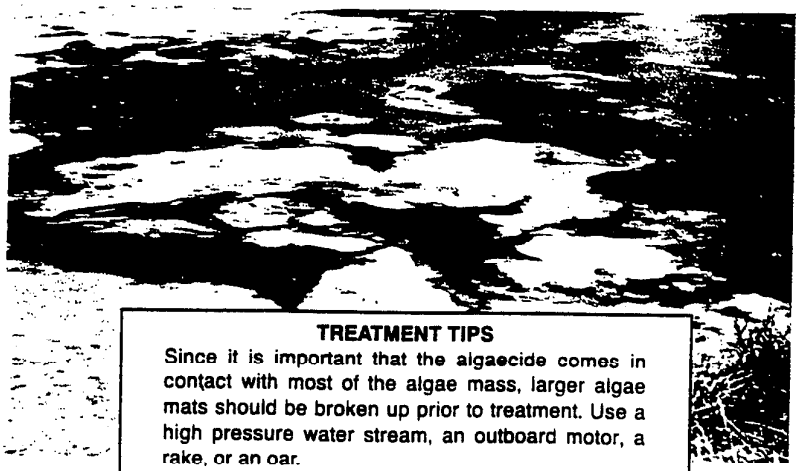


TREATMENT TIPS

Since it is important that the algaecide comes in contact with most of the algae mass, larger algae mats should be broken up prior to treatment. Use a high pressure water stream, an outboard motor, a rake, or an oar.

Description: Also known as "pond scum" or "moss" because it forms greenish mats upon the water's surface. Filamentous algae usually begins its growth along the edges or bottom of the pond and "mushrooms" to the surface buoyed by the oxygen it has produced. Individual filaments are a series of cells joined end to end which give the thread-like appearance. They also form fur-like growths on bottom logs, rocks and even on the backs of turtles. The texture of these growths may be slimy, cottony or coarse. Common names such as frog spittle and water net have been given to a few forms.

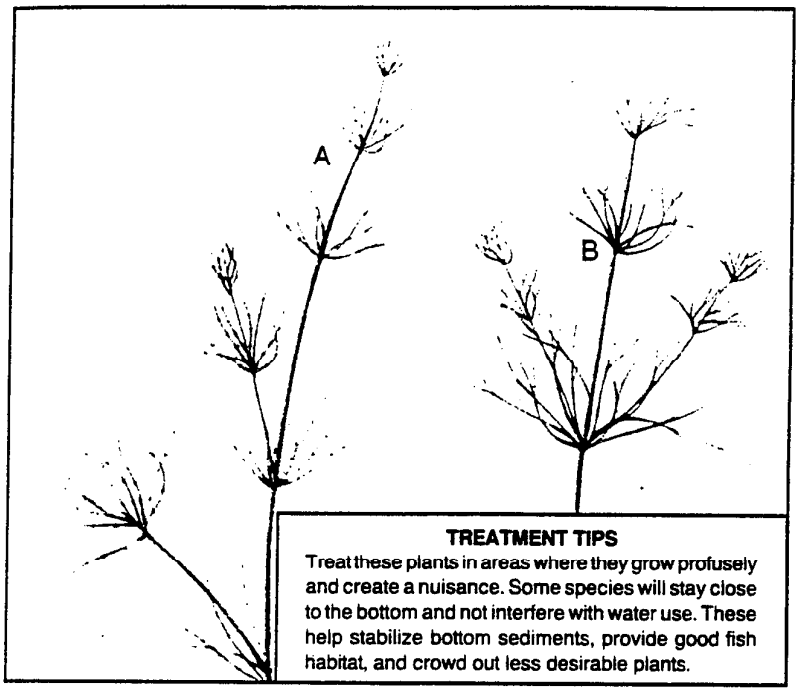
Distribution: Common in its many forms worldwide.

Recommended Control Method: Apply 0.6 gallons of CUTRINE®-PLUS per acre-foot of water. Chemical should be diluted at least 9 to 1 to achieve uniform dispersion of algaecide in water. For treatment of bottom growing algae, apply CUTRINE®PLUS GRANULAR at the rate of 60 pounds per acre. Granular can also be used to spot treat localized bottom infestations.

Several total or spot treatments may be required to maintain control during the season. Length of growing season, sunlight, temperature and nutrient concentrations affect the rate of regrowth.

ATTACHED-ERECT ALGAE (Weed-like)

CHARA (A) and NITELLA (B) - Common names: Muskgrass, Stonewort.



TREATMENT TIPS

Treat these plants in areas where they grow profusely and create a nuisance. Some species will stay close to the bottom and not interfere with water use. These help stabilize bottom sediments, provide good fish habitat, and crowd out less desirable plants.

Description: Advanced forms of algae, gray-green or yellow in appearance. They are often mistaken for higher vascular plants. Best way to identify it is by its musky odor and gritty, bristly feel due to calcium deposits on its surface. Leaf like structures are whorled about the stem at fairly uniform intervals. Hollow stem on chara. Dense growths, attached but not rooted, may cover entire bottom of pond or lake. Water in vicinity is usually clear.

Distribution: Commonly found in hard water worldwide.

Recommended Control Method: Apply 60 pounds of CUTRINE®-PLUS GRANULAR per acre of water. Best treatment results are achieved when plants are young and uncalcified.

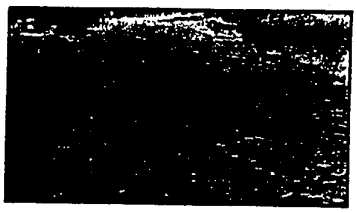
OR

Where chara is in water less than 3 feet deep or where growth is near the surface, liquid CUTRINE®-PLUS can be used. Apply 1.2 gallons of CUTRINE®-PLUS per acre-foot of water. Dilute at least 9 to 1 with water to achieve uniform distribution of chemical.

In hard water, or those with thick infestations, two applications of chemical may be required for control of chara. If not treated early, old growth will become hardened. Additional growth can be suppressed, but older plants may not die and decompose. Treat earlier next year.

RESISTANT ALGAE

A few forms of algae may be encountered which show some resistance to control with CUTRINE®-PLUS and other chemicals. In these situations, the following recommendations should be attempted to obtain **conditional control:**



"Pads" of Pithophora.

Pithophora is a dark green filamentous algae. Also known as horsehair algae. It commonly grows in coarse clumps of tangled filaments resembling pads of steel wool. Individual filaments show extensive branching. Due to its high production of reproductive cells known as akinetes, growth is quite prolific. Pithophora grows on the bottom and sporadically surfaces.

Lyngbya colonies on water surface.

Lyngbya spp. is a blue-green algae. The species which are particularly troublesome to control are those which grow in colonies forming small spongy masses of mucilage. These blue-green, black or gray clumps made up of thousands of individual cells will lay on the bottom or float to the surface. Because of the protective mucilage, chemical control is difficult.

Conditional Control Alternatives:

for Pithophora

When water temperatures are between 50°F and 60°F, apply 1.2 gallons of CUTRINE®-PLUS per acre-foot of water followed up 7 to 10 days later with 60 pounds of CUTRINE®-PLUS GRANULAR per surface acre.

for Pithophora or Lyngbya

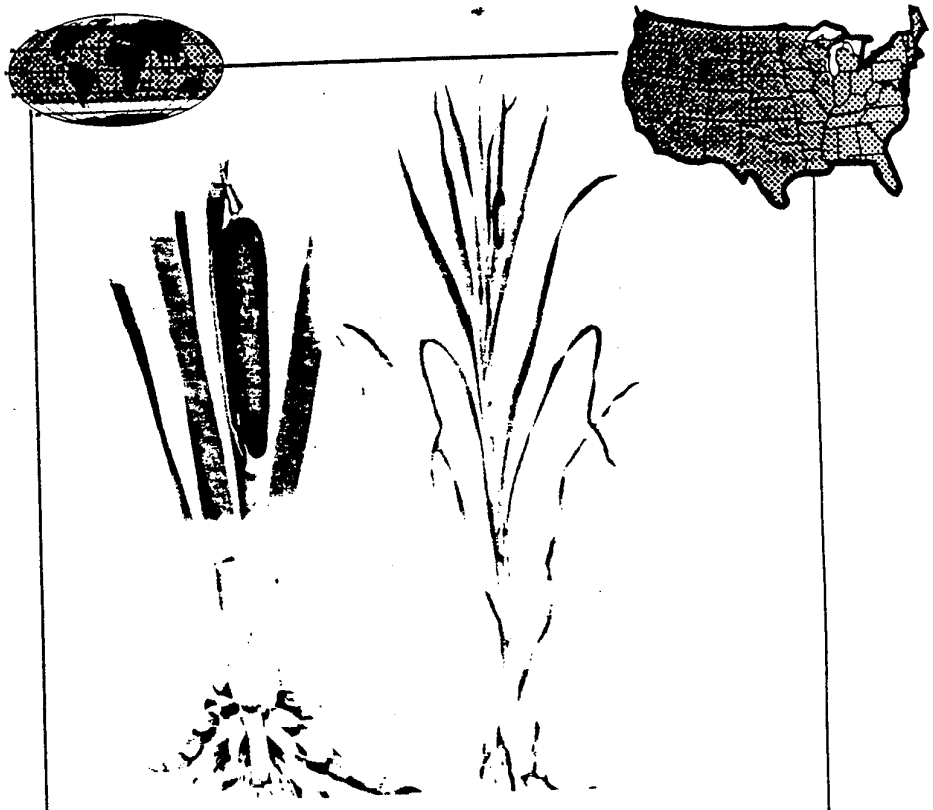
Tank mix 1 part Diquat to 1 part CUTRINE®-PLUS and apply at the rate of 2 gallons of mix per acre-foot.

OR

Tank mix 2 parts CUTRINE®-PLUS to 1 part Hydrothol 191 and apply at the rate of 1 gallon of mix per acre-foot.

Colonial diatoms on cement bottom.

Colonial Diatoms - diatoms are a form of algae characterized by having cell walls made of silica, a mineral substance. Certain species grow in colonies, usually on sand or concrete surfaces, and produce gelatinous masses. Generally, these colonies are brown to grayish in color. Effective control of these growths cannot be achieved. Physical removal is recommended.



TREATMENT TIPS

To assure good control, wet leaves thoroughly with a fine spray. Cut off dead leaves at ground level. Re-spray new shoots throughout season.

CATTAIL *(Typha spp.)*

Description: Long, slender, grasslike stalks up to 10 feet in height. Inhabits wet lowlands and water to 4 feet deep.

Distribution: Common throughout the United States.

Recommended Control Method: For areas less than 1 acre, mix 6.5 ounces of WEEDTRINE®-D with 1 gallon of water plus non-ionic surfactant. 10 gallons of solution will treat 1/10 acre.

OR

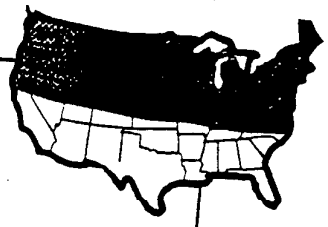
For areas larger than 1 acre, mix 1 gallon of Diquat in 100 gallons of water. Add non-ionic surfactant. Solution will treat 1 acre.

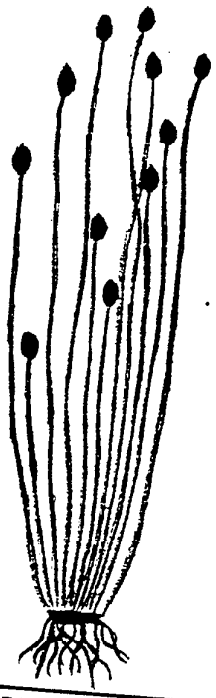
Alternative Control Methods:

Rodeo: Mix 1 ounce of Rodeo per gallon of water and add non-ionic surfactant in accordance with label instructions. 100 gallons of solution will treat 1 acre.

In northern areas:

Cut off cattails at ice level during winter. This will sometimes reduce their stands the following year.





TREATMENT TIPS

Only emergent plants are susceptible to chemical control. Masses of plants which break loose and float on the surface may also be treated.

SPIKERUSH *(Eleocharis spp.)*

Description: Stems green and leafless. Stem length ranges from 5 in. (2 cm) to 4 ft. (120 cm) with varying diameters. Plant grows in a clump, similar to turf. Mature stems are tipped with a brown to black, scaly, lance-shaped spikelet. Reproduces from rootstocks and seeds. Usually found on muddy or sandy shores and shallow water, but submerged forms do occur.

Distribution: Common throughout the United States in fresh and brackish water.

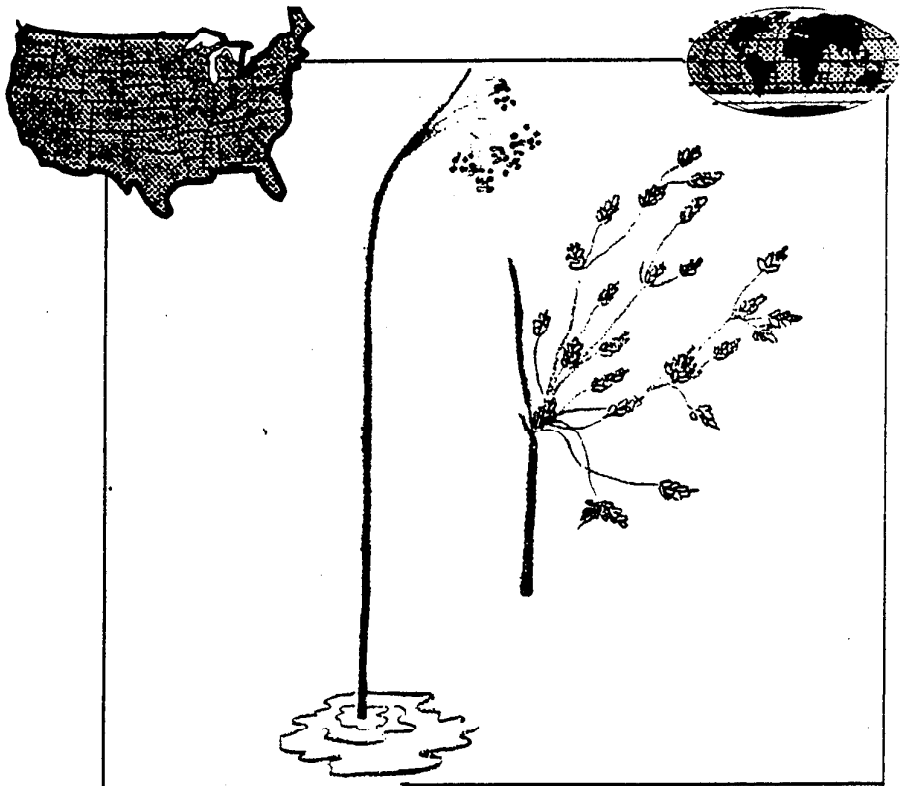
Recommended Control Method: For areas less than 1 acre, mix 6.5 ounces of WEEDTRINE®-D with 1 gallon of water plus non-ionic surfactant. 10 gallons of solution will treat 1/10 acre.

OR

For areas larger than 1 acre, mix 1 gallon of Diquat in 100 gallons of water. Add non-ionic surfactant. Solution will treat 1 acre.

Alternative Control Methods:

Rodeo: Mix 2 ounces of Rodeo per gallon of water and add non-ionic surfactant in accordance with label instructions. 36 gallons of solution will treat 1 acre.



TREATMENT TIPS
Use 'Recommended Control' only for early season growth. Choose 'Alternate Controls' later in season. Wet plants thoroughly when liquid sprays are used.

BULRUSH *(Scirpus spp.)*

Description: Long, tall, triangular or round-shaped stem. May or may not have leaves. Cluster of brownish flowers and seeds are located at the end of the stem. Inhabits shallow water along shorelines.

Distribution: Common throughout the United States.

Recommended Control Method: Mix 1 ounce of 2,4-D liquid in 1 gallon of water. Spray directly on plant. Approximately 75 gallons of this solution will be needed to treat 1 acre of plants.

OR

Apply WEEDTRINE® II Granular evenly at the rate of 150 pounds per acre of plants.

Alternative Control Methods:

Diquat: 1.3 ounces per gallon of water plus non-ionic surfactant.
Rodeo: 1 ounce per gallon of water plus non-ionic surfactant.
Weedtrine®-D: 6.5 ounces per gallon of water plus non-ionic surfactant.

100 gallons of above solution(s) will treat 1 acre of plants.

B. GENERAL RESTRICTIONS ON USE OF TREATED WATER (Number of Days)

(Always refer to current product label for specific requirements)

COMMON NAME	CHEMICAL NAME	AMOUNT OF ACTIVE INGREDIENT	HUMAN			ANIMAL	IRRIGATION		
			DRINKING	SWIMMING	FISH CONSUMPTION	DRINKING	TURF	FORAGE	CROPS FOODS
Cutrine®-Plus Liquid	Copper Alkanolamine complexes	9%	0	0	0	0	0	0	0
Cutrine®-Plus Granular	Copper Alkanolamine complexes	3.7%	0	0	0	0	0	0	0
Dichlobenil Granular	2,6-dichlorobenzonitrite	10%	*	*	90	*	*	*	*
2,4-D Liquid ester	2,4-dichlorophenoxyacetic acid	3.76 lbs. per gal	*	*	*	*	*	*	*
Weedtrine® II Granular ester	2,4-dichlorophenoxyacetic acid	28.4%	*	*	*	*	*	*	*
Diquat Liquid	Diquat dibromide	2 lbs. Diquat cation per gal.	14	0	0	14	14	14	14
Weedtrine® D Liquid	Diquat dibromide	8.53%	14	0	0	14	14	14	14
Aquathol K Liquid	Dipotassium salt of endothall	4.23 lbs. per gal	7-25	1	3	7-25	0	7-25	7-25
Aquathol Granular	Dipotassium salt of endothall	10.1%	7	1	3	7	0	7	7
Aquazine Wettable Powder	Simazine	80%	365	0	0	365	365	365	365
Hydrothol 191 Granular	Mono (N,N-dimethylalkylamine) salt of endothall	11.2%	7-25	1	3	7-25	7-25	7-25	7-25
Hydrothol 191 Liquid	Mono (N, N-dimethylalkylamine) salt of endothall	53.0%	7-25	1	3	7-25	7-25	7-25	7-25
Rodeo	Isopropylamine salt of glyphosate	53.5%	**	0	0	0	0	0	0
Sonar	Fluridone	41.7%	**	0	0	0	30***	30***	30***

*In cases where restrictions are not given in above chart, consult your State Conservation Commission or Fish & Game Department for specific restrictions. Chemical manufacturers and manufacturer's representatives can also supply you with specific recommendations based upon water usage.

**See label for distance allowed from potable water intake.

***Voluntary restriction suggested by manufacturer.

NOTE: Waiting period ranges given for endothall products (7-25 days) are dependent upon dosages used. See labels for accurate determinations.

NOTICE: Copper sulfate is not included in this chart nor is it recommended in this book due to problems with copper build-up in sediments and toxicity to aquatic organisms (see pages 5, 6, & 21).

PNW 224

Aquatic Vegetation Management and Control

Contents

Aquatic Vegetation Management and Control

R. Parker, Extension Weed Scientist, Washington State University, and R.D. Comes, Plant Physiologist, USDA Agricultural Research Service

There is an ever increasing demand upon water resources for recreational, agricultural, industrial, and numerous other purposes.

Water areas, like land areas, support plant life. The kinds and amounts of plants vary within the different aquatic environments of streams, rivers, lakes, ponds, marshes, and other wetlands. Aquatic plants can be the dominant visible feature of some water areas. In other cases, they may occupy only the water margin, grow out of sight beneath the water surface, or grow as minute organisms suspended in the water. Aquatic plants belong to two groups—vascular plants and algae.

The planned uses for a body of water determine, to a large extent, the need for management or control of aquatic plants. A given body of water may be used for irrigation, fishing, boating, swimming, water skiing, or water fowl hunting. Plant control may be required to meet the objectives of domestic, industrial, recreational, or agricultural consumption of water.

Many of the plants may be pests in some situations and desirable in others. The category into which they are placed depends upon:

- Their abundance
- The use of the waters which they inhabit
- Personal values of people using or living near the water

The information in this publication applies to control of plants in:

- Recreational waters used for fishing, boating, and aquatic sports
- Agricultural reservoirs and water distribution channels used for stock watering, irrigation, and drainage
- Ornamental ponds
- Coastal bays, estuaries, and channels
- Drinking water reservoirs
- Ditchbanks

CATEGORIES OF AQUATIC WEEDS

The first step toward prevention or control of aquatic weeds is to correctly identify them. Most control methods are aimed at specific plants or groups of plants with similar growth habits. Usually aquatic weeds are separated into four broad categories based on their life form. These are algae and emersed, submersed, and floating vascular plants.

Algae

Algae are the simplest plants in structure and organization as well as the most primitive. They are the most common and most uniformly distributed of all aquatic plants. The waters of the United States contain many species. Algae are simple aggregates of cells capable of carrying out all life processes without specialized tissue such as leaves, roots, or stems. They vary from microscopic forms to long, stringy mats. Under conditions of high nitrogen and phosphorus levels and during hot, calm, sunny weather, algae multiply rapidly and may accumulate in large masses. Algae reproduce by spores, cell division, and/or fragmentation. They are divided into two groups.

Filamentous algae consist of long, stringy hair-like filaments that form mats or "pond scums" during summer which can be seen without the aid of a microscope. Others may form a green, fur-like coating on stones and other bottom objects. In early spring they grow on the bottom and rise to the surface during hot, calm, sunny weather. Stonewart algae or muskgrass, because of their size, growth, and attachment to the pond bottom, may be mistaken for vascular plants. Examples are chara and nitella. Chara has a strong, musty odor, and is sometimes encrusted with calcium deposits which give it a rough, gritty texture.

