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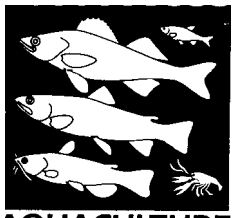

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General Fish Health Management

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AQUACULTURE is the production of fish and shellfish for market under controlled or semi-controlled conditions. For commercial success, an AQUACULTURE operation must maintain fish at densities that greatly exceed those normally found in nature. Under these conditions, fish must not only survive, but grow rapidly. Regardless of the culture system used (e.g., ponds, raceways, reuse systems, cages) it is imperative that the culturist maintain an environment conducive to good fish health.

A wide variety of parasites and pathogens can and do infect fish. Most disease agents are naturally present in low numbers and normally do not cause problems. The natural defense mechanisms of fish (i.e. undamaged skin, mucus covering the skin, and various components of the immune system) keep disease agents in check. However, when fish already crowded in culture operations are further stressed (e.g., by low dissolved oxygen, nutritionally inadequate feeds, excessive handling) their natural disease defense systems may be weakened and the ability of the fish to protect itself against infectious diseases maybe reduced. Disease induced catastrophic mortalities are frequently the result of, and response to, a stressful experience. **Most disease problems can be avoided with proper management.**

Avoidance of Disease

Fish are aquatic animals, they live in the water. Water provides the oxygen they breath, the food they eat, and the means to dispose of their wastes (e.g., carbon dioxide, urine, feces). The quality of the water determines how well the fish will grow and, indeed, if they will even survive. Maintenance of suitable water quality greatly reduces the likelihood of a disease problem. Critical water quality parameters include temperature (particularly sudden and dramatic shifts), dissolved oxygen, pH, alkalinity, hardness, nitrogenous wastes (unionized ammonia, NH_3; nitrites, $N0_2^-$), and toxic substances (e.g., heavy metals, pesticides, carbon dioxide). Many of these parameters are interrelated; for instance, as pH and temperature increase the proportion of Total Ammonia Nitrogen (TAN) in the toxic unionized form (NH_3) increases. Water quality should be monitored frequently and corrective measures initiated if conditions become stressful (e.g., dissolved oxygen below 3 ppm for warm water fishes or 5 ppm for cold water fishes, unionized ammonia above approximately 0.02 ppm, temperature above 210 C for cold water fishes).

Use of a high quality feed provides fish with the nutrients that they need to remain healthy and to grow rapidly. Fish fed a nutritionally complete diet are better able to cope with stress and to resist disease. Culturists should remember that even high quality feeds will deteriorate if improperly stored or kept too long. Feed should be purchased from a reputable supplier, stored in a cool and dry place, and used within 90 days of manufacture.

Light (excessive or rapid changes in intensity), noise and other disturbances can stress fish and should be minimized. Routine maintenance, stocking, and harvest require that fish be handled. When fish are removed and processed (e.g., weighed, transported) they compensate physiologically. To reduce the trauma of handling make sure all necessary materials (e.g., nets, hauling tanks, scales) and adequate personnel are immediately available. Use of salt (O. 1-0.5% by weight in the water, see the following section on *Treatment of Diseased Fish* for precautions), aeration or oxygenation, and anesthetics can reduce the stress associated with handling. Handle the fish gently and for as short a time as possible. If possible, do not handle fish that are already stressed or when environmental conditions are marginal.

Responding to Disease Problems

Regardless of how careful one is, if you culture fish long enough you will inevitably encounter a disease prob-

lem. When a disease problem develops, a quick and effective response is essential. There is no better preparation than to know your fish.

Under routine aquaculture conditions, healthy fish display "normal" behavior. Fish feed vigorously when food is presented or shortly thereafter. In ponds and cages, fish are usually invisible, except when feeding. Therefore, it is important for the aquaculturists to note the feeding behavior of the fish being cultured even when automatic feeders are used. A reduced feeding activity should serve notice to the aquaculturists that immediate further investigation for the cause is warranted. In raceways fish normally swim leisurely, either en masse or singly, depending on the species. Distribution in raceways varies for species, but is usually constant (e.g., some species prefer covered areas and others prefer uncovered areas, some concentrate toward the water inflow and others are more randomly distributed). As a culturist, **you should become familiar with the normal behavior of your fish.** If their behavior changes (e.g., they stop feeding, swim near the water surface, dart or scratch on objects), something has occurred and you need to find out what. The first response to a disease is abnormal behavior; to recognize what is abnormal, you must first be familiar with what is normal.

Routine monitoring of water quality in a production system is imperative. When abnormal behavior is observed, culturists should check their water quality (e.g., dissolved oxygen, nitrogenous wastes, temperature). A sudden change in weather (e.g., a cold front moves through) can cause a change in behavior. If water quality is a problem (e.g., low dissolved oxygen, high unionized ammonia) then corrective measures should be initiated. If abnormal behavior persists for several days or mortalities are observed, culturists should seek professional assistance. Water quality data should be provided to the diagnostic laboratory as well as information concerning the fish in question. The following sections describe what you should do and who you should contact. Become familiar with the process, have the necessary supplies available, and know your diagnostic personnel and where they are located before a problem arises so you can address quickly and effectively the situation before a catastrophic die-off occurs.