These plants consist of an erect central main stem

from which clusters of branches arise at various intervals. They generally grow as tall as 2 or 3 feet, and can completely cover a pond or lake bottom.

Plankton algae are commonly single cell or small colonial groups, free-floating, and either green, blue-green, or brown. In large numbers, plankton algae may color the water brown, yellow, pea soup green, or even red during the warm seasons. When this occurs, the lake or pond is said to be "blooming." These blooms may indirectly provide the food for fish, but they may also make water undesirable for swimming or fishing, or for use as a domestic water supply. Each ounce of water in this condition contains millions of microscopic algae cells. Upon death, they may release foul odors and tastes to the water and, in some species, toxins capable of poisoning livestock. Complete chemical treatment for "water blooms" is not normally desirable or feasible. Treatment would be expensive and would only be effective for a few days. Serious oxygen depletion from sudden death of the "bloom" could cause extensive kills of fish.

Vascular Plants

Vascular plants are more complex in structure and organization with specialized tissues such as roots, leaves, stems, and flowers. There are annuals and perennials; many flower and produce seed; others propagate asexually (tubers, winter buds, turions, and fragments).

Emersed plants are rooted or anchored in the substratum with most of the leaf-stem tissue above the water surface and not lowering or rising with changes in the water level. Most plants are perennial with creeping rootstocks. The foliage is aerial. Examples are cattails, tules, and yellow waterlilies.

Submersed plants are adapted to grow with all or most of their vegetative tissue below the water surface. They are usually rooted in the bottom soils. Examples of submersed plants are pondweeds, coontail, elodea, and milfoil.

Floating plants are either free floating or anchored to the bottom and produce most of their leaf-stem tissue or thalli at or above the water surface. Leaves or thalli of floating plants rise or lower with the water level. Examples of floating plants are the duckweeds, azolla, white waterlily, and water hyacinth.

The following basics must be considered in evaluating control methods. Floating and submersed plants can interfere with swimming or boating. In fact, dense plant growth can make swimming hazardous. Rooted emergent shoreline plants may make it difficult to launch boats and may limit the usefulness of beach areas. Good examples are reed canarygrass and cattails. Dense vegetation also interferes with fish propagation, hatchery operations, and fishery management. Aquatic plants may give water an off-flavor or fishy odor and make it unfit for drinking without treatment.

Free-floating aquatic vegetation and fragments of submersed plants often clog irrigation pipes and nozzles. In irrigation systems, aquatic plants reduce water-flow rates, increase evaporation and seepage rates, and increase the danger of breaks in canals because the water level is increased to maintain the water flow. Some aquatic plants may restrict industrial and agricultural withdrawals of water.

On the other hand, aquatic plants may be desirable for special purposes. Certain plants and their seeds are useful as cover and food to attract waterfowl for fall hunting. If fishing is a major interest, a limited number of aquatic plants, both floating and submerged, may be desirable. They provide fish with cover, food, and a spawning site. But when plants are over-abundant, they interfere with fish life and fishing.

It becomes apparent that the desirability of aquatic plants depends on the point of view of the water user. Reservoir managers and swimmers want clean, clear water that is free of vascular plants, algae, and other organisms. Waterfowl hunters want an abundance of aquatic plants that attract ducks and geese. Anglers prefer to see lily pads, plant beds, and plankton that nurture fish and the organisms they feed upon but only if they do not become widespread and spoil the fishing. Conservationists strive for suitable plant cover on watersheds and banks of streams, lakes, and ponds to control erosion and to protect water quality. Irrigators want clean, free-flowing water. It is clear that the owner or manager of a body of water should be knowledgeable about aquatic plants so the individual can

choose procedures to meet management objectives. The application of science to management of water areas and aquatic environments offers the best solution to meeting the diverse interests of all water users.

CONTRIBUTION OF PLANTS TO THE AQUATIC ENVIRONMENT

Energy

Aquatic plants, like all other green plants, use energy from the sun to manufacture carbohydrates. Part of the energy obtained is essential for plant growth. Excess energy is stored as carbohydrates, oil, and other products. This stored energy supports most other organisms in aquatic environments. Submerged aquatic plants and algae contribute to the water environment by taking in carbon dioxide and releasing oxygen during photosynthesis.

Food Chain

Algae and flowering plants form the base of the food pyramid, or the first link in the food chain. These plants, called producers, support the aquatic animal population, termed the consumers. Organisms that feed directly on these plants are called primary consumers. Part of the energy transferred to the consumer through food is used in the growth of the consumer, and the excess is stored. The primary consumer is eaten in turn by a secondary consumer, and so forth as the cycle of energy utilization and storage is repeated up the food pyramid. As the food pyramid becomes taller, or the food chain longer, fewer individual organisms can be supported.

The stems and leaves of submersed parts of vascular plants serve as host for a whole community of microscopic organisms, all of which contribute to the food chain in a pond or lake. Bacteria, fungi, algae, diatoms, protozoans, insect larvae, thread worms, bristle worms, rotifers, and small crustaceans are the principal members of the community of organisms that live on and around the larger plants. The population of this community is spread over all leaf and stem surfaces. Increasing in numbers until the end of the summer, this microscopic community provides support for the larger organisms, including fish.

Animal Habitat

The underwater plants contribute in another way to the ecological structure of the total pond or lake community. Many of the free swimming creatures, such as fish and amphibians, use plant beds as places to deposit eggs. The young of many fish use these beds for shelter from predators, or they seek the plants as a feeding area since a rich supply of food organisms is usually available there.

The game fish that fishermen seek are at the top of the food pyramid and, thus, the presence of green plants, especially plankton algae, are important to the success of this sport.

Pondweeds, arrowhead, bulrushes, and reeds are important foods for wildlife. The snapping turtle's diet consists of 90% vegetable matter; plants make up two-thirds of the food for the smaller painted turtle. Muskrats eat the rootstocks, tubers, and stems of emergent plants, including cattails, arrowheads, bulrushes, and waterlilies. They also use aquatic plants for building their houses and lining their dens. Aquatic plants are important food sources for waterfowl, upland game birds, and shore birds.

Eutrophication

In the course of extended time, a pond or a lake will fill with decayed plant matter, etc., and beome dry land. The deeper the lake the longer the time required to fill. This filling process is aided by the growth of aquatic plants in many ways. The continued cycle of plant growth and decomposition creates a slow buildup of organic matter in the basin. Plants also retard the flow of water and thereby cause suspended material to settle to the bottom. As the filling progresses, plants of the shallower zones become established in the former deeper zones. Most bogs and swamps are lakes that are being filled by these processes.

Water Pollution

Pollution associated with aquatic plant growth may be of two types—pollutants that *inhibit* growth and those that *stimulate* growth. Although both forms can be serious, this discussion is centered around the growth-stimulating pollutants.

Chemicals that stimulate growth are primarily nitrogen and phosphorus compounds that discharge from sewage plant effluents, home waste disposal systems, food producing plants, and well-fertilized agricultural watersheds. These nutrient materials stimulate profuse growth of both algae and vascular aquatic plants.

Depending on conditions, a polluted pond or lake may be either excessively turbid and scum-coated or clear and choked with plants. Either condition indicates water of relatively high fertility and optimum conditions for plant growth. Sewage treatment or disposal systems that meet governmental requirements may not circumvent the problem of increased fertility; nitrates and phosphates remaining in treated sewage stimulate plant growth in receiving waters.

Fish Kills

Dense aquatic plant growth may deplete oxygen and subsequently kill fish. Warm, calm, and cloudy weather in summer and thick, opaque, or snow-covered ice in winter contribute to this hazard. Under these conditions, plants do not photosynthesize and produce oxygen. Instead, they consume oxygen through respiration, and some die and decompose. Toxic substances may be released into the water during decomposition of algae, especially the blue-green algae.

Organic decomposition occurring throughout the year makes continuous demand upon available oxygen. If oxygen is not continuously added to the water through wave action, inflowing water, or photosynthesis, oxygen levels may be reduced to the extent that they are inadequate for survival of fish and many of their food organisms.

Also, in deep lakes the water below the photic zone may have a very low level of oxygen. When the lake turns over or breathes (moving of the bottom water and mixing with the water in the upper layers over a short time period in response to seasonal temperature changes), fish may be distressed or killed because of the subsequent low oxygen levels in the upper layers.

MANAGEMENT AND CONTROL

Wise management of water is necessary if control of aquatic vegetation is to be more than temporary. Management must begin with an evaluation of all uses of a given body of water. Chemical, biological, and physical factors should be manipulated as much as possible to obtain the maximum utilization of the water for benefit of the greatest number of people.

Management: Construction of Ponds, Reservoirs, Ditches, etc.

Proper design and construction of ponds and ditches are important factors in preventative control of aquatic plants. Shallow water at the margins of ponds and ditches provides an ideal habitat for emersed plants, such as cattail. Submersed plants can easily become established there and then spread into deeper waters. Steep banks with a 1:1 to 1:1.5 slope until water depth is at least 3 feet will help to prevent establishment of many emergent and bank weeds. However, steep sides may create other problems. If small children frequent a pond, steep sides would definitely be a safety hazard. Remove fertile topsoil from the pond or reservoir basin before filling. If a beach area for swimming and other recreational purposes is desired, remove the fertile topsoil and replace with sand. If possible, prevent waters heavily laden with silt and nutrients from entering an impoundment.

Construction of ponds, lakes, canals, and ditches so they can be drained is an effective means of controlling aquatic plants. The water levels in some large lakes and reservoirs may be lowered enough to expose plants in the shallow areas. Freezing or drying periods of several months may be necessary to control plants in some ponds and lakes. In most canals, it is not practical to interrupt water flow during the summer months when aquatic plants make their most rapid growth. The species of plants and the seasonal growing period will generally determine whether this method is practical or not. An overriding factor on lowering reservoirs or drying up ponds will be the presence of a fish population along with their spawning habitats.

If grass is planted on ditchbanks, 2,4-D can be applied to keep out most undesirable broadleaf plants. East of the Cascade Mountains, redtop or other low-

growing, adapted grasses should be seeded at the waterline and crested wheatgrass on the shoulders and top of the ditchbank. Provide roadways on both ditchbanks for weed control and other operations.

Mechanical Control

Physical removal is effective for small quantities of plants near shorelines. The techniques consist of cutting, mowing, raking, digging, or pulling. In small ponds or lakes, emergent plants such as sedges, cattails, and rushes can be mowed, pulled by hand, or dug with a hoe.

Chaining may be practical in some instances, particularly in canals. Draglines are useful for deepening and cleaning canals and margins of lakes and ponds. Underwater mowers are used in both lakes and canals for cutting plants.

Certain problems are associated with the above methods. Pulling or cutting usually must be repeated several times to eliminate new growth as it appears. Single cutting treatments usually are not effective because most submersed and emergent vegtation is perennial and the underground portion of the plants is unharmed by such a treatment. Attempts to remove submerged plants by cutting or dragging a chain or cable over the bottom are not effective. Actually, this practice may spread the infestation because the plants can regenerate from plant fragments. Also, plant fragments and other debris dislodged by such devices plug irrigation sprinklers; pumps, etc. Mechanical control may be slower and more costly than other methods of control.

Burning ditchbank weeds may increase the flow of water in a ditch and help prevent seed from infesting new land. Sear green vegetation the first time and then thoroughly burn 7 to 10 days later. Control by burning is also only temporary.

Biological Control

Biological control employs plant or animal agents to eliminate or reduce growth of vegetation or to alter the habitat to favorably change the type of plant growth. Insects, mites, snails, pathogenic microorganisms, fish, ducks, geese, manatees, and competitive plants have been tried for biological control of aquatic weeds. Biological control is not new, but practical and safe means of controlling aquatic plants by these methods are extremely limited.

Muskrats may cut considerable quantities of plants, but in doing so they leave fragments that may act as sources for plant propagation. Domestic waterfowl may feed on certain floating and submerged plants; however, the fertility resulting from their excrement may create excessive algae blooms that may be more undesirable than the original problem. Some exotic species of fish, such as the white amur, are being promoted to control aquatic vegetation. Since the impact of these organisms on the aquatic ecosystems is not fully known, their release is prohibited in many states. No biological-control agents for aquatic weeds are available in the Pacific Northwest.

Control with Herbicides

Unlike terrestrial herbicides, which are applied to a stationary, two-dimensional area, aquatic herbicides are applied to an area having a third dimension, depth, and usually having some degree of motion.

Responsible use of aquatic herbicides requires careful consideration of many factors. The most important consideration is the safety of the people using the treated water. Contamination of domestic water supplies, or failure to observe the proper precautions in water-use restrictions, may result in health hazards. Most waters are managed on a multiple-use concept. Game fish, waterfowl, and aquatic mammals share water usage with swimmers and boaters. Irrigation and domestic requirements also may be met by withdrawals from a lake, canal, or river.

Pesticides are often blamed for a phenomenon called swimmers' itch. Swimmers' itch, in fact, is caused by a parasite which is associated with snails and water birds. A brief summary of swimmers' itch is as follows:

> Birds, through their feces, deposit a blood fluke in the water. This fluke will deposit eggs in the water. When hatched, the small organisms, called miracidia, must find a snail for an intermediate host for a short time or they will die. In the snail, the

miracidia develop into cercaria, which leave the snail as free-swimming organisms that can penetrate the skin of man. After penetration, the cercaria cause an itching, burning sensation and small red spots that appear at the point of entry into the skin. These symptoms are noticed soon after the bather leaves the water.

Environmental Consideration and Restrictions

Incorrect application of herbicides to water may involve serious hazards to man, wildlife, fish, and desirable plant life. Consequently, you must analyze the biological, water-use, and physical aspects.

- Biological aspects
  - Identify the problem species.
  - Identify other species present.
  - Determine density, stand, or scope of problem and stage of weed growth.
- Water-use aspects
  - Irrigation, potable, recreational, fish production, livestock, wildlife.
  - Length of time water can be quarantined from each use.
  - Amount of and destination of outflow. Can outflow be regulated? If so, for how long?
- Physical aspects
  - Size of channel or pond to be treated.
  - Water depth and movement or velocity.
  - Water turbidity.
  - Water temperature.
  - Water quality.

After all these factors are carefully analyzed, choose the herbicide labeled for that use, considering safety, effectiveness and selectivity, residues, and cost. Obtain permission, if necessary, from appropriate state and/or federal agencies.

The control of aquatic vegetation presents special problems because:
- The water often has multiple uses.
- Herbicides do not always remain where they are placed.

Consider all the uses of the water to be treated, including those far downstream. Read the label to determine that the herbicide you choose is compatible with these uses.

Types of water uses to consider before applying herbicides include:
- Human use, such as drinking, cooking, and swimming. Few tolerances have been established for herbicide residues in such water. Copper sulfate has been used for control of algae in drinking water for many years and is permitted in raw drinking water. However, you should avoid contamination of any drinking water with any level of herbicide which is not registered for that use.
- Livestock and wild animal use.
- Irrigation.
- Industrial uses.
- Fish production—most aquatic herbicides are not toxic to fish or other animal life at the concentrations recommended for plant control. Notable exceptions are Grade B xylene, acrolein, and some solvents and emulsifiers in certain formulations of normally nontoxic herbicides. These should not be used in fisheries or where the water treated with these herbicides could enter fishery waters.

Trout are especially susceptible to copper sulfate. Do not treat trout waters with copper sulfate without consulting fish biologists.

Application Rates

Correct application of herbicides to aquatic situations involves equipment calibration and calculation of appropriate water volumes or areas. Environmental hazard can result from the incorrect application rate.

Excessive application can cause:
- Damage to fish, either from direct toxicity or from lack of oxygen caused by excessively rapid kill of plants. Bacterial contamination resulting from decay of killed fish might further contaminate downstream water supplies.
- The need for exclusion of livestock from use of the water for a longer time than necessary.
- Water unfit for irrigation use.

State and Federal Regulations

Many states have regulations that govern the use of pesticides in water. Check with the appropriate agency when in doubt. There also are stringent federal and state regulations controlling the importation of exotic fish and plants.

Treatment Techniques

Lower lakes and ponds that have a high rate of inflow prior to treatment to insure adequate contact time for the herbicide. Close the spillway and retain the treated water for at least the minimum period specified on the label before overflow. The amount of draw down will vary according to the situation. Avoid excessive exposure of bottom areas.

Most herbicides should be applied to submersed aquatic plants in late spring or early summer when the plants are young and growing. Treatment at this time usually gives the best control with a minimum of chemical. Applications in late summer or early fall require more chemical and usually give slow, erratic control. Furthermore, access to normally dense aquatic vegetation is best in the spring or early summer before the plants reach the surface.

Points to Remember

The applicator should:

- Be certain of the identity of the vegetation to be treated and the capability of the chemical to control it.
- Obtain a permit (if necessary) to treat any lake or pond—whether for plant control, cleaning, or other purposes.
- Never use more chemical than suggested on the label. Fish and other valuable aquatic life may be killed.
- Use treated water only as suggested on the label.

Environmental Changes Caused by Aquatic Plant Control

The sudden elimination of a dense growth of vegetation from an aquatic environment often causes side effects that can produce significant changes in the biological and physical makeup of a lake, pond, or stream.

Following the death of large quantities of vascular plants in a pond or lake, a greenish or yellowish-brown turbid condition may be noticed. This condition is due to the presence of billions of microscopic algal cells which have used the nutrients released from the decaying vascular plants for their growth and reproduction. The green or blue-green algae are often responsible for a pea soup appearance, whereas, other algae and various one-celled organisms cause the yellowish-brown colors in water.

When conditions are optimal for development of algae, a dense bloom can quickly develop. These dense blooms of plankton algae cut down light penetration and, thereby, inhibit the regrowth of those species defoliated by the treatment, but the algae may turn out to be more objectionable than the original plant infestation.

Chemical Formulations

Aquatic herbicides are available in several formulations.

Sprayable formulations. Most herbicides are formulated to be mixed with water and sprayed.

Kinds available are:

- Water-soluble powders or crystals that form true solutions in water.
- Wettable powders that can be dispersed in water.
- Water-soluble liquid concentrates that form true solutions in water.
- Emulsifiable liquid concentrates that form ordinary "oil-in-water" emulsions in water.
- Special liquid concentrates that form "water-in-oil" emulsions (called invert emulsions) when mixed with water and oil in the spray tank or when applied through special mixing nozzles.

Granular formulations. Many aquatic herbicides are used as dry granules of various sizes. Kinds available are:

- Granulated pure chemical, such as crystalline copper sulfate.
- Granules or larger pellets of clay and other materials impregnated with the parent herbicide.
- Slow release granules or pellets designed to release the chemical into the water over an extended period.

Application Techniques

Four zones of a body of water may be treated:

- Water surface
- Total water volume
- Bottom 1- to 3-foot layer of water
- Bottom substrate surface

Surface Treatment

Generally, only one-fourth to one-third of the surface area of the water should be treated at a time. This helps protect fish from a possible shortage of oxygen from vegetative decomposition. Surface acreage of a rectangular body of water equals length in feet times width in feet divided by 43,560.

Total Water Volume Treatment

The whole body of water (from surface to the bottom) is treated; more frequently, one-fourth or one-third of the total water volume is treated at a time. Calculate the volume of the body of water and add chemicals to obtain the required dilution in the water.

The concentration of chemical needed to kill aquatic plants is often very small and is stated in "parts per million" (ppm).

If the toxicity level of a certain chemical for a particular aquatic plant is 2 ppm of active ingredient (ai), for example, the chemical should be applied at a rate of 2 parts of "ai" to 1 million parts of water in the area to be treated.

First, calculate the acre-feet of the body of water to be treated. Multiply surface acres by the average depth in feet. An acre-foot of water weighs 2.7 million pounds. If one dissolves 2.7 pounds of any material in 1 acre-foot of water, there will be a concentration of 1 ppm by weight (ppmw). Use the following formula to determine the material needed to obtain a desired ppm concentration:

2.7 × ppm wanted × acre-feet = pounds required

Assume one wants to treat a pond containing 10 acre-feet. The concentration of active ingredient required is 0.5 ppm. Use this formula:

2.7 × 0.5 × 10 = 13.5 pounds of active ingredient

Bottom Layer Treatment

Treating the deepest 1 to 3 feet of water is especially useful in deep lakes where it is impractical and too costly to treat the entire volume of water. Such treatments are generally made by attaching several flexible hoses at 3- to 5-foot intervals on a rigid boom. Each hose is usually equipped with some type of nozzle at the end. They may be weighted to reach the depth desired. The length of hose and speed of the boat carrying the application equipment also affect the depth of application. Successful bottom treatments apply the herbicide as a "blanket" in the lower 1 to 3 feet of water.

Bottom Soil Treatment

Herbicide applications may be made to the bottom soil of a drained pond, lake, or channel to control certain submersed and emersed species. The interval between treatment and reintroducing water varies up to 3 weeks, depending on the herbicide used.

VEGETATION MANAGEMENT IN STATIC WATER

Floating and Emersed Weeds

Sprayable formulations are almost always preferred for floating and emersed plants. These plants are killed by direct foliage applications of the spray mixture:

- By aircraft.
- By ground equipment—operated from the bank of small ponds or if plants occur only around the margin.
- From a boat, using various types of booms or spray guns.

Submersed Plants

The herbicide formulations for the control of submerged plants and algae in static water may be in the form of sprays or granules.

Sprayable formulations are most often applied as water-surface treatments, particularly in shallow water. The herbicide is dispersed throughout the water by diffusion, thermal currents, and wave action. Sprayable herbicides can be applied under the surface by:

- Injection through a hose pulled along behind a boat.
- Injection into the water by booms.

Sprayable herbicides sometimes are used for bottom soil treatments. Some sprays may be applied from aircraft at low volumes, e.g., 5 to 10 gallons per acre. Both surface and injection treatments made by boat or ground equipment are more effective and

are easier when large volumes of liquid carrier are used. A handy sprayer for making applications by boat uses a special pumping system that draws water from the lake or pond as the boat moves along. Concentrated herbicide is metered into the pumped water to achieve the concentration required. This avoids both frequent interruptions to prepare spray solutions and the need to carry water on board.

Granular formulations are most often used for control of algae or submersed plants, although some are effective on certain emersed plants. Because granules sink to the substrate, they perform about the same way as herbicides applied as bottom soil treatments. Application rates for granular herbicides may be based on:

- Amount of herbicide per unit of surface area.
- The concentration (ppm) that would be achieved if the same amount of herbicide were dissolved and totally dispersed in the water (total water volume treatment).

Granular herbicides perform best when distributed evenly over the water surface. They may be broadcast by hand or manual spreader over small areas. Special granule spreaders mounted on aircraft or boats are used for large-scale applications. Advantages of granular herbicides are:

- Treatment is usually confined to the bottom where the submersed plants are.
- They can be made to provide a long contact time with plants (slow release granules).
- The herbicide concentration can be held to a low level.
- They make it possible to use chemicals that in other formulations would be toxic to fish.

Plant Control in Large Impoundments

Herbicide applications that are successful in smaller bodies of water often perform poorly in large impoundments. These impoundments often have much water movement caused by thermal currents or the wind. Plant control may sometimes be improved in these sites by:

- Using the maximum recommended application rates.
- Treating relatively large water areas at one time.
- Applying herbicides only during periods of minimum wind.
- Using bottom treatment in deep water.
- Using granular formulations when possible.
- Selecting herbicides that are absorbed quickly by the plants.

VEGETATION MANAGEMENT IN FLOWING WATER

Aquatic plants in flowing water are the most difficult to control. Because the water is moving from one location to another, the possible hazards of herbicide use are greater.

Herbicides are sometimes used to control plants in natural streams. Control of aquatic plants in man-made water distribution and drainage systems is more common. Most of these carry irrigation water. Do not irrigate crops with treated water unless permitted by the pesticide label. Some systems also carry domestic, industrial, and recreational water. As the number of water uses increases, more restrictions and precautions are required.

Floating and Emersed Plants

When floating and emersed plants are found in flowing water and control of these plants becomes necessary, the procedure when using herbicides will be the same as when applied in static waters. Precautions for flowing waters are important. What are the flowing waters used for? Do they support fish life, are they used for recreation, etc.? Much concern for the environment is in order when applying pesticides to flowing water.

Submersed Plants and Algae

These plants can be effectively controlled in flowing water only by continuously applying enough herbicide at a given spot to maintain the needed concentration and contact time.

The greater the cross-sectional area and the depth of the stream and the greater the speed of flow, the larger the volume of water that must be treated.

The large volume of water that must be treated makes the use of herbicides in flowing water costly, particularly when:

- The plant infestation covers only a small area.
- The herbicides are effective for only a short distance downstream.

Few herbicides are available for control of submers-

ed plants in flowing water. The more common ones are:

- Copper sulfate, used for control of algae. It is toxic to trout at recommended treatment rates, but only moderately toxic to most other fish species. The toxicity of copper to fish increases with decreased total alkalinity of the water.
- Grade B xylene and acrolein, are highly toxic to fish and many other forms of aquatic life. They are used primarily in water delivery systems that contain no fish, or where the water delivery is far more important than the value of the few fish that might be present. These products are usually injected below the flowing water surface, to enhance distribution in the water, to reduce volatilization, and to increase the stability of Grade B xylene emulsions.

Be certain that the residues in the treated water and runoff water are at or below the levels permitted for all subsequent uses.

PLANT CONTROL IN LIMITED FLOW WATERWAYS

Flood drainage canals, sloughs, and drains are good examples of limited flow waterways. Plant control methods in these systems of little water movement are very similar to those used in static water. Consider the possible contamination of water used for other purposes when you plan the use of herbicides in limited flow water. In some areas, drainage water may flow directly onto cropland and be used for irrigation or it may enter a fishery or drinking water supply.

VEGETATION MANAGEMENT ON DITCHBANKS

Weeds on ditchbanks are a major obstacle in irrigation of crops and subsequent drainage. They reduce the flow of water and thus cause flooding, seepage, breaks in ditchbanks, increased evaporation and transpiration loss, decreased water delivery, and decreased drainage of water. They obstruct inspection and maintenance operations of the irrigation systems and cause silt deposits in the irrigation channels. Also, seeds and other propagules produced by weeds on ditchbanks can infest cropland.

Ditchbanks provide a variable plant habitat. A major reason for this is that soil moisture varies greatly within a short distance on an irrigation ditchbank. Emergent aquatic species are often found at the waterline. Within a few feet of this area, up over the top of the bank, the soil may be very dry with drought-tolerant species predominant.

Plant control methods will depend on which plants are to be controlled in relation to the water level, intended water use, and the subsequent use of the water "downstream."

When spraying ditchbanks, the sprayer should travel upstream to avoid the possiblility of concentrating any herbicide which may get into the water.

SELECTED HERBICIDES USED IN AQUATIC SITES

The following is a brief description of herbicides used to control weeds growing in aquatic situations. Specific recommendations for control of aquatic and ditchbank weeds are not included. Current recommendations can be obtained within your state from Cooperative Extension and by consulting appropriate product labels for specific rates, timing, and registered uses.

Acrolein (Magnacide-H)

Acrolein is a contact herbicide used to control submersed and floating weeds and algae in irrigation canals, ditches, drains, and ponds. It is not toxic to common field crops irrigated with treated water when used as directed by the product label. Acrolein is volatile, flammable, and very toxic to mammals, birds, fish, and many other aquatic organisms.

Apply acrolein before weed growth is 4 to 6 inches tall. Specialized equipment is required for application. Acrolein is injected directly into the water using oxygen-free nitrogen as a propellant.

Repeat treatment every 3 to 4 weeks during the remainder of the season. There is no potable (drinking) water tolerance for acrolein, and it must not be applied in potable waters. Do not permit treated water to return to water courses containing desirable fish, vegetation, or other organisms until the herbicide has completely dissipated from the water.

Copper sulfate (Various Trade Names)

Copper sulfate can be used to control most algae in

most waters, except in streams and rivers. It is an inorganic herbicide formulated as various-sized crystals. Dissolution rates in the water vary according to crystal size, water quality, flow rate, and other factors. The effectiveness of the product is influenced by water hardness, organic matter content, and algal density. Make the first treatment before a severe algae problem develops; repeat treatments at 2- to 3-week intervals may be required for continued control. The herbicide can be applied by:

- Suspending the crystals in porous bags beneath the water surface or dragging the bags through the water.
- Pouring directly into water of irrigation channels if the irrigation channel is concrete lined.
- Apply over the water surface of impoundments.
- Using a specially-designed continuous feeder.

When applying to fish-containing waters, note label cautions for application and rates due to different fish sensitivities. Potable water has a tolerance of 1 ppm of copper.

Copper sulfate will not eliminate established growths of submersed vascular weeds. However, continuously maintained concentrations, begun in early spring for control of algae in municipal-water canals and reservoirs, inhibit the growth of rooted submersed plants.

Dalapon (Dowpon M)

Dalapon is a translocated, foliage-applied herbicide used to control emersed, marginal, and bank grasses along the inside of irrigation canals and drainage ditches. Best results occur when a suitable nonionic surfactant is used in the spray solution. Fishing and grazing are restricted after using dalapon. Minimize contact of the spray solution with the water surface.

Water-use restrictions occur following use of dalapon, particularly when used in situations other than described above. Thus, observe all label directions and restrictions.

Dichlobenil (Casoron G-10)

Only the granular formulation of dichlobenil, which is labeled for aquatic use, should be used. Dichlobenil will control submersed weeds in lakes and ponds when applied before or immediately after weed growth emerges from the hydrosoil. Apply the granules in early spring to the exposed lake or pond bottom or over the water surface.

Dichlobenil should be used only on lakes and ponds with little or no outflows. Do not use treated water for irrigation or drinking. Do not use fish from treated water for food or feed within 90 days after treatment. Observe all other labeled water-use restrictions listed on the label.

Diquat (Diquat Water Weed Killer)

Diquat is a contact herbicide. It will control the top growth of most species of submersed weeds in clear-water ponds and lakes when injected below the water surface. Apply before submersed weeds reach the water surface.

Diquat is readily adsorbed by silt or other suspended material in water, and its effectiveness is greatly reduced when mixed with such water. It is also an effective herbicide for control of free-floating species such as duckweed. On floating weeds, apply diquat as a foliage spray with surface equipment. When this type of application is made, use a suitable nonionic surfactant recommended by the manufacturer in the spray solution. The effectiveness of diquat on free-floating aquatic weeds is due to the rapid desiccation of the above-water leaves and stems and rapid absorption of the chemical from the water by roots and stems. Diquat only temporarily affects floating-leaf or emersed species rooted in the hydrosoil. It is not effective on chara or attached algae.

Do not use treated water for animal consumption, swimming, spraying or irrigation nor for drinking until 10 days after treatment. Observe all other label restrictions.

Endothall (Hydrothol, Aquathol)

Endothall is a contact herbicide and, depending on formulation, is used to control algae and submersed weeds. For algae control in irrigation systems, lakes, ponds, and reservoirs, the dimethylamine salt (Hydrothol) formulations are sprayed on the water or injected below the water surface when growth appears.

Submersed weeds in lakes and ponds can be controlled with either the dipotassium salt or

dimethylamine salt of endothall (Aquathol and Hydrothol, respectively). Apply either material by spraying on the water or injecting below the water surface after growth has developed in the late spring or early summer. The dipotassium salt formulation works best when water temperatures reach a consistent 62° to 65°F.

Endothall is not effective on chara or elodea. There are several restrictions on the use of water following treatment with endothall, depending on product used and rates applied. The Hydrothol formulations may be toxic to fish at the concentrations required for control of submersed weeds. Consult and observe the restrictions on the appropriate label.

Glyphosate (Roundup)

Glyphosate is a nonselective, translocated, foliage-applied herbicide used for control of a variety of emersed, marginal, and bank weeds along irrigation and drainage ditches. Apply glyphosate to the inside of dewatered ditches only. Best weed control is obtained when the herbicide is applied to vigorously growing weeds at the labeled growth stage. It is especially effective against perennial grasses such as reed canarygrass and johnsongrass. The herbicide rate and timing depends on the target weed species.

Since glyphosate is not selective, occasionally all the vegetation may be killed, allowing erosion of the canal banks. When this occurs, make provisions to establish a desirable low-growing grass, such as redtop or creeping red fescue east of the Cascade Mountains.

Consult the label for any restrictions that apply following treatment with glyphosate.

Xylene

Xylene is a nonselective, contact herbicide used to control submersed weeds in flowing canals. Apply this product after weed growth is well established, but before it becomes matted at the surface or causes channeling of the water. When applying xylene, mix with an emulsifier and inject under pressure near the bottom of the channel, preferably in turbulent water. The emulsifier will help the xylene form a stable emulsion with the water. Without the emulsifier, xylene will float on the water surface and evaporate.

Xylene is flammable, volatile, and very toxic to fish and many other aquatic organisms. There is no potable water tolerance for xylene, and it must not be applied to potable waters. Do not allow the treated water to return to water containing desirable fish, vegetation, or other organisms until the herbicide has completely dissipated from the water.

Repeat treatments as required during the remainder of the season. Do not allow man or animal to drink the treated water nor flood irrigate seedling crop plants with treated water. Xylene can be used only in programs of the Bureau of Reclamation and cooperating user organizations.

Simazine (Aquazine)

Simazine is a nonselective herbicide used to control algae and submersed weeds in lakes and ponds with little or no outflow. Apply simazine in the spring while the submersed plants are actively growing and before they reach the water surface. Make treatments for algae control when 5% to 10% of the water surface is covered with scum.

Trees on the shoreline may be injured or killed by simazine applied to the water. Do not use water from treated ponds for irrigation, livestock water, or human consumption until 12 months following treatment. Fishing and swimming are permitted any time after application.

2,4-D (Various Trade Names)

2,4-D is a selective, foliage-applied herbicide used to control broadleaf weeds. When selecting a formulation of 2,4-D for a particular situation, be sure it is registered for that use. At this time, Weedar 64 is the only formulation of 2,4-D registered for use in controlling broadleaved weeds on the inside perimeter of irrigation channels in the western United States. The use of other products for this purpose is an illegal application.

Some granular formulations of 2,4-D are registered to control Eurasian watermilfoil and other weeds in lakes and ponds. Other formulations of 2,4-D are available for control of floating, emersed, marginal, and bank weeds of ponds and lakes.

Restrictions apply to livestock grazing and the use of water treated with 2,4-D. Consult and observe all other water-use restrictions on the herbicide label. These restrictions will vary with the particular use and site of application. Some formulations of 2,4-D are more toxic to fish than others. Avoid drift to nearby 2,4-D susceptible crops.

This publication was compiled from these study guides and our own sources to provide what we feel is the minimum of information required for aquatic herbicide application.

1. The Aquatic Plant Manual by E.P.A., which was developed by California State Polytechnic University (contract 68-01-2918);
2. Pesticide Training Manual on Aquatic Pest Control, Maryland Department of Agriculture, prepared by the College of Agriculture, Pennsylvania State University;
3. Aquatic Plant Control Training Manual, prepared by the staff of the Florida Department of Natural Resources, Division of Resources Management, Bureau of Aquatic Plant Research and Control;
4. The Pesticide Applicator Training Manual on Aquatic Pest Control, prepared by the College of Agriculture and Life Science, Cornell University.
5. Pacific Northwest Pest Control Handbook, prepared by state agencies in the Pacific Northwest.

EQUIVALENTS AND EQUATIONS

Liquid Measurements

1 gallon	=	4 quarts
1 gallon	=	8 pints
1 pint	=	16 ounces
1 cup	=	8 ounces
1/2 cup	=	4 ounces
1/4 cup	=	2 ounces
1 tablespoon	=	1/2 ounce
8 tablespoons	=	4 ounces
16 tablespoons	=	8 ounces

0.1 gallon	=	12.8 ounces
0.2 gallon	=	25.6 ounces
0.25 gallon	=	32.0 ounces (1 qt)
0.3 gallon	=	38.4 ounces
0.4 gallon	=	51.2 ounces
0.5 gallon	=	64.0 ounces
0.6 gallon	=	76.8 ounces
0.7 gallon	=	89.6 ounces
0.8 gallon	=	102.4 ounces
0.9 gallon	=	115.2 ounces
1.0 gallon	=	128.0 ounces

Solid Measurements

0.1 pound	=	1.6 ounces
0.2 pound	=	3.2 ounces
0.3 pound	=	4.8 ounces
0.4 pound	=	6.4 ounces
0.5 pound	=	8.0 ounces
0.6 pound	=	9.6 ounces
0.7 pound	=	11.2 ounces
0.8 pound	=	12.8 ounces
0.9 pound	=	14.4 ounces
1.0 pound	=	16.0 ounces

Units and Conversion Equivalents

1 ac = 43,560 sq ft

1 ac ft (ac ft) = 43,560 cu ft = 325,762 gal = 2,720,000 lb of water

1 cu ft/second (cfs) = 450 gal/minute (gpm)

1 cu ft = 7.48 gal = 62.4 lb of water

1 gal = 128 fl oz = 8.33 lb of water

1 ppm by volume (ppmv) = 1 gal/million gal of water

1 ppm by weight (ppmw) = 8.33 lb of chemical/million gal of water

1 ppmw = 2.72 lb of chemical/ac ft of water

$$\text{gal of liquid formulation required} = \frac{\text{lb ai required}}{\text{lb ai/gal of concentrate}}$$

$$\text{lb of dry formulation required} = \frac{\text{lb ai required} \times 100}{\text{\% ai in formulation by weight}}$$

(ai = active ingredient)

Formulas for Herbicide Application to Ponds or Lakes

Volume of pond in cu ft = surface area in sq ft × average depth in ft

Volume of pond in ac ft = surface area in ac × average depth in ft

$$\text{Volume of pond in ac ft} = \frac{\text{volume of pond in cu ft}}{43{,}560}$$

$$\text{ppmv} = \frac{\text{gal of 100\% ai}}{\text{volume in ac ft} \times 0.33}$$

Total gal of chem required = ac ft × ppmv × 0.33

$$\text{ppmw} = \frac{\text{lb ai of chem applied}}{\text{volume in ac ft} \times 2.72}$$

Total lb ai required = ac ft × 1.72 × ppmw desired

$$\text{Total gal of liquid formulation required} = \frac{\text{ac ft} \times 2.72 \times \text{ppmw desired}}{\text{lb ai/gal of concentrate}}$$

Formulas for Herbicide Application to Channels

cfs = cross section area in sq ft × average velocity in ft/second (fps)

cross section area of rectangular channel in sq ft = average width in ft × the average depth in ft

$$\text{ppmv} = \frac{\text{gal of chemical} \times 1{,}000{,}000}{\text{cfs} \times 450 \times \text{minutes applied}}$$

$$\text{gal of chemical/cfs} = \frac{\text{ppmv} \times 450 \times \text{minutes applied}}{1{,}000{,}000}$$

$$\text{total gal of chemical required} = \frac{\text{ppmv} \times 450 \times \text{cfs} \times \text{minutes applied}}{1{,}000{,}000}$$

$$\text{ppmw} = \frac{\text{lb of chemical} \times 1{,}000{,}000}{\text{cfs} \times 3{,}744 \times \text{minutes applied}}$$

$$\text{ppmw} = \frac{\text{gal of formulation} \times \text{lb ai/gal} \times 1{,}000{,}000}{\text{cfs} \times 3{,}744 \times \text{minutes applied}}$$

$$\text{lb of chemical/cfs} = \frac{\text{ppmw} \times 3{,}744 \times \text{minutes applied}}{1{,}000{,}000}$$

$$\text{gal of formulation/cfs} = \frac{\text{ppmw} \times 3{,}744 \times \text{minutes applied}}{\text{lb ai/gal} \times 1{,}000{,}000}$$

DEFINITION OF TERMS USED IN WEED CONTROL

Abscission—The formation of a layer of cells which cause the fruit, leaf, or stem to fall off the plant.

Absorption—Penetration of a substance from the surface to below the surface.

Acid Equivalent (ae)—The theoretical yield of parent acid from an active ingredient content of a formulation.

Activator—Materials used in a pesticide formulation to increase the effectiveness of the toxic materials towards the target pest.

Active Ingredient (ai)—The chemical(s) in a formulated product that is/are principally responsible for the herbicidal effects and that is/are shown as active ingredient(s) on herbicide labels.

Acute Oral LD_{50}—The dosage required to kill 50% of the test animals when given in a single oral dose in toxicity studies.

Acute Toxicity—The amount of a substance, as a single dose, to cause poisoning in a test animal.

Adhesive—A substance that will cause a spray material to stick to the sprayed surface, often referred to as a sticking agent.

Adjuvant—Any substance in a herbicide formulation which enhances the effectiveness of the herbicide.

Adsorption—Adherence of a substance to a surface.

Aerobic—Living in the air; opposite to anaerobic.

Aesthetic—Producing a pleasant or satisfying feeling to an exposure; enjoy seeing a beautiful flower or handsome animal.

Agitate—Keeping a mixture stirred up.

Algae—Nonvascular chlorophyll-containing plants, usually aquatic.

Alkalinity—Containing sodium and potassium carbonate salts. (Calcareous: Containing an excess of calcium usually in the form of the compound calcium carbonate-Limy.)

Anaerobic—Living in the absence of air; opposite to aerobic.

Anionic Surfactant—A surface-active additive to a herbicide having a negative charge.

Annual Plant—A plant that completes its life cycle in one year.

Antagonism—Opposing action of different chemicals such that the action of one is impaired, or the total effect is less than that of one component used separately.

Antidote—A practical immediate treatment, including first aid, in case of poisoning.

Aquatic Plants—A plant that grows in water. There are three types: submergent, grow beneath the surface; emergent, root below the surface but foliage above the water; and floating.

At Emergence—Treatment applied during the visible emerging phase of the specified crop or weed.

Band or Row Application—An application to a continuous restricted area, such as in or along a crop row, rather than over the entire field area.

Basal Treatment—A treatment applied to the stems of woody plants at and just above the ground.

Bed-Up—To build up beds or ridges with a tillage implement.

Berm—Narrow shelf typically along the water's edge of canals formed by deposited silt.

Biennial—A plant that completes its life cycle in two years. The first year the seed germinates and the plant produces leaves, roots, and stores food. The second year it flowers and produces fruits and seeds.

Bioassay—The qualitative or quantitative determination of a substance by response measurements of treated living organisms as compared to measurement on nontreated, check, or standard living organisms.

Biological Control or Biocontrol—Controlling a pest by its natural enemies, including competitive plants; these may already occur in the area or be introduced.

Broadleaf Plants—Basically classified as dicotyledons. Plants have two cotyledon leaves in the seedling stage; true leaves are broad and have netlike or reticulate veins.

Brush Control—Control of woody plants.

Carcinogen—A substance capable of producing cancer.

Carrier—A gas, liquid, or solid substance used to dilute, propel, or suspend a herbicide during its application.

cfs—Cubic feet per second.

Chlorosis—Loss of green color in foliage followed by yellowing of the tissue.

Chronic Toxicity—Results produced in test animals exposed for long periods to chemicals.

Combustible—Will burn when near an open flame or spark.

Compatible—Mixable in the formulation or in the spray tank for application together in the same carrier without undesirably altering the separate effects of components.

Concentration—The amount of active ingredient or herbicide in a quantity of diluent expressed as percent, lb/gal, etc.

Contact Herbicide—A herbicide that is phytotoxic by contact with plant tissue rather than as a result of translocation.

Contaminate—To alter or render a material unfit for a specified use by allowing the pesticide to come into contact with it.

Control—May not mean eradication, but reduction of the weed problem to a point where it does not cause economic damage.

Crown—The point where the stem and root join in a seed plant.

Cuticle—Waxy, fatty material that covers plant surfaces such as leaves.

Cut-Surface Application—Treatments applied to frills or girdles that have been made through the bark into the wood of a tree.

Deciduous Plants—Those plants which are perennial in habit but lose their leaves during winter.

Deflocculating Agent—A material added to suspension to prevent particles from clumping together and settling out of spray tanks.

Defoliant or Defoliator—Any substance or mixture of substances for which the primary use is to cause the leaves or foliage to drop from a plant.

Degradation—The process by which a chemical is decomposed or broken down into less complex compounds or elements.

Deoxygenation—Depletion of oxygen.

Dermal Toxicity—Measures the amount of a pesticide or poisonous material that can be absorbed through the skin of animals to produce toxic symptoms.

Desiccant—Any substance or mixture of substances used to accelerate the drying of plant tissue.

Detergent—Primarly used as a cleaning agent. It is often used as a wetting agent to reduce surface tension of spray droplets.

Dewatered Ditch—A drained ditch.

Dicot (Dicotyledon)—A plant that has two seed leaves or cotyledons; broadleaf plants.

Diluent—Any gas, liquid or solid material used to reduce the concentration of an active ingredient in a formulation.

Directed Application—Precise application to a specific area or plant organ such as to a row or bed or to the lower leaves and stems of plants.

Dispersing Agent—A material that reduces the cohesive forces between similar particles.

Dissolve—Refers to getting solids into solutions.

Dormancy—State of inhibited germination of seeds or growth of plant organs. A state of suspended development.

Dose (Rate)—The terms are the same; however, rate is preferred. Refers to the amount of active ingredient applied to a unit area regardless of percentage of chemical in the carrier.

Drift—The movement of airborne particles by air motion or wind away from the intended target area.

Early Postemergence—Applied after emergence during the cotyledonary growth phase of crop or weed seedlings.

Efficacy—Capacity for serving to produce effects; effectiveness.

Emergence—The act by germinating seedlings of breaking through the soil surface.

Emersed Plant—A rooted or anchored aquatic plant adapted to grow with most of its leafstem tissue above the water surface and not lowering or rising with the water level.

Emetic—A material used to cause vomiting to rid stomach of poisonous compounds.

Emulsifiable Concentrate (ec)—A concentrated herbicide formulation containing organic solvents and adjuvants to facilitate emulsification with water.

Emulsifier—A surface active substance which promotes the suspension of one liquid in another.

Emulsion—The suspension of one liquid as a minute globule in another liquid (for example, oil dispersed in water).

Epidermis—The outer cellular tissue of an animal or plant.

Epinasty—More rapid growth on the upper surface of a plant organ or part (especially leaves) causing it to bend downward.

Erosion—Wear away by wind or water.

Ester—A compound formed by reaction of an acid and an alcohol accompanied by the loss of water formed during the reaction.

Filler—A diluent in the powdered form.

Flag Stage—Stage of growth of cereals and other grasses at which the sheath and leaf have been produced from which the head will emerge.

Floating Plant—A free-floating or anchored aquatic plant adapted to growth with most of its vegetative tissue at or above the water surface and lowering or rising with the water level.

Foliar Application—Application of a herbicide to the leaves or foliage of plants.

Formulation—A mixture containing the active pesticide, the carrier, diluents, and other additives required to make the material ready for application.

Freeboard—Distance above water level.

gpa—Gallons per acre.

Gradient—Steps or progress in the rate of growth (plant) or development (seed).

Granule or Granular—A dry formulation of herbicide in which the active ingredient is impregnated on small particles of carrier such as clay or ground-up corncobs.

Grass—Botanically, any plant of the *Gramineae* family. Grasses are characterized by narrow leaves with parallel veins; by leaves composed of blade, sheath, and ligule; by jointed stems and fibrous roots; and by inconspicuous flowers usually arranged in spikelets.

Growth Regulator—A substance used for controlling or modifying plant growth processes without appreciable phytotoxic effect at the dosage applied.

Habitat—Environment (place) where plant grows naturally.

Hard Water—Generally defined as water containing 332 ppm of calcium carbonate. Water that contains certain minerals, usually calcium and magnesium sulfates, chlorides, or carbonates, in solution in sufficient amounts to cause a curd or precipitate instead of a lather when soap is added. Very hard water may cause precipitates in some herbicide sprays.

Hazard—The probability that injury or detrimental effects will result if a substance is not used properly.

Hazard Ratio—The relationship of the degree of risk.

Herbaceous Plant—A vascular plant that does not develop persistent woody tissue above ground.

Herbicide—A chemical used for killing plants or severely interrupting their normal growth processes.

High Volume Sprays—Spray applications of more than 60 gallons per acre volume.

Hormone—A naturally occurring substance in plants that controls growth or other physiological processes. It is used with reference to certain man-made chemicals that regulate or affect growth activity.

Hydrosoil—Soil at bottom of the body of water. Soil-water interface at the bottom of the body of water.

Incorporate Into Soil—The mixing of a herbicide into the soil, generally by mechanical means.

Inert Ingredient—That part of compound without toxic or killing properties, sometimes called the carrier.

Inhibit—To hold in check or stop.

Integrated Control—Utilizes multiple approaches for pest control, giving consideration to minimum pesticide usage.

Invert Emulsion—The suspension of minute water droplets in a continuous oil phase.

Ionic Surfactant—One that ionizes or dissociates in water.

Jointing Stage—When the internodes of grass stems are elongating.

Label—All written, printed, or graphic matter on or attached to pesticide containers as required by law.

Lactation—To secrete milk.

Late Postemergence—Applied after the specified crop or weeds are well established.

Lateral Movement—Chemical movement in a plant or in a soil to the side or horizontal movement in the roots or soil layer.

Layby Application—Applied with or after the last cultivation of a crop.

LC_{50}—Means of expressing the lethal concentrations of a compound. It is a statistical estimate of the dosage necessary to kill 50% of a test animal population, usually expressed in ppm.

LD_{50}—Means of expressing the dosage necessary to kill 50% of a test animal population. It is expressed in weight of the chemical (mg) per unit of body weight (kg).

Leaching—The downward movement of a substance in solution through the soil.

Leaf Blade—The flat portion of a leaf.

Low-Volatile Ester—An ester compound with a high molecular weight and a low vapor pressure such as butoxy-ethanol, iso-octyl, or propylene glycol butyl ether ester.

Low-volume Spray—A spray application of 5 to 20 gallons per acre.

Marginal Plants—Those plants growing near shoreline.

Marl—A calcium carbonate deposit on algae.

Miscible Liquids—Two or more liquids capable of being mixed, which will remain mixed under normal conditions.

Moncot—A seed plant having a single cotyledon (monocotyledon) or leaf; includes grasses, corn, and lilies.

Mutagen—A compound having the property to induce mutations.

Necrosis—Localized death of living tissue (as, for example, following desiccation, browning, and loss of function).

Node—Region of plant stem where leaf or leaves are attached.

Non-ionic Surfactant—Chemically inert.

Nonselective Herbicide—A chemical that is generally toxic to plants without regard to species (may be a function of dosage, method of application, etc.).

Noxious Weed—A weed specified by law as being especially undesirable, troublesome, and difficult to control. Definition will vary according to legal interpretations.

Oral Toxicity—Toxicity of a compound when it is ingested.

Overall Treatment—Uniform application over the entire area.

Overtop Application—Uniform over the top of transplanted or growing plants such as by airplane or raised spray boom of ground rigs. A broadcast application above the plant canopy.

Pellet—A dry formulation of herbicide and other components in discrete particles usually larger than 10 cubic millimeters.

Penetrant—Wetting agents that enhance the ability of a liquid to enter into the pores of a substrate.

Perennial—A plant that lives for more than two years.

Persistent Herbicide—A herbicide which, when applied at the recommended rate, will harm susceptible crops planted in normal rotation after harvesting the treated crop, or which interferes with regrowth of native vegetation in noncrop sites.

Pesticide—Any substance or mixtures of substances used to control or kill insects, rodents, weeds, fungi, and other pests.

Pesticide Tolerance—The amount of pesticide residue which may legally remain in or on a food crop.

Photic Zone—Zone where light is sufficient for plant growth.

Photosynthesis—The manufacture of simple sugars by green plants utilizing light as the energy source.

Phylogenetic—Origin and evolutionary developments of plants.

Phytoplankton—Microscopic plant life living suspended in water.

Phytotoxic—Injurious or toxic to plants.

Postemergence (poe)—After emergence of the specified weed or planted crop.

Postharvest—Application of a pesticide to the soil or plant after crops have been harvested.

Potable Water—Drinkable water.

Preemergence (pre)—Prior to the emergence of the specified weed or planted crop.

Preemergence Incorporated—Applied after seeding and incorporated in the soil above the seed.

Preplanting Application—Applied on the soil surface before seeding or transplanting.

Preplanting Soil Incorporated (ppi)—Applied and tilled into the soil before seeding or transplanting.

psi—Pounds per square inch.

Pubescent—In reference to hair on plants.

Quiescent—Quiet, still, inactive.

Rate—The amount of active ingredient or acid equivalent applied per unit area or other treatment unit.

Registered—Pesticides that have been approved for use by the Environmental Protection Agency.

Residual—To have continued killing effect over a period of time.

Residue—The amount of pesticide that is on or in the crop at the time an analysis is made.

Residue Tolerance—The amount of pesticide residue which may legally remain in or on a food crop.

Resistance—The ability of an organism to suppress or retard the injurious effects of a pesticide.

Rhizome—Underground root-like stem that produces roots and leafy shoots.

Seed—The part of a flowering plant that typically contains the embryo with its protective coat and stored food and will develop into a new plant if sown.

Seedling Stage—Early stage of plant growth, within a few days to a few weeks after seed germination and emergence.

Selective Herbicide—A chemical that is more toxic to some plant species than to others (may be a function of dosage or mode of application).

Silty Water—Water clouded with very small particles of clay, silt, and sand.

Soil Application—Applied primarily to the soil surface rather than to vegetation.

Soil Injection—Placement of the herbicide beneath the soil surface with a minimum mixing or stirring of the soil as with an injection blade, knife, or tine.

Soil Layered—Placement of the herbicide in a discrete horizontal zone under a lifted or tilled layer of soil.

Soil Persistence—Refers to the length of time that a herbicide application on or in the soil remains effective.

Soil Residual—A herbicide that prevents the growth of plants when present in the soil. Soil residual effects may be temporary or relatively permanent.

Soil Sterilant—See Soil Residual.

Solubility—The amount of a substance which will dissolve in a given amount of liquid at a specific temperature.

Soluble Solid—A dry herbicide formulation that is soluble in the carrier liquid.

Solvent—A liquid such as water or oil used to dissolve other material such as herbicides.

Spore—A reproductive body of bacteria; algae, mosses, and ferns.

Spot Treatment—The application of a herbicide to a selected individual area; usually defined as less than 10% of a field or given area.

Spray Drift—The movement of airborne spray particles from the intended area of application.

Spreading Agent—A substance to improve the wetting, spreading, or possibly the adhesive properties of a spray.

Static Water—Pond, lake, or reservoir water that has little or no inflow or outflow.

Stolon—The above-ground runners or slender stems that develop roots and shoots and new plants at the tips or nodes.

Stunting—In reference to plant, the retarding effect of growth and development.

Subacute Toxicity—Results produced in test animals by long-term exposure to repeated doses or concentrations of a substance.

Submersed Plant—An aquatic plant adapted to grow with most all of its vegetative tissue below the water surface.

Surface Tension—A property of liquids related to surface molecular forces, a drop of liquid tends to form an apparent membrane that causes it to ball up rather than spread as a film.

Surfactant—A material which favors or improves the emulsifying, dispersing, spreading, wetting, or other surface modifying properties of liquids.

Surveillance—To keep watch on change in activity, growth, or performance.

Susceptibility—Lack of capacity to tolerate herbicide treatment.

Suspension—Finely divided solid particles dispersed in a solid, liquid, or gas.

Synergism—Complimentary action of different chemicals such that the total effect is greater than the sum of the independent effects.

Systemic—A compound which moves freely within a plant such that application to one area will result in movement to all areas of the plant to exert its effect.

Taxonomy—Science of classification—arrangement according to characteristics.

Teratogen—A compound having the property of causing congenital malformations in the fetus (birth defects).

Terrestrial Plant—A land plant.

Thallus—A nonvascular plant body with distinguishable roots, stems, or leaves.

Tolerance—Capacity to withstand herbicide treatment without marked deviation from normal growth or function.

Topical Application—Treatment of a localized surface site such as a single leaf blade, petiole, or growing point.

Transient—Not permanent; lasting for a short time.

Translocated Herbicide—A herbicide that is moved within the plant. Translocated herbicide may be either phloem mobile or xylem mobile, but the term is frequently used in a more restrictive sense to refer to herbicides that are moved in the phloem.

Translocation—Transfer of food or other materials such as 2,4-D from one part to another in plants (see Systemic).

Tuber—An underground plant storage stem of reserve food; may also be a reproductive organ.

Turbidity—Suspended material in water preventing light penetration.

Turion—A scaly, often thick and fleshy, detached winter bud, by means of which many water plants survive winter.

Vapor Drift—The movement of chemical vapors from the area of application.

Vascular plant—Plants which have specialized food and water conducting cells.

Vigilance—Staying watchful and alert.

Volatile—A compound is volatile when it evaporates or vaporizes (changes from liquid to a gas) at ordinary temperatures on exposure to the air.

Water Dispersible Slurry—A two-phase concentrate that contains solid herbicide suspended in liquid which is capable of suspension in water.

Water Soluble Powder—A finely ground herbicide powder which will dissolve in water.

Weed—A plant growing where it is not desired. Any plant that is a nuisance, hazard, or causes injury to man, animal, or the desired crop.

Weed Control—The process of limiting weed infestations or killing weeds for aesthetic, economic, public health, or other reasons.

Weed Eradication—The elimination of all live plant parts and seeds of a weed from a site.

Wettable Powder (wp)—A finely-divided, dry herbicide formulation that can be suspended readily in water.

Wetting Agent—Substance which serves to reduce interfacial tensions and causes spray solutions or suspensions to make better contact with treated surfaces.

Zooplankton—Microscopic animal life living suspended in water.

A Pacific Northwest Extension Publication

Washington • Oregon • Idaho

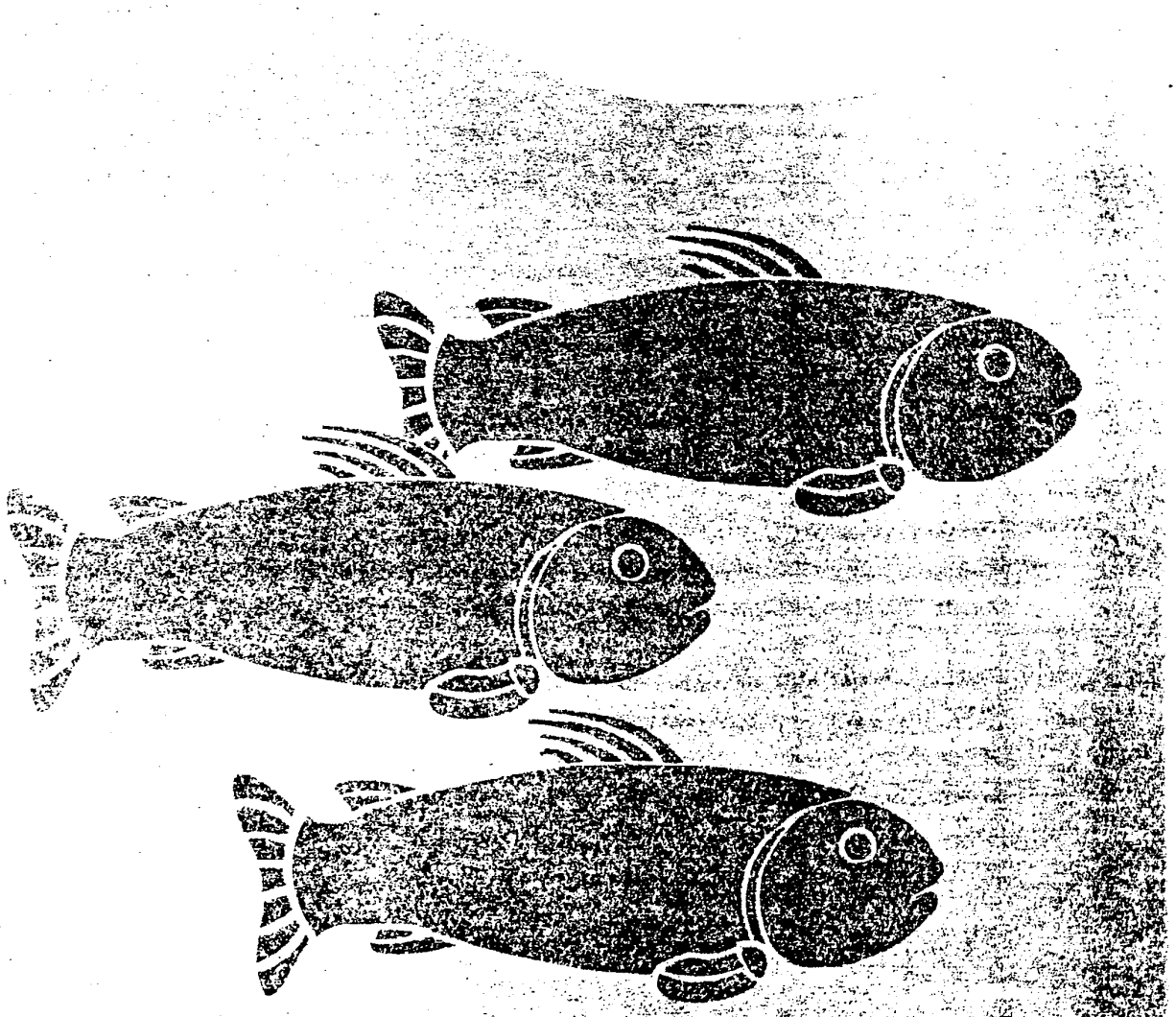
Pacific Northwest cooperative Extension bulletins are joint publications of the three Pacific Northwest states—Washington, Oregon, and Idaho. Similar crops, climate, and topography create a natural geographic unit that crosses state lines. Since 1949, the PNW program has published over 200 titles. Joint writing, editing, and production have prevented duplication of effort, broadened the availability of faculty specialists, and substantially reduced costs for the participating states.

Published and distributed cooperatively in furtherance of the Acts of Congress of May 8 and June 30, 1914, by the University of Idaho Cooperative Extension Service, H.R. Guenthner, director; the Oregon State University Extension Service, Henry A Wadsworth, director; Washington State University Cooperative Extension, J.O. Young, director; and the U.S. Department of Agriculture. The three participating Extension Services offer educational programs, activities, and materials without regard to race, color, religion, national origin, sex, age, or handicap as required by Title VI of the Civil Rights Act of 1964 and Title IX of the Education Amendments of 1972 and are Equal Opportunity employers. Trade names have been used to simplify information; no endorsement is intended. Published October 1982. 50/50/50

B-5085

Texas Agricultural Extension Service
The Texas A&M University System

Guide to Drug, Vaccine, and Pesticide Use in Aquaculture



Prepared by the Federal Joint Subcommittee on Aquaculture

Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Tex

The *Guide to Drug, Vaccine, and Pesticide Use in Aquaculture* is available from the Aquaculture Information Center, National Agricultural Library, U.S. Department of Agriculture, 10301 Baltimore Blvd., Rm. 304, Beltsville, MD 20705; 301/504-5558 (telephone) or aic@nalusda.gov (Internet e-mail). The *Guide* is also available from state Cooperative Extension Services, state Sea Grant Marine Advisory Services, and national aquaculture associations.

August 1994

Printed with vegetable-based ink on recycled, recyclable paper.

Guide to Drug, Vaccine, and Pesticide Use in Aquaculture

Prepared by the Federal Joint Subcommittee on Aquaculture,
Working Group on Quality Assurance in Aquaculture Production, in
cooperation with the Extension Service, U.S. Department of Agriculture

Preface

The *Guide to Drug, Vaccine, and Pesticide Use in Aquaculture* has been prepared by the Working Group on Quality Assurance in Aquaculture Production, which was established by the Federal Joint Subcommittee on Aquaculture in November 1990. This publication provides current information on federally regulated drugs, vaccines, and pesticides in aquaculture production and in aquatic sites. Sources of additional information and assistance are also presented.

The Working Group on Quality Assurance in Aquaculture Production provides a national forum for addressing drug, biologic, and pesticide use in aquaculture through education and the coordination of related efforts in government, industry, and academia. The Working Group, chaired by Gary Stefan of the Center for Veterinary Medicine, Food and Drug Administration (FDA), is composed of representatives of the following agencies and organizations:

Federal and State Agencies

National Association of State Aquaculture Coordinators
State Departments of Wildlife and Fisheries
U.S. Department of Agriculture
  Animal and Plant Health Inspection Service
  Cooperative State Research Service
  Extension Service
  Food Safety and Inspection Service
  National Agricultural Library
U.S. Department of Health and Human Services
  Food and Drug Administration
    Center for Food Safety and Applied Nutrition
    Center for Veterinary Medicine
U.S. Department of the Interior
  Fish and Wildlife Service
  National Biological Survey
U.S. Environmental Protection Agency

Trade, Industry, Professional, and Private Organizations

American Feed Industry Association
American Fisheries Society
  Fish Culture Section
  Fish Health Section
American Tilapia Association
American Veterinary Medical Association
Animal Health Institute
Atlantic Coast Shellfish Producers Association
Baitfish Industry
Catfish Farmers of America
Florida Tropical Fish Farms Association
Louisiana Crawfish Farmers Association
Maine Aquaculture Association
Marine Shrimp Industry
National Aquaculture Association
National Aquaculture Council
National Ornamental Goldfish Growers Association, Inc.
Pacific Coast Oyster Growers Association
Striped Bass Growers Association
U.S. Trout Farmers Association
Washington Fish Growers Association

Acknowledgments

The printing of this publication was supported by contributions from the following organizations and agencies:

American Feed Industry Association
American Tilapia Association
Catfish Farmers of America
National Aquaculture Association
National Aquaculture Council
U.S. Department of Agriculture
  Animal and Plant Health Inspection Service
  Cooperative State Research Service
  Extension Service
U.S. Department of Health and Human Services
  Food and Drug Administration
    Center for Food Safety and Applied Nutrition
    Center for Veterinary Medicine
U.S. Department of the Interior
  Fish and Wildlife Service
U.S. Trout Farmers Association

Special appreciation is expressed to Gary Jensen, USDA Extension Service, and Wendell Lorio, Louisiana Cooperative Extension Service, for compiling the *Guide*. The assistance of the following individuals in providing information and obtaining agency approvals and clearances is also acknowledged: Antonio Bravo, Environmental Protection Agency (EPA); Althaea Langston, USDA Animal and Plant Health Inspection Service; Gary Stefan, FDA Center for Veterinary Medicine; and Kim Young, FDA Center for Food Safety and Applied Nutrition. Rosalie Schnick, U.S. National Biological Survey, contributed valuable comments and suggestions. Marjorie Harter, editorial consultant; Frances Gould, Louisiana Cooperative Extension Service; and Tracy Martin, USDA Extension Service are acknowledged for their efforts in the development of the *Guide*.

The following persons are recognized for their critical review of this publication:

B.T. Alford
Nathan Birnbaum
Antonio Bravo
Marty Brunson
James Davis
Larry Dorman
John Ewart
Mike Freeze
Susan Homire
Gary Jensen
Kenneth Kasweck
Althaea Langston
George Lewis
Wendell Lorio
Brian Lynch
John R. MacMillan
Joe McCraren
Hugh Mitchell
Joseph Morris
George Nardi
John Nickum
Paul Norton
Paul Olin
Bradley Powers
Robert Ringer
Rosalie Schnick
Darrell Scovell
R. Oneal Smitherman
Gary Stefan
Curt Stutzman
Steve Sundlof
Pete Taylor
Hugh Warren
Curry Woods III
Kim Young

Appreciation is also expressed to James Davis, Texas Agricultural Extension Service, and Edna Smith, Department of Agricultural Communications, The Texas A&M University System, who provided valuable assistance in the printing of the *Guide*.

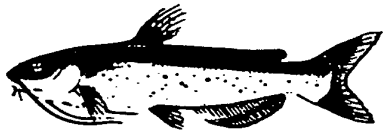
Contents

Introduction

The aquaculture industry in the United States has grown considerably in recent years and is now recognized as a significant supplier of food products for U.S. consumers. Aquaculture also provides aquatic stocks for recreational fishing, the restoration of threatened and endangered species, and wild stock enhancement, as well as for the bait, aquarium, and ornamental fish trades. In order to ensure the safety of aquatic food products, the integrity of the environment, the safety of target animals, and the safety of persons who administer various compounds, it is critical that all regulated aquaculture products be used correctly and responsibly.

Another important consideration is the implementation of aquacultural quality assurance programs. These industry-developed and driven programs are essential for U.S. producers and the entire U.S. aquaculture industry, regardless of type of system, location, size of operation, and species grown. Private and public aquacultural producers should use best management practices to provide consumers with safe, wholesome food products and to minimize the use of federally regulated products.

On some occasions, various drugs, disinfectants, pesticides, and veterinary biologics are needed to ensure the health, productivity, and well-being of cultured aquatic stocks and to maintain production efficiency. These regulated products must be used in such a manner as to avoid risks to public safety and animal health as well as potential loss of consumer trust.



It is the responsibility of everyone using, prescribing, and/or recommending the use of regulated products to know which products legally can be used under federal, state, and local regulations. Regulated-product uses may vary with different sites, life stages, and conditions.

This *Guide* presents information that can assist U.S. aquacultural producers in providing high-quality, wholesome products. Information is included on drugs, pesticides, vaccines, and other veterinary biologics that currently may be used in commercial or noncommercial aquacultural production.

The reader is encouraged to note the information presented in the Appendixes. Appendix A is concerned with FDA-regulated drugs for use in aquaculture. In Appendix B, EPA-registered pesticides for aquaculture and aquatic sites are listed. USDA-licensed biologics for fish are presented in Appendix C. Readers may find the glossary of common terms listed in Appendix D a handy reference. For sources of further information and assistance, see Appendix E. Appendix F lists sponsors, registrants, licensees, and permittees for the federally regulated products included in the *Guide*.

Although food additives and color additives are used in aquaculture, they are not the focus of this publication. More information on these products may be obtained by contacting governmental agencies or other sources of assistance listed in Appendix E.

Electronic Access

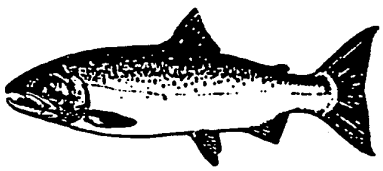
The guide can be accessed electronically via Internet using the Aquaculture Network Information Center (AquaNIC) of the Purdue Cooperative Extension Service and the Purdue University libraries. For details, contact AquaNIC at 317/494-6264 (telephone); 317/494-9347 (fax); or lswann@hub.ansc.purdue.edu (Internet e-mail).

Updating the *Guide*

New information on the regulatory status of products listed in the *Guide* will be provided biennially. To facilitate the updating process, it is suggested that this publication be bound in a three-ring binder.

As updated information becomes available, replacement pages will be distributed. Each new page should be inserted into the binder to replace the former one. The date of each original page appears just above the page number. Replacement pages will also be dated appropriately.

The electronic version of the *Guide* will be updated as changes occur. Individuals wishing updates on specific products may also contact the Food Animal Residue Avoidance Databank (FARAD) Regional Access Centers listed in Appendix E.



Regulatory Agencies

Several federal and state agencies are involved in regulating the aquacultural use of drugs, vaccines, pesticides, and other products. Each federal agency has specific responsibilities, mandated by Congress, to regulate the products under its respective jurisdiction.

U.S. Food and Drug Administration

The Food and Drug Administration is responsible for ensuring the safety, wholesomeness, and proper labeling of food products; ensuring the safety and effectiveness of human and animal drugs; and protecting consumers from economic fraud. The Federal Food, Drug, and Cosmetic Act (FFDCA), the basic food and drug law of the United States, includes provisions for regulating the manufacture, distribution, and use of new animal drugs and animal feed. This law applies to public agencies and organizations as well as to private industry.

FDA's regulatory programs are intended to ensure compliance with existing laws. Enforcement activities include actions to correct and prevent violations, remove illegal products or goods from the market, and punish offenders. The testing of domestic and imported aquacultural products for drug and pesticide residues is part of these enforcement activities. The range of enforcement action includes warning letters, seizures, injunctions, and criminal prosecution. FDA's field offices are responsible for initiating and recommending regulatory action. These field offices use guidance provided by FDA headquarters, including the various FDA Centers, to determine whether violations have occurred and, if so, what enforcement action is warranted.

Center for Veterinary Medicine

FDA's Center for Veterinary Medicine (CVM) regulates the manufacture, distribution, and use of animal drugs. CVM is responsible for ensuring that drugs used in food-producing animals are safe and effective and that food products derived from treated animals are free from potentially harmful residues.

CVM approves new animal drugs based on data provided by a sponsor (usually a drug company). To be approved, an animal drug must be effective for the claim on the label and safe when used as directed for (1) treated animals; (2) persons administering treatment; (3) the environment, including nontarget organisms; and (4) consumers. CVM establishes tolerances and withdrawal periods as needed for all drugs approved for use in food-producing animals. CVM has the authority to grant investigational new animal drug (INAD) exemptions so that data can be generated to support the approval of a new animal drug.

Center for Food Safety and Applied Nutrition

FDA's Center for Food Safety and Applied Nutrition (CFSAN) conducts research on and develops standards for the composition, quality, nutrition, labeling, and safety of food, food additives, and color additives. The Center's responsibilities include domestic and imported seafood inspection and the development of seafood policies, standards, and programs, along with seafood research and educational activities. One ongoing program involves the annual pesticide and contaminant sampling of food items, including domestic and imported aquacultural products. CFSAN also reviews and approves industry petitions for the safe use of food and color additives. The Center's Office of Seafood has proposed mandatory seafood inspection regulations for the nation's seafood processors and seafood importers based on Hazard Analysis Critical Control Points (HACCP) principles. This is important for producers because the first critical control point is the quality of the raw product.

U.S. Environmental Protection Agency

The Environmental Protection Agency is responsible for registering or licensing all pesticides used in the United States under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). FIFRA requires that EPA register pesticides for specific uses, provided that the use does not pose an unreasonable risk to human health or the environment. Any pesticide sold or distributed in the United States must be registered by EPA. Places or establishments where pesticides are produced or formulated are also subject to registration.

In addition, EPA sets tolerances or maximum legal limits for pesticide residues in food commodities and animal feed under the Federal Food, Drug, and Cosmetic Act. The purpose of the tolerance program is to ensure that consumers are not exposed to harmful pesticide residues in food.

EPA is required by law to reregister those pesticides registered prior to 1984 in order to reflect changing registration standards that are critical to the protection of human health and the environment. Products regarded as pesticides include algicides, disinfectants, fish toxicants, and herbicides.

Animal and Plant Health Inspection Service

The Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture regulates all veterinary biologics produced in, shipped into, or exported from the United States. This includes vaccines, nondrug biological therapeutants, and test kits for the diagnosis of disease.

It is unlawful to prepare, sell, barter, or exchange worthless, contaminated, dangerous, or harmful veterinary biologics or to ship unlicensed veterinary biologics for experimental use in animals.

States may impose additional requirements on the use of veterinary biologics. For example, APHIS requires that conditional state approval for distribution of products be obtained before APHIS authorizes field trials with experimental products or before a conditionally licensed product is marketed in the state.

An extensive inspection program involves the monitoring of manufacturing site activities; the testing and release of product batches; and the monitoring of veterinary biologics after licensing to ensure that they are pure, safe, potent, and effective. Every batch of a product produced in the United States or offered for importation is tested by the manufacturer. In addition, samples are sent to APHIS, and each batch is subject to general and/or specific testing by APHIS to ensure that high quality is maintained.

Interagency Jurisdiction

FDA and EPA have some areas of mutual regulatory responsibility. A memorandum of understanding sets forth the responsibilities of each agency under FFDCA and FIFRA. The memorandum also provides guidance in the area of aquaculture, particularly as to which agency has jurisdiction over a particular substance for its intended use.

EPA has jurisdiction over disinfectants, sanitizers, and aquatic treatments used solely for the control of algae or bacterial slime and over any other aquatic treatments used solely for pest control that do not include claims for control of parasites or diseases of fish. EPA or a delegated state regulatory agency also regulates the National Pollutant Discharge Elimination System (NPDES) permit, which allows the discharge of drugs or pesticides into receiving waters.

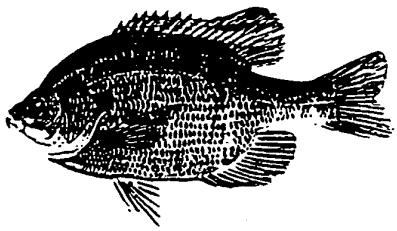
FDA has jurisdiction over new animal drugs, including products intended to treat or prevent parasites or diseases of fish, anesthetize aquatic species, and alter the sex or regulate the reproduction of aquatic species. FDA has taken the position that if a pesticide registered by EPA for aquaculture or aquatic site use is being used properly (i.e., the labeled conditions in fact exist in the facility or site at the time the pesticide is used, and the compound is not misused under FIFRA), FDA will not object to that proper use even though the pesticide may have a secondary therapeutic benefit.

State Regulatory Agencies

State Departments of Agriculture or other designated state agencies may also register federally approved pesticides to permit their legal distribution and sale within a state or territory. States may have additional regulatory requirements, including additional data and/or additional restrictions on use and licensing. These requirements can affect the distribution and use of pesticides that are purchased from a distributor in one state for intended use in another. States can also issue Experimental Use Permits for a pesticide with an EPA-approved state plan and can provide registration for additional uses of federally registered pesticides to meet special local needs.

Some states license or impose additional regulations on the use of certain veterinary biologics. Some states may not allow the use of specific products or may require that they be administered only by licensed veterinarians. States also participate in the approval of field trials of veterinary biologics in their respective jurisdictions and in the experimental use of certain veterinary biologics.

The use of a drug under an investigational new animal drug (INAD) exemption may require approval by a state agency to comply with any local, state, and/or regional EPA discharge regulations. Discharge approval is intended to ensure that the possible impacts of a discharge (effluent) containing a specific compound or its residues are addressed.



Use of Federally Regulated Products

The proper use of regulated products in aquacultural production, handling, and processing promotes human, target organism, and environmental safety; ensures to the greatest extent possible the effectiveness of the products used; reduces overuse, expense, and possible undesirable side effects; and prevents illegal residues in edible products available for human consumption. Food safety and quality are critical factors that influence the long-term development and economic competitiveness of all food production.

Public perception of the safety of food is also very important. Through the proper use of regulated products, the U.S. aquaculture industry can benefit while ensuring public trust and consumer confidence in the safety of U.S. aquacultural products in domestic and international markets.

Safety Considerations

Producers need to establish systems and adopt controls in production and processing that ensure the proper use of regulated products. Producers should evaluate the need for the products carefully and should use them on a schedule to maximize product effectiveness and minimize the amount of the product used. They should also keep detailed chronological records of treatment and of the amounts of the product used.

Users should not mix different regulated products unless this is specifically recommended on the product label. Combining products can have many—mostly undesirable—effects. One or both products can be inactivated, and chemical reactions can produce harmful gases or other reaction products and by-products—some of them toxic.

Applicators and persons near treatment areas can be affected by various regulated products through contact, exposure to evaporated material in the air, or exposure to dusts or aerosols. Treated waters or airborne drift can carry

restricted products to distant locations, where the products may affect nontarget organisms and sites.

Accidental self-injection of some veterinary biologics and injectable drugs can cause local tissue reactions, allergic reactions, or infections. Use of common sense and strict compliance with product label directions can minimize undesirable effects in humans, nontarget plants and animals, and the environment. Seek professional advice when in doubt.

The Product Label

Always read and understand the product label before using any compound. Label directions and information are important for two reasons. First, they describe the conditions of use under which the product can be expected to be effective and safe. Second, labels for approved products describe uses allowed by law. Any departure from the directions and conditions on the product label or on special state labels could mean a violation of law.

The product label and package inserts provided with regulated products present information on proper storage, mixing, dosage, and administration; date of expiration; diluting or reconstituting the product; safe disposal of the unused product and product containers; and withdrawal times. Pesticide labels list precautionary statements on environmental, physical, and chemical hazards. Pesticide toxicity is identified by signal words on the product label. The terms "danger" and "poison" are used with the most toxic products, whereas "warning" and "caution" are associated with those that are less toxic. The label also identifies restricted use pesticides (RUP).

Prescribed aquatic-use information is usually not found on the product labels of those substances determined by FDA to be unapproved new animal drugs of low regulatory priority (LRP). These compounds are listed in Appendix A (Table 2), as are the specific treatment rates and uses allowed by FDA. Generally, LRP substances are not marketed specifically for aquaculture use.

Economic Considerations

Drugs, pesticides, and vaccines are used to control or prevent specific diseases, water quality conditions, and pest (e.g., weed) or stress problems. **These treatments should be used only when needed.** Each treatment has an economic value in terms of treatment cost and expected economic benefit. The proper use of regulated products, some of which are quite costly, can be important in preventing significant economic losses. Such losses are more likely to occur if the actual problem is incorrectly diagnosed, if precautions for treatment are ignored, or if treatments are improperly applied.

The use of best management practices in aquatic animal husbandry and water quality maintenance can reduce the use of regulated products and thereby increase profitability. Higher production based on increased dependence on chemicals does not necessarily mean higher profits. Such short-term goals may lead to long-term problems.

Using regulated products at less than the concentrations or dosages specified on the label can cause the treatment to be ineffective or only partially effective. For example, water quality may not be sufficiently improved, pests may not be controlled, vaccines may not protect adequately, and resistant strains of disease organisms may develop.

Using these compounds at concentrations or in dosages greater than those specified on the label (overdosing or overtreating) wastes the product and can cause unwanted side effects, including stress and toxicity problems in aquatic stocks and nontarget organisms as well as environmental damage. Persons applying regulated products should recognize their legal responsibility for any harm to nontarget aquatic and nonaquatic species and for off-site damage.

Options for Proper Drug Use

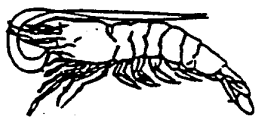
According to the Federal Food, Drug, and Cosmetic Act, a drug is defined as an article that is intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease in man or other animals; an article (other than food) intended to affect the structure or any function of the body of man or other animals; or an article that is recognized in official drug compendia. (See Appendix D.) A new animal drug is a drug intended for animals that is not generally recognized by qualified experts as safe and effective for the uses recommended on the label. **New animal drugs are considered adulterated, and therefore in violation of the law, unless they have been approved by FDA or are the subject of an INAD exemption.**

At present, no drugs used in aquaculture are considered by FDA to be generally recognized as safe (GRAS) or effective (GRAE) for their proposed uses. For a drug to be classified as GRAS or GRAE, general recognition by experts must be supported by published scientific studies that meet strict FDA standards.

There are several options for properly obtaining and using drugs and chemicals:

1. FDA-approved new animal drugs. A limited number of new animal drugs are currently approved by FDA for use in food-producing aquatic species. Each drug is approved for specific species, for specific disease conditions, and at specific dosages. Refer to Appendix A (Table 1) for a listing of these approved drugs.

2. Investigational new animal drugs. These drugs are used under an investigational new animal drug exemption. INAD exemptions are granted by FDA CVM to permit the purchase, shipment, and use of an unapproved new animal drug



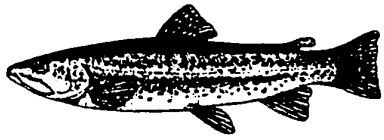
for investigational purposes. INAD exemptions are granted with the expectation that meaningful data will be generated to support a new animal drug approval.

Numerous requirements must be met for the establishment and maintenance of aquaculture INADs. There are two types of INADs: standard and compassionate. Aquaculture INADs, most of which are compassionate, consist of two types: routine and emergency (see Appendix D). A compassionate INAD exemption is used in cases in which the aquatic animal's health is of primary concern.

In certain situations, producers can use unapproved drugs as clinical investigators (under a compassionate INAD exemption), subject to FDA authorization. In these cases, producer facilities are used to conduct closely monitored clinical field trials. Producers are thus enabled not only to supply important information to contribute toward the approval of a new animal drug, but also to use unapproved drugs for emergency situations and for special needs in cases in which approved new animal drugs are not available.

FDA reviews protocols, authorizes specific conditions of use, and closely monitors any drug use under an INAD exemption. An application to renew this type of exemption is required each year. Data recording and reporting are required under the INAD exemption in order to support the approval of a new animal drug or an extension of approval for new uses of the drug.

3. Unapproved new animal drugs of low regulatory priority. Neither an approved new animal drug application (NADA) nor an INAD exemption is required for drugs in this category. Although FDA is not aware of safety prob-



lems associated with the specific uses of these substances, their uses have not been shown to be safe and effective in well-controlled scientific studies. Regulatory action is unlikely if an appropriate grade is used, good management practices are followed, and local environmental requirements are met. (See Appendix A, Table 2.)

4. Extra-label use of an approved new animal drug. Extra-label drug use refers to the actual or intended use of an approved new animal drug in a manner that is not in accordance with the approved label directions. This includes, but is not limited to, use in species or for indications not listed on the label. **Under FDA CVM's extra-label drug use policy, extra-label drugs can be prescribed only by a licensed veterinarian.**

FDA CVM recognizes that there are some diseases for which no drugs are approved. A strict enforcement policy would not allow for the proper treatment of these conditions. CVM's extra-label drug use policy (*Compliance Policy Guide, 7125.06*) states that licensed veterinarians may consider extra-label drug use in treating food-producing animals if the health of animals is immediately threatened and if suffering or death would result from failure to treat the affected animals. The extra-label policy does not allow the use of drugs to prevent diseases (prophylactic use), improve growth rates, or enhance reproduction or fertility. Spawning hormones cannot be used under the extra-label policy. The veterinarian assumes responsibility for drug safety and efficacy and for potential drug residues in the animal. For further information regarding extra-label drug use, producers should contact their veterinarian.

Use of drugs in a manner other than the options discussed is subject to regulatory action by FDA.

Drugs in Aquaculture Feed

New animal drugs that are added to aquaculture feed are subject to FDA approval and must be specifically approved for use in aquaculture feed. Drugs approved for use in feed, like the drugs approved for administration in other forms, must be safe and effective.

Approved new animal drugs may be mixed in feed only for uses and at levels that are specified in FDA medicated-feed regulations. It is unlawful to add drugs to feed unless the drugs are approved for feed use. For example, producers may not top-dress feed with a water-soluble, over-the-counter antibiotic product.

Some medicated feeds, such as Romet 30, may be manufactured only after FDA has approved a medicated-feed application (*Form FDA 1900*) submitted by the feed manufacturer. This requirement applies whether the producer or a commercial company makes the medicated feed. Neither an approved *Form 1900* nor FDA registration is required for the manufacture of certain other medicated feeds, such as those containing Terramycin. However, those who manufacture such feeds are subject to the regulations covering current good manufacturing practices and drug usage.

Water Treatments

Many of the chemicals used in aquaculture are applied directly to water. The federal agency (either FDA or EPA) with jurisdiction over chemicals applied to the water is determined by the intended use of the product.

Fish and other aquatic species are exposed to any compound present in the water. An off-flavor is an example of a condition that can develop when fish are exposed to certain compounds—even those found naturally in water.

Although some products may be beneficial when applied to aquaculture systems at low concentrations, they may also act as irritants or even become toxic at higher concentrations. The improper use or application of water treatments can cause severe stress, which can lead to an animal disease outbreak or even death. Some compounds can accumulate in the animal and may cause illegal chemical residues in tissues intended for human consumption. Illegal residues can also result from the improper use of products to control weeds or unwanted fish or to alter water quality. To prevent possible fish losses and illegal chemical residues from excessive treatment levels, always read and strictly follow product label directions.

Recordkeeping

Recordkeeping is essential for any aquaculture business and is a critical element of quality assurance programs. A good recordkeeping system helps producers keep track of specific treatments and their results with identifiable, known populations or stocks of aquatic animals, as well as the specific water and land areas involved.

Good records provide a basis for sound, cost-effective management decisions. The treatment status of animals, ponds, and other areas is known at all times. Records are needed to determine dosage rates and certify withdrawal times. Processors may require records to demonstrate that all drugs and chemicals have been used properly. Federal seafood processing inspection regulations may also require such recordkeeping. Records provide valuable evidence and protection in liability cases.

Accurate recordkeeping is required for any producer using an INAD exemption in clinical field trials. In case of crop loss resulting from a natural disaster, proper records are necessary for eligibility and possible compensation under federal programs. Lenders may require that production input and output records be kept for at least 2 years.

New pesticide recordkeeping regulations for farmers went into effect in 1993. The regulations require that private as well as commercial users of restricted use pesticides keep records of the use of these compounds. No recordkeeping is required for general use pesticides, which do not have the restricted use pesticide designation. The records must indicate the date of use, the product name, the EPA product registration number, the size of the area treated, and the amount of the product used on the site as well as the name and license number of the applicator. Records must be kept for 2 years from the date of application.

Check with your county agricultural Extension office for recordkeeping help and recordkeeping requirements, such as those for restricted use pesticides. Assistance is also available for other farm recordkeeping systems.

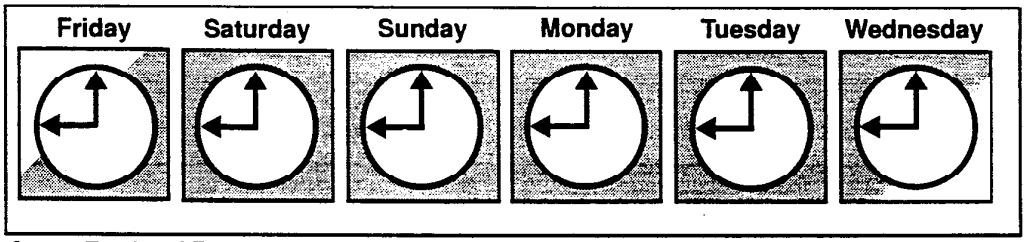
Calculating Withdrawal Times

Product withdrawal times must be observed to ensure that a product used in an aquatic site or on animals does not exceed legal tolerance levels in the animal tissue. Using proper withdrawal times helps to ensure that products reaching consumers are safe and wholesome.

All federally approved products list any specific required withdrawal times. Withdrawal information is found on the product label, package insert, or feed tag. An exception to withdrawal requirements is made for products used in an extra-label manner. Extra-label use may require the same or a different withdrawal time from that listed on the label, depending on the species, treatment, and other conditions. Withdrawal times for the extra-label use of an approved product are not listed on the label and must be determined by the prescribing licensed veterinarian.

Withdrawal times are usually reported as a specific number of days. Each withdrawal day is a full 24 hours, starting from the last time an animal receives or is exposed to a drug, pesticide, or vaccine. For example, a treatment with a product that has a 5-day withdrawal time is completed at 9:00 a.m. on Friday (see Figure 1). At 9:00 a.m. on Saturday, the treated animals have completed their first withdrawal day. The fifth withdrawal day will end at 9:00 a.m. on Wednesday. Waiting restrictions may apply not only to the slaughter time for treated aquaculture stocks but also to treated water used for swimming, livestock watering, crop or turf irrigation, a potable drinking supply, or other purposes.

Figure 1. Product Withdrawal Times



Source: Food and Drug Administration.

Storage, Handling, Mixing, and Disposal

Always follow label directions for storing, handling, mixing, diluting, reconstituting, and disposing of regulated products and their containers. This preserves the activity and quality of the product and helps prevent misuse, damaging effects on plants and animals, human injury, and environmental contamination.

Disinfectants, pesticides, and most drugs should be stored in a locked cabinet in a dry, well-ventilated utility area located away from children, animals, food, feed, and living areas. Some drugs and veterinary biologics require refrigerated storage; other products require storage in a freezer or at room temperature. All disinfectants, pesticides, drugs, and veterinary biologics should be stored away from bright light, because light can cause inactivation or deterioration of the product. Most of these compounds should be stored in a dark area, or at least in a closed carton.

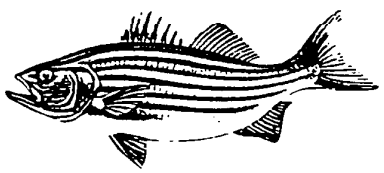
Regulated products should be stored in their original containers, with the original label left attached to the container. Dampness in storage areas can cause paper packages to deteriorate, metal containers to rust, and metal and glass containers to lose their labels. Disinfectants, pesticides, and drugs should not be stored where flooding is possible or in sites where they might spill or leak into the environment. High-temperature storage (above 80° or 90° F) can cause excessive pressure in and bursting of sealed containers. Exposure to high temperatures can also result in product deterioration, shortened shelf-life, premature inactivity, and inactivation.

Proper mixing, diluting, and reconstituting are essential for the effectiveness of products requiring such steps as well as for reasons of safety. Powders may be harmful or toxic if they are inhaled as dusts; fumes and evaporating ingredients may also be harmful or toxic. Improper dilution may cause the concentration or dosage administered to be too great or too small. Incomplete mixing can cause variations in the concentration or dosage applied or administered, with uneven effects ranging from ineffectiveness to overdose and toxicity. Some veterinary biologics are supplied with accompanying diluents that are necessary for reconstitution and the proper concentration of materials.

The use of any pesticide (and some other regulated products) requires adequate protection from exposure. Users should always read the product label for information on recommended personal protective equipment. Common-sense precautions should be followed, such as wearing gloves, long-sleeved shirts and long pants, socks, shoes or boots, a hat and goggles, protective glasses, and/or a face shield. Some pesticides may require use of a respirator. Persons mixing and/or applying pesticides, or working in an area where pesticides are being applied or have recently been applied, should shower and wash their clothes after actual or possible exposure.

As emphasized earlier, **users should not mix different regulated products unless this is specifically recommended on the label**. The combining of products can have many—mostly undesirable—effects. One or both products can be inactivated, and chemical reactions can produce harmful gases or other reaction products and by-products, some of them toxic. Following appropriate precautions can prevent accidental poisoning from pesticide contact with bare skin or from the inhalation of fumes or dust.

The pesticide label provides important product-specific information on mixing, diluting, storage, and disposal, as well as on first aid in the event of accidental poisoning. Material Safety Data Sheets, provided by product manufacturers upon request, are a source of additional information on safety precautions.



It is important that unused portions of a regulated product and empty containers be disposed of properly. The best approach is to purchase only the amount of material that will be used within a reasonable time period and to use all of the product for its intended purpose. Empty containers must be disposed of, however, and often a quantity of the product is left over. Product labels provide instructions for safe disposal; these instructions should be followed. Improper disposal can result in product toxicity, environmental contamination, and liability problems.

Contact the county agricultural Extension office in your area for further information on product storage and handling and on local regulations for the disposal of pesticide containers.

Pesticide Applicator Certification

Restricted use pesticides can be purchased and applied only by a Certified Pesticide Applicator or under a Certified Applicator's direct supervision. Certification includes both "private" (mostly farmers) and "commercial" applicators. Pesticide certification programs are offered through state Departments of Agriculture and state Cooperative Extension Services and through EPA regional offices.

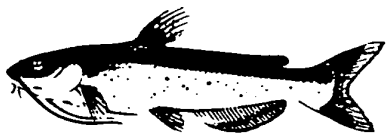
Fish toxicants listed in Appendix B (Table 2) provide examples of restricted use pesticides. For information on pesticide use, training programs, and certification requirements in any state, contact your county agricultural Extension office.

Importation of Regulated Products

To be imported, a new animal drug must either be approved by FDA or be intended for investigational use under an INAD exemption. Without approval or proper identification as an investigational new animal drug, a compound can be refused entry into the United States. If the drug is imported under false pretenses, the responsible person(s) involved are subject to enforcement action by FDA as well as the U.S. Customs Service.

Veterinary biologics may be imported only under a permit, and veterinary biologics for sale must meet U.S. requirements. To ensure compliance, manufacturing specifications are monitored, and manufacturing facilities are inspected. Manufacturers of veterinary biologics for experimental use or field testing must meet strict permit requirements and must have provided extensive information to APHIS prior to the issuance of a permit. Permits are not issued for preventive products if the organism in question does not exist in this country.

Regulations also require that before a person in a state or foreign country can sell or distribute any pesticide in the United States, he or she must obtain a registration from EPA. Pesticides produced by foreign manufacturers and imported into the United States must comply with all requirements applicable to domestic manufacturers. In addition, the regulations require an importer to submit to EPA a Notice of Arrival of Pesticides and Devices for review and for a determination as to whether the shipment should be sampled and/or permitted entry into the United States.



Tips for Use of Regulated Products

1. **Obtain a diagnosis** of the problem(s) before applying any treatment.

2. **Seek professional advice** if ever in doubt as to when or how to use regulated products.

3. **Use regulated products only for those species and indications listed on the product label,** unless extra-label use is specifically prescribed by a licensed veterinarian.

4. **Read the product label carefully.**

5. **Use the proper dosage, amount, or concentration** for the species, area, and/or specific condition.

6. **Use the correct method and route of application or administration,** whether by spraying vegetation, water treatment (ponds, tanks, or immersion), injection, or oral administration (used with medicated feed and some biologics).

7. **Calculate withdrawal times accurately.**

8. **Identify treated populations or stocks** with clear markings of production and holding units.

9. **Do not use antibiotic drugs or medicated feed for disease prevention** unless they are specifically approved for that use.

10. **Do not substitute unlabeled or generic products** for trade-name products that are labeled and approved for aquaculture or aquatic site uses.

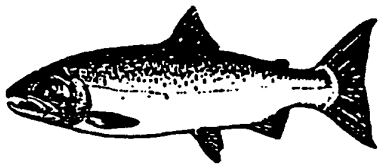
11. **Keep accurate records.**

12. **Consider the environmental impact** of discharging treated water, including possible effects on nontarget organisms.

13. **Adopt a producer quality assurance program or a Hazard Analysis Critical Control Points program** that provides guidelines for preventing tissue residue violations and for producing high-quality, wholesome products for consumer use.

14. **Be aware of personal safety measures** and proper procedures for farm workers and pesticide applicators who handle or apply regulated products.

15. **Consider the economic consequences,** both short- and long-term, of treatment before using a regulated product.



Appendixes

Federally Regulated Products and Diagnostic Test Kits

The legal status of regulated products approved, registered, or licensed for aquaculture or for aquatic site uses can change for a variety of reasons, such as new or terminated approvals, reregistrations, or new data. The product listings in this section are based on May 1994 data provided by the Food and Animal Residue Avoidance Databank. For updated information on the status of a regulated product, contact any FARAD Regional Access Center or other organizations and agencies listed in Appendix E.

It is especially important to avoid introducing potentially harmful chemicals into the food chain through improper product use. This can occur not only through direct exposure of food fish to such chemicals, but also through indirect means (for example, livestock contact with contaminated water).

Some products may be approved only for use with nonfood fish or for certain life stages of aquatic species. The use of products may also be restricted to specified aquatic sites (for example, drainage ditches) rather than sites containing aquatic food species.

It is the user's responsibility to know whether a particular product is approved for an intended use in aquaculture. Refer to the product label for information on dosages, conditions of use, withdrawal times, and other instructions for product use. Be sure to read the entire label.

Appendix A

FDA-Regulated Drugs for Aquaculture

The drugs listed in this section include FDA-approved new animal drugs as well as unapproved new animal drugs of low regulatory priority for FDA. Federal approval of new animal drugs applies only to specific products that are the subject of approved new animal drug applications.

Active ingredients from sources other than the listed sponsors are not considered approved new animal drugs. Such products cannot legally be marketed or used.

States and other jurisdictions may impose additional regulatory requirements and restrictions on FDA-regulated drugs for aquaculture.

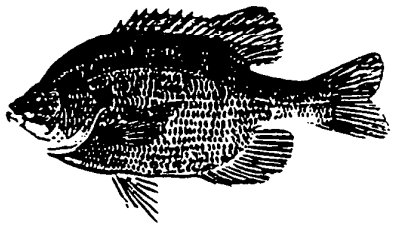


Table 1. FDA-Approved New Animal Drugs

Trade Name	*NADA Number*	*Sponsor*	*Active Drug*	*Species*	*Uses*
Finquel (MS-222)	42-427	Argent Chemical Laboratories, Inc.	Tricaine methanesulfonate	Ictaluridae, Salmonidae, Esocidae, and Percidae. (In other fish and cold-blooded animals, the drug should be limited to hatchery or laboratory use.)	Temporary immobilization (anesthetic)
Formalin-F	137-687	Natchez Animal Supply	Formalin	Trout, salmon, catfish, largemouth bass, and bluegill	Control of external protozoa and monogenetic trematodes
				Salmon, trout, and esocid eggs	Control of fungi of the family Saprolegniacae
Paracide-F	140-831	Argent Chemical Laboratories, Inc.	Formalin	Trout, salmon, catfish, largemouth bass, and bluegill	Control of external protozoa and monogenetic trematodes
				Salmon, trout, and esocid eggs	Control of fungi of the family Saprolegniacae
Parasite-S	140-989	Western Chemical Inc.	Formalin	Trout, salmon, catfish, largemouth bass, and bluegill	Control of external protozoa and monogenetic trematodes
				Salmon, trout, and esocid eggs	Control of fungi of the family Saprolegniacae
				Cultured penaeid shrimp	Control of external protozoan parasites

(continued)

Table 1. FDA-Approved New Animal Drugs, continued

Trade Name	*NADA Number*	*Sponsor*	*Active Drug*	*Species*	*Uses*
Romet 30	125-933	Hoffmann-LaRoche, Inc.	Sulfadimethoxine and ormetoprim	Catfish	Control of enteric septicemia
				Salmonids	Control of furunculosis
Sulfamerazine in Fish Grade[1]	033-950	American Cyanamid Company	Sulfamerazine	Rainbow trout, brook trout, and brown trout	Control of furunculosis
Terramycin For Fish	038-439	Pfizer, Inc.	Oxytetracycline	Catfish	Control of bacterial hemorrhagic septicemia and pseudomonas disease
				Lobster	Control of gaffkemia
				Salmonids	Control of ulcer disease, furunculosis, bacterial hemorrhagic septicemia, and pseudomonas disease
				Pacific salmon	Marking of skeletal tissue

[1]According to sponsor, this drug is not presently being distributed.

Table 2. Unapproved New Animal Drugs of Low Regulatory Priority for FDA[1]

Common Name	*Permitted Use*
Acetic acid	Used as a dip at a concentration of 1,000-2,000 milligrams per liter (mg/L) for 1-10 minutes as a parasiticide for fish.
Calcium chloride	Used to increase water calcium concentration to ensure proper egg hardening. Dosages used would be those necessary to raise calcium concentration to 10-20 mg/L calcium carbonate. Also used to increase water hardness up to 150 mg/L to aid in maintenance of osmotic balance in fish by preventing electrolyte loss.
Calcium oxide	Used as an external protozoacide for fingerling to adult fish at a concentration of 2,000 mg/L for 5 seconds.
Carbon dioxide gas	Used for anesthetic purposes in cold, cool, and warmwater fish.
Fuller's earth	Used to reduce the adhesiveness of fish eggs in order to improve hatchability.
Garlic (whole)	Used for control of helminth and sea lice infestations in marine salmonids at all life stages.
Hydrogen peroxide	Used at 250-500 mg/L to control fungi on all species and at all life stages of fish, including eggs.
Ice	Used to reduce metabolic rate of fish during transport.
Magnesium sulfate (Epsom salts)	Used to treat external monogenetic trematode infestations and external crustacean infestations in fish at all life stages. Used in freshwater species. Fish are immersed in a solution of 30,000 mg/L magnesium sulfate and 7,000 mg/L sodium chloride for 5-10 minutes.
Onion (whole)	Used to treat external crustacean parasites and to deter sea lice from infesting external surface of fish at all life stages.
Papain	Used as a 0.2% solution in removing the gelatinous matrix of fish egg masses in order to improve hatchability and decrease the incidence of disease.

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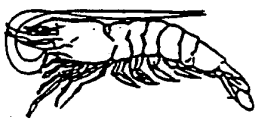

Table 2. Unapproved New Animal Drugs of Low Regulatory Priority for FDA,[1] continued

Common Name	*Permitted Use*
Potassium chloride	Used as an aid in osmoregulation to relieve stress and prevent shock. Dosages used would be those necessary to increase chloride ion concentration to 10-2,000 mg/L.
Povidone iodine compounds	Used as a fish egg disinfectant at rates of 50 mg/L for 30 minutes during water hardening and 100 mg/L solution for 10 minutes after water hardening.
Sodium bicarbonate (baking soda)	Used at 142-642 mg/L for 5 minutes as a means of introducing carbon dioxide into the water to anesthetize fish.
Sodium chloride (salt)	Used as a 0.5-1% solution for an indefinite period as an osmoregulatory aid for the relief of stress and prevention of shock. Used as a 3% solution for 10-30 minutes as a parasiticide.
Sodium sulfite	Used as a 15% solution for 5-8 minutes to treat eggs in order to improve hatchability.
Urea and tannic acid	Used to denature the adhesive component of fish eggs at concentrations of 15 g urea and 20 g NaCl/5 L of water for approximately 6 minutes, followed by a separate solution of 0.75 g tannic acid/5 L of water for an additional 6 minutes. These amounts will treat approximately 400,000 eggs.

[1]FDA is unlikely to object at present to the use of these low regulatory priority substances if the following conditions are met:

1. The drugs are used for the prescribed indications, including species and life stage where specified.
2. The drugs are used at the prescribed dosages.
3. The drugs are used according to good management practices.
4. The product is of an appropriate grade for use in food animals.
5. An adverse effect on the environment is unlikely.

FDA's enforcement position on the use of these substances should be considered neither an approval nor an affirmation of their safety and effectiveness. Based on information available in the future, FDA may take a different position on their use.

Classification of substances as new animal drugs of low regulatory priority does not exempt facilities from complying with other federal, state, and local environmental requirements. For example, facilities using these substances would still be required to comply with National Pollutant Discharge Elimination System requirements.

Appendix B

EPA-Registered Pesticides for Aquaculture/Aquatic Sites

The trade names and common names listed in this section are registered by EPA for application and use in aquatic sites. Before purchasing or using any commercial product, read the label carefully to make certain that the product is approved for its intended use. **It is the responsibility of the applicator to use the proper compound(s) and to read and follow label directions.**

The following tables include general information rather than detailed instructions on the specific conditions of use for each product. A number of restrictions may apply to the use of some compounds. For example, a pesticide or fish toxicant **may be approved only for use with nonfood fish species** or for certain sites, such as drainage ditches. In some cases, a specified waiting time must elapse before treated water can be used for crop irrigation, livestock watering, or other purposes.

Restricted use products such as rotenone fish toxicants can be purchased only by a Certified Pesticide Applicator and can be applied only by a Certified Pesticide Applicator or under a certified applicator's direct supervision. To identify such products, look for the "restricted use pesticide" designation on the label.

The following explanations are necessary to understand the product listings in this section. The products are subject to manufacturers' name changes as well as inevitable lag time between EPA registration and updates of the EPA PESTBANK database from which the listings are derived. Some products are not currently being distributed despite the fact that their EPA registrations are still active. EPA is currently reregistering all pesticides registered prior to 1984. In many cases, this process requires new data. Consequently, some product registrations are not being maintained.

Disinfectants are not included in this listing. Refer to FARAD for current information on EPA-registered disinfectants used to sanitize or disinfect facilities and equipment.

Always refer to the product label for details on recommended or approved treatment rates and usage as well as for any restrictions on use. Updated information on the status of regulated products may be obtained by contacting the Food Animal Residue Avoidance Databank or other sources of information and assistance listed in Appendix E.

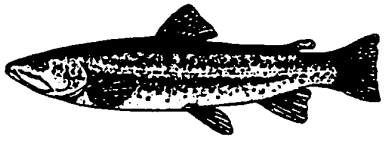

Table 1. EPA-Registered Algicides

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Common Name: Chelated Copper			
Algae-Rhap CU-7 Liquid	55146-42	Agtrol Chemical Products	Broad-range algicide for use in farm and fish ponds, lakes, and fish hatcheries.
Algimycin PLL	7364-10	Great Lakes Biochemical Co., Inc.	Algicide for small, ornamental ponds and pools.
Algimycin PLL-C	7364-9	Great Lakes Biochemical Co., Inc.	Algicide for pools, lakes, ponds, and similar waters.
Aquatrine Algaecide[1]	8959-33	Applied Biochemists, Inc.	Algicide for fish and shrimp aquaculture facilities (e.g., ponds, tanks, and raceways).
Copper Control	47677-1	Argent Chemical Laboratories, Inc.	Algicide for fish ponds and hatcheries.
Copper Control Granular	47677-8	Argent Chemical Laboratories, Inc.	Algicide for fish ponds and hatcheries.
Cutrine Algaecide[1]	8959-1	Applied Biochemists, Inc.	Algicide for fish ponds, lakes, and hatcheries.

[1]According to registrant, this product is not presently being distributed.

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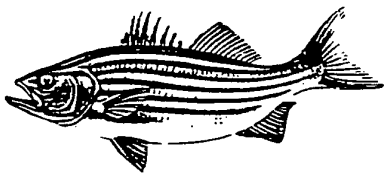

Table 1. EPA-Registered Algicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Chelated Copper, continued			
Cutrine Granular Algaecide[1]	8959-3	Applied Biochemists, Inc.	Granular algicide for control of Chara and Nitella in fish ponds, lakes, and hatcheries.
Cutrine Plus Algaecide/Herbicide	8959-10	Applied Biochemists, Inc.	Algicide/herbicide for fish ponds, lakes, and hatcheries.
Cutrine Plus II Algaecide[1]	8959-20	Applied Biochemists, Inc.	Algicide for fish ponds, lakes, and hatcheries.
Cutrine Plus Granular Algaecide	8959-12	Applied Biochemists, Inc.	Algicide (especially for Chara and Nitella) in fish ponds and hatcheries.
Komeen Aquatic Herbicide	1812-312	Griffin Corporation	Algicide for freshwater lakes and fish hatcheries.
K-Tea Algaecide	1812-307	Griffin Corporation	Algicide for freshwater lakes and fish hatcheries.
SCI-62 Algicide/ Bactericide	61943-1	Chem-A-Co, Inc.	Algicide/bactericide for lakes and ponds.
Slow Release Algimycin PLL Concentrate	7364-26	Great Lakes Biochemical Co., Inc.	Algicide for ponds, lakes; especially for Chara and Nitella.
Stocktrine II	8959-34	Applied Biochemists, Inc.	For algae control in stock-watering tanks, troughs, and ponds.

[1]According to registrant, this product is not presently being distributed.

(continued)

Table 1. EPA-Registered Algicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Common Name: Copper			
Alco Cutrine Algaecide RTU[1]	5481-140	Amvac Chemical Corporation	Algicide for fish ponds, lakes, and hatcheries.
Common Name: Copper as Elemental			
Algon Algaecide	11474-15	Sungro Chemicals, Inc.	Algicide for use in lakes, fish ponds, and fish hatcheries.
A & V-70 Granular Algaecide[1]	12014-5	A & V Inc.	Granular algicide for lakes and ponds.
AV-70 Plus Algicide	12014-10	A & V Inc.	Algicide for fish ponds, lakes, and hatcheries.
Common Name: Copper Sulfate Pentahydrate			
Blue Viking Kocide Copper Sulfate Star Glow Powder	1812-314	Griffin Corporation	Algicide for freshwater lakes and ponds.
Blue Viking Kocide Copper Sulfate Star Shine Crystals	1812-313	Griffin Corporation	Algicide for lakes, ponds, and impounded water.

[1]According to registrant, this product is not presently being distributed.

(continued)

Table 1. EPA-Registered Algicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Copper Sulfate Pentahydrate, continued			
Calco Copper Sulfate[1]	39295-8	Calabrian International Corporation	For algae control in impounded water, lakes, and ponds.
Copper Sulfate Crystals	56576-1	Chem One Corporation	For algae control in impounded lakes and ponds.
Copper Sulfate Large Crystals	1109-1	Boliden Intertrade, Inc.	For algae control in lakes and ponds.
Copper Sulfate Medium Crystals	1109-19	Boliden Intertrade, Inc.	For algae control in lakes and ponds.
Copper Sulfate Pentahydrate Algicide/Herbicide	35896-19	C.P. Chemicals	Algicide/herbicide for controlled-outflow lakes and ponds.
Copper Sulfate Pentahydrate Instant Powder[1]	1278-5	Phelps Dodge Refining Corporation	Algicide for root and fungus control.
Copper Sulfate Powder	1109-7	Boliden Intertrade, Inc.	For algae control in lakes and ponds.
Copper Sulfate Superfine Crystals	1109-32	Boliden Intertrade, Inc.	For algae control in lakes and ponds.
Dionne Root Eliminator	34797-39	Qualis, Inc.	For algae control in lakes and ponds.

[1]According to registrant, this product is not presently being distributed.

(continued)

Table 1. EPA-Registered Algicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Copper Sulfate Pentahydrate, continued			
Granular Crystals Copper Sulfate	1109-20	Boliden Intertrade, Inc.	For algae control in lakes and ponds.
Kocide Copper Sulfate Pentahydrate Crystals[1]	1812-304	Griffin Corporation	Algicide for lakes and ponds.
Root Killer RK-11[1]	8123-117	Frank Miller & Sons, Inc.	For algae control in impounded water (e.g., lakes, ponds).
SA-50 Brand Copper Sulfate Granular Crystals	829-210	Southern Agricultural Insecticides, Inc.	For algae control in ponds.
Snow Crystals Copper Sulfate	1109-21	Boliden Intertrade, Inc.	For algae control in lakes and ponds.
Triangle Brand Copper Sulfate Crystals	1278-8	Phelps Dodge Refining Corporation	For algae control in impounded water, lakes, ponds, and reservoirs.

[1]According to registrant, this product is not presently being distributed.

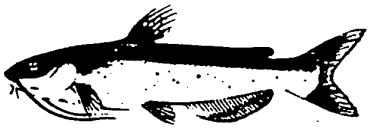

Table 2. EPA-Registered Fish Toxicants

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Common Name: Antimycin			
Fintrol Concentrate	39096-2	Aquabiotics Corporation	Fish toxicant/piscicide
Common Name: Cube Resins/Rotenone			
Chem Fish Regular	1439-157	Tifa Limited	Fish toxicant/piscicide
Chem Fish Synergized	1439-159	Tifa Limited	Fish toxicant/piscicide
Finely Ground Cube Powder	6458-6	Foreign Domestic Chemicals Corp.	Fish toxicant/piscicide
Fish-Tox-5	769-309	Sureco, Inc.	Fish toxicant/piscicide
Martin's Rotenone Powder	299-227	C.J. Martin Company	Fish toxicant/piscicide
Noxfish Fish Toxicant Liquid Emulsifiable	432-172	Roussel Uclaf Corporation	Fish toxicant/piscicide
Nusyn-Noxfish Fish Toxicant	432-550	Roussel Uclaf Corporation	Fish toxicant/piscicide
Pearson's 5% Rotenone Wettable Powder	19713-316	Drexel Chemical Company	Fish toxicant/piscicide
Powdered Cube	769-414	Sureco, Inc.	Fish toxicant/piscicide

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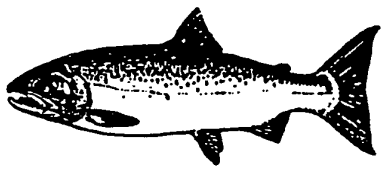

Table 2. EPA-Registered Fish Toxicants, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Cube Resins/Rotenone, continued			
Prentox Prenfish Toxicant	655-422	Prentiss Incorporated	Fish toxicant/piscicide
Prentox Rotenone Fish Toxicant Powder	655-691	Prentiss Incorporated	Fish toxicant/piscicide
Prentox Sympren Fish Toxicant	655-421	Prentiss Incorporated	Fish toxicant/piscicide
Rotenone 5% Fish Toxicant Powder	47677-4	Argent Chemical Laboratories, Inc.	Fish toxicant/piscicide
Rotenone 5% Liquid Emulsifiable	47677-3	Argent Chemical Laboratories, Inc.	Fish toxicant/piscicide

Table 3. EPA-Registered Herbicides

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Common Name: Acid Blue and Acid Yellow			
Aquashade	33068-1	Applied Biochemists, Inc.	Aquatic plant control through selective light filtering; usable in controlled-outflow natural and man-made lakes and ponds.
Common Name: Dichlobenil			
Acme Norosac 10G	2217-679	PBI/Gordon Corporation	Aquatic weed control for lakes and ponds.
Casoron 10-G	400-178	Uniroyal Chemical Company, Inc.	Aquatic herbicide for submerged weeds in nonflowing water.
Common Name: Diquat Dibromide			
Aqua Clear	2155-63	I. Schneid, Inc.	Contact, nonselective vegetation killer for aquatic weeds.
Aqua-Kil Plus	37347-6	Uni-Chem Corporation of Florida	Contact, nonselective vegetation killer to control aquatic weeds and grasses.
Aquaquat	5080-4	Aquacide Company	Liquid weed killer for lakes and ponds with controlled outflow.

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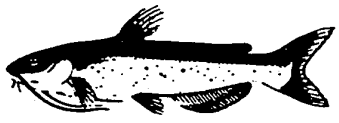

Table 3. EPA-Registered Herbicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Diquat Dibromide, continued			
Aquatic Weed Killer[1]	10292-13	Venus Laboratories, Inc.	For the elimination of aquatic weeds and algae.
Clean-Up	2155-64	I. Schneid, Inc.	Algicide and nonselective weed killer.
Conkill	10088-13	Athea Laboratories, Inc.	Contact, nonselective herbicide for aquatic weeds.
Contact Vegetation Controller	8123-102	Frank Miller & Sons, Inc.	For the control of aquatic vegetation.
Diquat-L Weed Killer 1/5 Lb.	34704-589	Platte Chemical Co., Inc.	Aquatic weed killer for controlled-outflow lakes and ponds.
Formula 268 Aqua-Quat	1685-64	State Chemical Manufacturing Company	Aquatic weed killer in lakes, ponds, and impounded water.
Ind-Sol 435	10827-78	Chemical Specialties, Inc.	Nonselective weed killer for controlled-outflow lakes and ponds.
Miller Liquid Vegetation Control	8123-37	Frank Miller & Sons, Inc.	For the control of aquatic vegetation.
No. 401 Water Plant Killer	11515-29	ABC Chemical Corporation	Contact, nonselective weed killer for aquatic weeds.

[1]According to registrant, this product is not presently being distributed.

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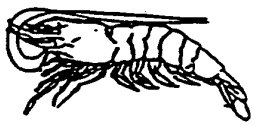

Table 3. EPA-Registered Herbicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Diquat Dibromide, continued			
Norkem 500	5197-37	Systems General, Inc.	Contact, nonselective weed killer for controlled-outflow lakes and ponds.
P.D.Q. Non-Selective Weed Killer	2155-43	I. Schneid, Inc.	Algicide and non-selective weed killer.
Reward	10182-353	Zeneca Professional Products	Aquatic and noncrop herbicide.
Selig's Mister Trim No. 10	491-201	Selig Chemical Industries	Contact, nonselective vegetation killer for aquatic weeds.
Watrol	1769-174	NCH Corporation	Herbicide for aquatic weeds.
Weedtrine D Aquatic Herbicide	8959-9	Applied Biochemists, Inc.	Aquatic herbicide for still lakes and fish ponds.
Yardman	10663-11	Sentry Chemical Company	Nonselective weed, algae, and aquatic foliage killer.
Common Name: Endothall			
Aquathol Granular Aquatic Herbicide	4581-201	Elf Atochem North America, Inc.	Aquatic herbicide for ponds and lakes.
Aquathol K Aquatic Herbicide	4581-204	Elf Atochem North America, Inc.	Contact aquatic herbicide for lakes and ponds.

(continued)

Table 3. EPA-Registered Herbicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
		Endothall, continued	
Hydrothol 191 Aquatic Algicide and Herbicide	4581-174	Elf Atochem North America, Inc.	Aquatic algicide/herbicide for lakes and ponds.
Hydrothol 191 Granular Aquatic Algicide and Herbicide	4581-172	Elf Atochem North America, Inc.	Aquatic algicide/herbicide for lakes and ponds.
		Common Name: Fluridone	
Sonar A.S.	62719-124	SePRO	Herbicide for the management of aquatic vegetation in freshwater ponds, lakes, and drainage canals.
Sonar SRP	62719-123	SePRO	Herbicide for the management of aquatic vegetation in freshwater ponds, lakes, and drainage canals.
		Common Name: Glyphosate	
Rodeo	524-343	The Agricultural Group of Monsanto Company	Aquatic herbicide for freshwater and brackish water applications.

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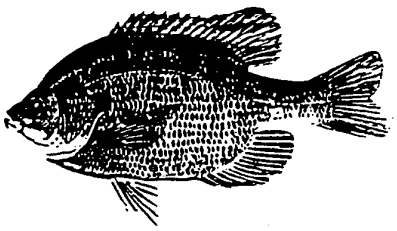

Table 3. EPA-Registered Herbicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Common Name: 2,4-D			
Weed-Rhap A-4D	5905-501	Helena Chemical Company	For control of aquatic weeds in lakes and ponds.
Weed-Rhap A-6D Herbicide	5905-503	Helena Chemical Company	For control of aquatic weeds in lakes and ponds.
Common Name: 2,4-D, Acetic Acid			
A C Aquacide Pellets	5080-2	Aquacide Company	Herbicide for submerged weeds in recreational lakes and ponds. Predominantly for broad-leafed plants.
Common Name: 2,4-D, Butoxyethyl Ester			
Aqua-Kleen	264-109	Rhone-Poulenc Agricultural Co.	For control of aquatic weeds in lakes and ponds.
Navigate	264-109-8959	Applied Biochemists, Inc.[1]	For control of aquatic weeds in lakes and ponds.
Common Name: 2,4-D, Dimethylamine Salt			
Class 40A Phenoxy Herbicide	1381-103	Cenex/Land O'Lakes	For aquatic weeds in lakes and ponds.
Clean Crop Amine 2,4-D Granules[2]	34704-645	Platte Chemical Co., Inc.	Aquatic herbicide for emersed/ submerged weeds.
Clean Crop Amine 6 2,4-D Herbicide	34704-646	Platte Chemical Co., Inc.	Herbicide for lakes and ponds.
Rhodia 2,4-D Gran 20[2]	42750-16	Albaugh	Herbicide for aquatic weeds in lakes and ponds.

[1]Distributor
[2]According to registrant, this product is not presently being distributed.

(continued)

Table 3. EPA-Registered Herbicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
2,4-D, Dimethylamine Salt, continued			
Riverdale 1D Amine	228-238	Riverdale Chemical Company	For control of broadleaf weeds in ponds.
Riverdale Solution Water Soluble	228-260	Riverdale Chemical Company	For control of aquatic weeds in lakes and ponds.
Riverdale 2,4-D 6 Amine	228-242	Riverdale Chemical Company	For control of aquatic weeds in lakes and ponds.
Riverdale Weedestroy AM-40 Amine Salt	228-145	Riverdale Chemical Company	For control of broadleaf weeds and aquatic weeds in lakes and ponds.
2,4-D Amine 4	9779-263	Terra International, Inc.	For control of water hyacinth in slow-moving waters, lakes, and ponds.
2,4-D Amine 4 Herbicide	42750-19	Albaugh	Herbicide for aquatic weeds in lakes and ponds.
2,4-D Amine 6 Herbicide	42750-21	Albaugh	Herbicide for aquatic weeds in lakes and ponds.
2,4-D 380 Amine Weed Killer	407-430	Imperial, Inc.	Aquatic herbicide for lakes and ponds.
Weedar 64	264-2	Rhone-Poulenc Agricultural Co.	Broadleaf herbicide; toxic to aquatic invertebrates.

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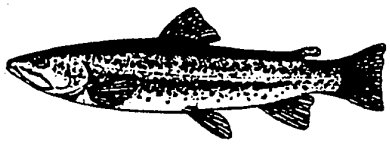


Table 3. EPA-Registered Herbicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
Common Name: 2,4-D, Isooctyl Ester			
Barrage (Weed-Rhap LV-5D Herbicide)	5905-504	Helena Chemical Company	For control of aquatic weeds in lakes and ponds.
Brush-Rhap Low Volatile 4-D Herbicide	5905-498	Helena Chemical Company	For control of aquatic weeds in lakes and ponds.
Riverdale 2,4-D Granules	228-61	Riverdale Chemical Company	For control of broadleaf and certain aquatic weeds.
Riverdale 2,4-D L. V. 4 Ester	228-139	Riverdale Chemical Company	For control of aquatic weeds in lakes and ponds.
Riverdale 2,4-D L. V. 6 Ester	228-95	Riverdale Chemical Company	For control of aquatic weeds in lakes and ponds.
SEE 2,4-D Low Volatile Ester Solventless Herbicide	42750-22	Albaugh	For aquatic weeds in lakes and ponds.
2,4-D LV Ester 4[1]	5905-90	Helena Chemical Company	Selective aquatic herbicide.
2,4-D LV Ester 6[1]	5905-93	Helena Chemical Company	Selective aquatic herbicide.
Visko-Rhap Low Volatile Ester 2D[1]	42750-17	Albaugh	For aquatic weeds in lakes and ponds.

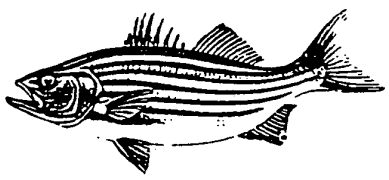
[1]According to registrant, this product is not presently being distributed.

(continued)

Table 3. EPA-Registered Herbicides, continued

Trade Name	*EPA Registration Number*	*Registrant*	*Indications for Use*
2,4-D, Isooctyl Ester, continued			
Weed-Rhap Low Volatile Granular D Herbicide	5905-507	Helena Chemical Company	For control of aquatic weeds in lakes and ponds.
Weed-Rhap LV-4D Herbicide	5905-505	Helena Chemical Company	For control of aquatic weeds in lakes and ponds.
Weed-Rhap LV-6D[1]	5905-508	Helena Chemical Company	For control of aquatic weeds in lakes and ponds.

[1]According to registrant, this product is not presently being distributed.



Appendix C

USDA-Licensed Biologics for Fish

Veterinary biologics are used in the prevention, diagnosis, and treatment of animal diseases. Preventive and therapeutic veterinary biologics act on or in concert with the body's immune system to provide or enhance resistance to disease. Diagnostic veterinary biologics are used to detect the presence of a disease organism or diseased cells as well as to detect immunity in the fish against disease organisms.

Proper storage and administration of veterinary biologics is essential to ensure the maximum effectiveness of the product. Always read label directions and follow them carefully.

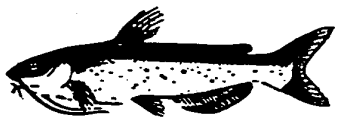


Table 1. Vaccines

Trade Name	*Product Name*	*USDA Product Code*	*Licensee/ Permittee*	*Species*	*Disease*
Autogenous Bacterin	Autogenous Bacterin	2051.00	BioMed, Inc.	Fish	Bacterial diseases
Autogenous Bacterin	Autogenous Bacterin	2051.00	Jerry Zinn[1]	Fish	Bacterial diseases
Biojec 1500	Aeromonas Salmonicida Bacterin	2035.00	BioMed, Inc.	Salmonids	Furunculosis
Biojec 1900	Aeromonas Salmonicida-Vibrio Anguillarum-Salmonicida Bacterin	2137.00	BioMed, Inc.	Salmonids	Furunculosis, vibriosis
Biovax 1100	Yersinia Ruckeri Bacterin	2638.00	Biomed, Inc.	Salmonids	Yersiniosis (enteric red-mouth disease)
Biovax 1150	Yersinia Ruckeri Bacterin	2638.01	Biomed, Inc.	Salmonids	Yersiniosis (enteric red-mouth disease)
Biovax 1200	Vibrio Salmonicida Bacterin	2870.00	BioMed, Inc.	Salmonids	Vibriosis
Biovax 1300	Vibrio Anguil-larum-Ordalii Bacterin	2858.02	BioMed, Inc.	Salmonids	Vibriosis

[1]Permittee for Aqua Health, Ltd. (Canada).

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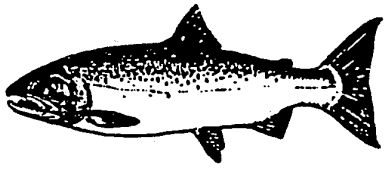


Table 1. Vaccines, continued

Trade Name	*Product Name*	*USDA Product Code*	*Licensee/ Permittee*	*Species*	*Disease*
Biovax 1600	Vibrio Anguillarum-Salmonicida Bacterin	2868.00	BioMed, Inc.	Salmonids	Vibriosis
Biovax 1700	Vibrio Anguillarum-Ordalii-Yersinia Ruckeri Bacterin	2871.00	BioMed, Inc.	Salmonids	Vibriosis, yersiniosis (enteric red-mouth disease)
Ermogen	Yersinia Ruckeri Bacterin	2638.00	Jerry Zinn[1]	Salmonids	Yersiniosis (enteric red-mouth disease)
Escogen	Edwardsiella Ictaluri Bacterin	2637.00	Jerry Zinn[1]	Catfish	Enteric septicemia
Furogen	Aeromonas Salmonicida Bacterin	2035.01	Jerry Zinn[1]	Salmonids	Furunculosis
Vibrogen	Vibrio Anguillarum-Ordalii Bacterin	2858.02	Jerry Zinn[1]	Salmonids	Vibriosis
Vibrogen-2	Vibrio Anguillarum-Ordalii Bacterin	2858.03	Jerry Zinn[1]	Salmonids	Vibriosis

[1]Permittee for Aqua Health, Ltd. (Canada).

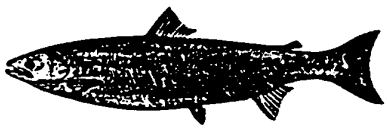
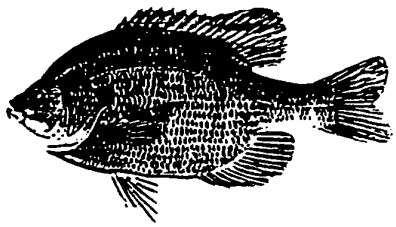


Table 2. Diagnostic Test Kits

Trade Name	*USDA Product Code*	*Licensee*	*Disease Detected*	*Species*	*Use*
K-Dtect	5800.00	DiagXotics, Inc.	Renibacterium salmoninarum (bacterial kidney disease)	Salmonids	Laboratory
KwiK-Dtect	5800.01	DiagXotics, Inc.	Renibacterium salmoninarum (bacterial kidney disease)	Salmonids	Field



Appendix D

Glossary of Common Terms

Active ingredient

In a drug product, the ingredient responsible for the intended effect of the product. In any pesticide product, the component that kills or otherwise controls the target pests. (Pesticides are regulated primarily on the basis of their active ingredients.)

Autogenous bacterin

A bacterin (see below) made by a firm licensed to produce autogenous bacterins from organisms isolated from a particular farm, to be sold to and used on that farm only, and for a specified, limited time only.

Bacterin

A vaccine made from killed bacteria.

Best management practices

Husbandry practices that strive to ensure optimal health, production, and economic performance.

Clinical field trial

A research study of the effectiveness of a compound under actual commercial production conditions; involves strict adherence to FDA or USDA protocols and recordkeeping requirements.

Drug

An article that is intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease in man or other animals; an article (other than food) intended to affect the structure or any function of the body of man or other animals; or an article that is recognized in official drug compendia.

Drug sponsor

An individual or firm seeking FDA approval of a drug product.

Extra-label use

The actual or intended use of an approved new animal drug in a manner that is not in accordance with the approved label directions. Extra-label use is permitted only by or on the prescription of a licensed veterinarian when a valid veterinarian-client-patient relationship exists.

Hazard Analysis Critical Control Points (HACCP)

A systematic approach to hazard identification, assessment, and control that can be used by all concerned to ensure safe, sound, and properly labeled foods.

INAD exemption (standard)

Exemption authorized under the Federal Food, Drug, and Cosmetic Act to permit the shipment of new animal drugs in interstate commerce without an approved new animal drug application. Specifically limits the distribution of unapproved new animal drugs and their use to experts qualified by scientific training and experience to investigate the safety and effectiveness of animal drugs. In order for an individual or firm to obtain and use a new animal drug for clinical investigations, an investigational new animal drug (INAD) exemption for that drug must be granted by the FDA Center for Veterinary Medicine. Standard INAD exemptions typically are sought by pharmaceutical companies.

INAD exemption (emergency compassionate)

A type of compassionate investigational new animal drug exemption that is used for nonpredictable diseases or conditions and is authorized for one site, one disease, one drug, and one emergency INAD use for present disease outbreak only. Involves specific requirements, including data submission along with other information.

INAD exemption (routine compassionate)

A type of investigational new animal drug exemption that allows producers to use an unapproved compound under certain conditions (e.g., an FDA decision that a particular producer qualifies as a clinical investigator) for purposes related to the health or well-being of an animal. Annual renewal applications are required, including data submission along with other information.

Inert ingredient

Ingredient in a drug or pesticide product that does not contribute to the intended activity of the product.

Low regulatory priority (LRP) substance

Unapproved new animal drug for which FDA has a policy of regulatory discretion that allows the use of such a substance without an approved new animal drug application or INAD exemption.

New animal drug

Any drug intended for use in animals other than people, the composition of which is not generally recognized among experts qualified by scientific training and experience as safe and effective for use under the conditions prescribed, recommended, or suggested in its labeling.

New animal drug application (NADA)

An application package submitted to FDA for review that requests the approval of a new animal drug. The application includes sufficient data to establish the safety and effectiveness of the drug product, along with other requirements.

Nontarget organisms

Organisms at which treatment is not aimed but which contact the product and may be affected by it.

Over-the-counter (OTC) drugs

Drugs that have adequate written directions for lay use and are permitted to be sold without a veterinary prescription.

Pest

An insect, rodent, nematode, or weed or any other form of terrestrial or aquatic plant or animal life or virus, fungus, bacteria, or other microorganism that is considered to be an annoyance and that may be injurious to health or to the environment.

Pesticide

Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

Prescription (Rx) drug

An animal drug for which adequate directions for safe and effective use by a lay-person cannot be written and which therefore must be prescribed by a licensed veterinarian. The label bears the statement, "Caution: Federal law restricts this drug to use by or on the order of a licensed veterinarian."

Quality assurance program

A proactive, industry-driven code of production practices, carefully designed to ensure that producers supply a wholesome, safe product to consumers.

Registration

Under the Federal Insecticide, Fungicide, and Rodenticide Act, the formal listing with EPA of a new pesticidal active ingredient prior to its marketing or distribution in intra- or interstate commerce.

Restricted use pesticide (RUP)

A registered pesticide that has been classified for restricted use under the Federal Insecticide, Fungicide, and Rodenticide Act for some or all of its applications because it is toxic and requires special handling. Restricted use pesticides may be applied only by trained, certified applicators or by individuals under their direct supervision and may be utilized only for those uses covered by the certified applicator's certification.

Sponsor (drug)
An individual or company that applies for an INAD exemption to develop data with the intent of seeking a new animal drug approval for the compound used under the INAD exemption.

Target organism
The plant, animal, or microorganism that is treated or at which treatment is aimed.

Tissue residue
The drug, pesticide, or toxic breakdown product remaining in edible tissue after natural or technological processes of removal or degradation have occurred.

Tolerance
The maximum amount of pesticide or drug residue allowed by law to remain in or on a harvested crop or food animal product. EPA sets tolerances for pesticides and FDA sets tolerances for drugs so that treated crops or animals consumed do not pose an unreasonable risk to consumers. Tolerances are set for food-use crops on a per-crop basis. Tolerances are set for animal products on the basis of individual species and tissue (muscle, liver, etc.).

Vaccine
A preparation of killed microorganisms; living attenuated, fully virulent, or related nonvirulent microorganisms; or parts of micro- or macroorganisms that are administered to produce or increase immunity to a particular disease.

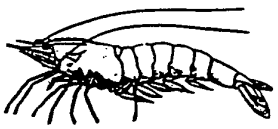
Veterinary biologics
All viruses, serums, toxins, and analogous products of natural or synthetic origin, such as diagnostics, antitoxins, vaccines, and live microorganisms intended for use in the diagnosis, treatment, or prevention of diseases of animals.

Veterinarian-client-patient relationship
Exists when (1) the veterinarian has assumed responsibility for making medical judgments regarding the health of the animals and the need for medical treat-

ment, and the client has agreed to follow the instructions of the veterinarian; (2) there is sufficient knowledge of the animals by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animals (i.e., the veterinarian has recently seen and is personally acquainted with the keeping and care of the animals by virtue of an examination of the animals and/or by medically appropriate and timely visits to the premises where the animals are kept); and (3) the veterinarian is readily available for follow-up in case of adverse reactions or failure of treatment.

Withdrawal time

The minimum required period of time between the last drug treatment of an animal and the slaughter or release of that animal.



Appendix E

Sources of Information and Assistance

A number of resources are available to persons seeking further information about drug, vaccine, and pesticide use in aquaculture. These resources include the following consumer hotlines, federal and state agency contacts, producer quality assurance programs, and organizations.

Consumer Hotlines

APHIS Consumer Hotline: 515/232-5789. The Animal and Plant Health Inspection Service Consumer Hotline can be used to report a problem with a veterinary biologic or diagnostic test kit or to obtain information about biologics.

EPA National Pesticide Telecommunications Network (NPTN) Hotline: 1-800/858-7378. Call this hotline for information on pesticide products; human and animal poisonings; protective equipment; safety; health and environmental effects; and clean-up and disposal procedures.

FDA Office of Seafood Hotline: 1-800/FDA-4010. The hotline can be used to obtain information on the safety of the seafood supply; various publications; and other assistance.

Federal Agency Contacts

U.S. Food and Drug Administration

Information on the drug approval process or on INADs:
Office of New Animal Drug Evaluation
Center for Veterinary Medicine
(HFV-100)
7500 Standish Place
Rockville, MD 20855
301/594-1620

Information on approved drugs, regulations, and policies:
Office of Surveillance and Compliance
Center for Veterinary Medicine
(HFV-200)
7500 Standish Place
Rockville, MD 20855
301/594-1761

Information on seafood standards, safety, and color additives:
Office of Seafood
Center for Food Safety and Applied Nutrition
(HFS-417)
200 C St., SW
Washington, DC 20204
202/254-3995

Information on food additives:
Division of Animal Feeds
Center for Veterinary Medicine
(HFV-220)
7500 Standish Place
Rockville, MD 20855
301/594-1731

USDA Animal and Plant Health Inspection Service

Licensing and program policy information:
Deputy Director
Veterinary Biologics
Animal and Plant Health Inspection Service
Rm. 838, Federal Building
6505 Belcrest Rd.
Hyattsville, MD 20782
301/436-8245

Inspection and enforcement information:
Deputy Director
Veterinary Biologics, Field Operations
Animal and Plant Health Inspection Service
223 S. Walnut Ave.
Ames, IA 50010
515/232-5785

U.S. Environmental Protection Agency

Information on registration requirements, tolerances, and experimental use permits:
Office of Pesticide Programs
Environmental Protection Agency
Registration Division (7505W)
Registration Support Branch
401 M St., SW
Washington, DC 20460
703/308-8340

U.S. Department of the Interior

Information on chemicals and drugs used in aquaculture:
Technical Information Specialist
National Biological Survey
National Fisheries Research Center
P.O. Box 818
LaCrosse, WI 54602-0818
608/781-6200

Information on investigational new animal drugs:
INAD Coordinator
Fish and Wildlife Service
Mailstop 820, Arlington Square
1849 C St., NW
Washington, DC 20240
703/358-1715

Food Animal Residue Avoidance Databank

The Food Animal Residue Avoidance Databank (FARAD) provides information on drugs, pesticides, and other chemicals used in aquaculture. For customized assistance, contact one of the Regional Access Centers listed below.

California

Department of Environmental Toxicology
College of Agriculture and Environmental Sciences
University of California
Davis, CA 95616
916/752-7507
Internet e-mail: farad@ucdavis.edu

North Carolina

College of Veterinary Medicine
North Carolina State University
4700 Hillsborough St.
Raleigh, NC 27606
919/829-4431

Illinois

National Animal Poison Control Center
College of Veterinary Medicine
University of Illinois
1220 Veterinary Medicine Basic Sciences Building
2001 S. Lincoln Ave.
Urbana, IL 61801
217/333-6731

State Agency Contacts

State-level sources of information on aquaculture topics include Cooperative Extension Services; Sea Grant Marine Advisory Services; Departments of Agriculture; and Departments of Natural Resources.

National NADA Coordinator

The National NADA Coordinator for Aquaculture acts as a liaison among various segments of the aquaculture industry and also as a liaison between the industry and FDA. The Coordinator's office serves as a repository for INAD information available to the public. The Coordinator also works with the aquaculture industry to identify data needed for complete data packages to support FDA approval of new animal drugs for aquaculture.

May 2-October 31 of each year:
National NADA Coordinator
9740 SW Bay Shore
Traverse City, MI 49684
616/947-9287

November 1-May 1 of each year:
National NADA Coordinator
625 High Point Drive
Mt. Dora, FL 32757
904/383-2589

Aquaculture Producer Quality Assurance Programs

The following national aquaculture associations either have completed or are in the process of developing industry-driven quality assurance programs. These programs are designed to improve production efficiency and to provide consumers with safe, wholesome, farm-raised aquatic foods.

For further information, contact any of the associations listed below.
American Tilapia Association, Kalona, IA: 319/683-2495
Catfish Farmers of America, Indianola, MS: 601/887-2699
National Aquaculture Association, Shepherdstown, WV: 1-800/626-3301
Striped Bass Growers Association, Columbia, SC: 803/734-2151
U.S. Trout Farmers Association, Shepherdstown, WV: 304/876-6666

Additional Information Sources and References

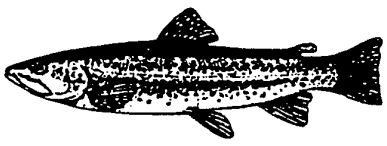
Office of Industry Programs
Center for Veterinary Medicine
U.S. Food and Drug Administration
7500 Standish Place
Rockville, MD 20855
301/443-1544

Office of Prevention, Pesticides and Toxic Substances
U.S. Environmental Protection Agency
401 M St., SW
Washington, DC 20460
202/260-2902

The following publications are available from the EPA Office of Prevention, Pesticides and Toxic Substances: *EPA's Pesticide Programs* (1991); *Citizen's Guide to Pesticides* (1991); *Pesticide Safety for Non-Certified Mixers, Loaders, and Applicators* (1986); and *Pesticide Safety for Farmworkers* (1985).

USDA National Agricultural Library
Aquaculture Information Center
10301 Baltimore Blvd., Rm. 304
Beltsville, MD 20705
301/504-5558

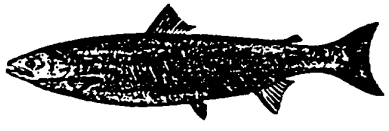
Contact the USDA National Agricultural Library to obtain publications prepared by the Federal Joint Subcommittee on Aquaculture (JSA) and for additional copies of this publication. An especially helpful JSA publication is *Federal Regulation of Drugs, Biologicals, and Chemicals Used in Aquaculture Production* (1992).



Appendix F

Sponsors, Registrants, Licensees, and Permittees for Federally Regulated Products

The following section contains the names and addresses of current sponsors, registrants, licensees, and permittees for federally regulated products. These companies may be contacted for information on product availability as well as for other information related to product use.



A & V Inc.
N62 W22632 Village Drive
Sussex, WI 53089
414/246-6922

ABC Chemical Corporation
14288 Meyers Rd.
Detroit, MI 48227
313/935-1550

The Agricultural Group of
Monsanto Company
800 North Lindbergh Blvd.
St. Louis, MO 63167
314/694-1000

Agtrol Chemical Products
7322 Southwest Freeway
Suite 1400
Houston, TX 77074
713/995-0111

Albaugh
1517 N. Ankeny Blvd.
Suite A
Ankeny, IA 50021
515/964-9444

American Cyanamid Company
Agricultural Research Division
Quaker Bridge & Clarksville Road
P.O. Box 400
Princeton, NJ 08543
609/799-0400

Amvac Chemical Corporation
4100 East Washington Blvd.
Los Angeles, CA 90023
213/264-3910

Applied Biochemists, Inc.
6120 W. Douglas Avenue
Milwaukee, WI 53218
414/464-8450

Aquabiotics Corporation
P.O. Box 10576
Bainbridge Island, WA 98110
206/842-1708

Aquacide Company
1627 9th St.
P.O. Box 10748
White Bear Lake, MN 55110
612/429-6742

Argent Chemical Laboratories, Inc.
8702 152nd Ave., NE
Redmond, WA 98052
206/885-3777

Athea Laboratories, Inc.
7855 N. Faulkner Rd.
P.O. Box 23926
Milwaukee, WI 53224
414/354-6417

Biomed, Inc.
1720 130th Avenue, NE
Bellevue, WA 98005-2203
206/882-0448

Boliden Intertrade, Inc.
3379 Peachtree Rd., NE
Suite 300
Atlanta, GA 30326
404/233-6811

Calabrian International Corporation
15,600 J.F. Kennedy Blvd.
Suite 570
Houston, TX 77032
713/590-5007

Cenex/Land O'Lakes
5500 Cenex Drive
P.O. Box 64089
St. Paul, MN 55164-0089
612/451-5151

Chem-A-Co, Inc.
721 North First St.
Monticello, IN 47960
219/583-6842

Chem One Corporation
P.O. Box 79133
Houston, TX 77279-9133
713/974-1104

Chemical Specialties, Inc.
P.O. Box 312
San Marcos, TX 78666

C.J. Martin Company
P.O. Box 630009
Nacogdoches, TX 75963
409/564-3711

C.P. Chemicals
One Parker Place
Fort Lee, NJ 07024
201/944-6020

DiagXotics, Inc.
27 Cannon Rd.
Wilton, CT 06897
203/762-0279

Drexel Chemical Company
P.O. Box 9306
Memphis, TN 38190
901/774-4370

Elf Atochem North America, Inc.
2000 Market St.
Philadelphia, PA 19102
1-800/225-7788

Foreign Domestic Chemicals Corp.
95 Chestnut Ridge Rd.
Montvale, NJ 07645
201/307-3333

Frank Miller & Sons, Inc.
13831 S. Emerald Ave.
Riverdale, IL 60627
312/468-3500

Great Lakes Biochemical Co., Inc.
6120 West Douglas Ave.
Milwaukee, WI 53218
414/464-1200

Griffin Corporation
P.O. Box 1847
Valdosta, GA 31603
912/242-8635

Helena Chemical Company
6075 Poplar Avenue
Suite 500
Memphis, TN 38119
901/761-0050

Hoffmann-LaRoche, Inc.
340 Kingsland St.
Nutley, NJ 07110
201/235-5000

I. Schneid, Inc.
1429 Fairmont Ave., NW
Atlanta, GA 30318
404/351-4705

Imperial, Inc.
P.O. Box 98
Shenandoah, IA 51601
712/246-2150

NCH Corporation
2727 Chemsearch Blvd.
Irving, TX 75062
Outside Texas: 1-800/527-9921
Within Texas: 1-800/442-7950

Natchez Animal Supply
201 John R. Junkin Dr.
Natchez, MS 39120
601/445-0997

PBI/Gordon Corporation
1217 West 12th St.
P.O. Box 014090
Kansas City, MO 64101-0090
816/421-4070

Pfizer, Inc.
North American Animal
Health Division
1107 South State, Rt. 291
Lee's Summit, MO 64081
816/524-5580

Phelps Dodge Refining Corporation
Phelps Dodge Refinery
P.O. Box 20001
El Paso, TX 79998
915/778-9881

Platte Chemical Co., Inc.
150 South Main St.
Freemont, NE 68025
402/727-8222

Prentiss Incorporated
C.B. 2000
Floral Park, NY 11001
516/326-1919

Qualis, Inc.
4600 Park Avenue
Des Moines, IA 50321
515/243-3000

Rhone-Poulenc Agricultural Co.
P.O. Box 12014
Research Triangle Park, NC 27709
1-800/334-9745

Riverdale Chemical Company
425 West 194th St.
Glenwood, IL 60425
708/754-3330

Roussel Uclaf Corporation
95 Chestnut Ridge Road
Montvale, NJ 07645
201/307-9700

Selig Chemical Industries
P.O. Box 43106
Atlanta, GA 30378
404/691-9220

Sentry Chemical Company
1481 Rock Mountain Blvd.
Stone Mountain, GA 30086
404/934-4242

SePRO
11550 North Meridian St.
Suite 200
Carmel, IN 46032
317/580-8282

Southern Agricultural Insecticides, Inc.
P.O. Box 218
Palmetto, FL 34220
813/722-3285

State Chemical Manufacturing Company
3100 Hamilton Avenue
Cleveland, OH 44114
216/861-7114

Sungro Chemicals, Inc.
P.O. Box 24632
Los Angeles, CA 90024
213/747-4125

Sureco, Inc.
P.O. Box 938
Fort Valley, GA 31030
912/825-3351

Systems General, Inc.
P.O. Box 152170
Irving, TX 75015-2170
Outside Texas: 1-800/527-9921
Within Texas: 1-800/442-7950

Terra International, Inc.
600 Fourth St.
Sioux City, IA 51102-6000
712/277-1340

Tifa Limited
50 Division Avenue
Millington, NJ 07946
908/647-4570

Uni-Chem Corporation of Florida
P.O. Box 6336
Ft. Lauderdale, FL 33310
305/484-1401

Uniroyal Chemical Company, Inc.
74 Amity Rd.
Bethany, CT 06524-3402
203/393-2163

Venus Laboratories, Inc.
P.O. Box 607
855 Lively Blvd.
Wood Dale, IL 60191
708/595-1900

Western Chemical Inc.
1269 Lattimore Rd.
Ferndale, WA 98248
206/384-5898

Zeneca Professional Products
P.O. Box 751
Wilmington, DE 19897
1-800-759-2500

Jerry Zinn
Aqua Health, Ltd.
Rt. 3, P.O. Box 299
Buhl, ID 83316
208/543-5369