Shipping Fish to a Disease Diagnostic Laboratory

Before shipping any fish, telephone your disease diagnostic laboratory (a list of facilities in the northeastern United States is included at the end of this publication). Describe to the laboratory personnel the disease signs that you have observed and determine how they want you to ship your fish. **Do not expect a diagnosis over the telephone.**

By informing the laboratory personnel of your problem and answering accurately their questions you can facilitate a rapid and accurate diagnosis. The more information that you can provide to the diagnostic laboratory, the better the evaluation of your disease case. The laboratory personnel recognize that you are in a difficult situation and they are anxious to help. Some general guidelines in specimen collection, preparation, and shipment follow.

I. The Specimen

The quality of specimen submitted to a fish disease diagnostic laboratory can greatly influence the ability of-the fish health specialist to provide you with a diagnosis and recommendation for corrective action. **Live fish showing the disease signs in question should be collected.** Dead fish are of little value for disease diagnosis; because:

a) Fish decompose very rapidly once death occurs. If the disease in question was caused by a bacterium, other bacteria that take part in the normal decomposition process can quickly overgrow the pathogen and make its identification difficult or impossible.

b) Parasites require a live host for survival. When a fish dies, the parasites will often quickly leave the fish in search of another live fish upon which to live.

c) Viruses also require a live host in which to live. Once the fish dies the viruses will survive for only a 1imited period of time, sometimes only a few hours.

d) The time the fish has been dead is often impossible to know. Time is often wasted by providing a specimen that, although it may appear "fresh dead", is actually unsuitable for processing. The extra effort to collect live fish that show the clinical signs of the disease in question is time well invested.

It is best to collect 3-5 living fish that show the signs of the disease and submit them to the fish health specialist.

II. Packing and Shipping the Specimens

The best possible way to transport sick fish to a disease diagnostic laboratory is for the culturist to bring them to the laboratory alive. This will provide the fish health specialist with the best specimens and the opportunity to obtain from the culturist additional information regarding the circumstances surrounding the mortalities. The culturist should also bring a water sample from the culture system if requested. This water sample should be collected in a clean container that can be capped tightly. If a chemical contaminant is suspected, the sample must be collected in a glass jar (not plastic) and handled according to instructions provided by the disease diagnostic laboratory.

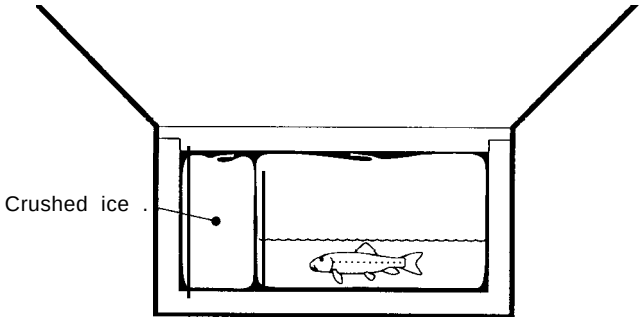
If the culturist cannot transport the specimens and the fish must be shipped, the following methods **(from most desirable to least desirable) can be** used:

a) Live fish
b) Iced fish
c) Frozen fish
d) Formalin fixed fish

Most diagnostic laboratories prefer specimens that are not in formalin because the formalin will also fix (kill) pathogenic or disease causing microorganisms, Reaching a diagnosis may depend on the ability of the diagnostic laboratory to culture a bacterium or virus from the fish. This can be done only if the bacteria or viruses are not killed. In addition, a very important aspect of recommending a treatment for bacterial diseases is to determine the antibiotic resistance of the bacterium. The diagnostician must culture the microorganism in the laboratory to determine its resistance. Formalin fixed materials can yield important diagnostic information following histological examination, but because of its limitations, most diagnostic laboratories prefer materials from which they can culture pathogenic microorganisms. This issue should be discussed with the diagnostic laboratory with which you will interact.

Fish shipped by any of the above methods should be **collected alive** from those fish in the system that are showing the disease signs. It is best to collect the fish with a net or trap. Capture of fish by rod and reel will select individual fish that are still feeding actively. One of the first signs of many diseases is that fish stop feeding. Thus, collecting fish with a rod and reel will select the healthiest fish in the population. Accurate diagnosis of the disease may not be possible as these fish may not yet be infected.

A. Live Fish



1) Obtain a strong, waterproof, insulated shipping container (e.g., a disposable styrofoam cooler in a sturdy cardboard box).

2) Fill a heavy-duty plastic bag approximately 1/3 full of clean water from the culture facility. Place the bag in the shipping container and add the fish. Fill the bag with pure oxygen or air. Seal the bag by twisting the open end tightly shut and securing it closed with several heavy-duty rubber bands or plastic tie-downs. An air tight seal is essential.

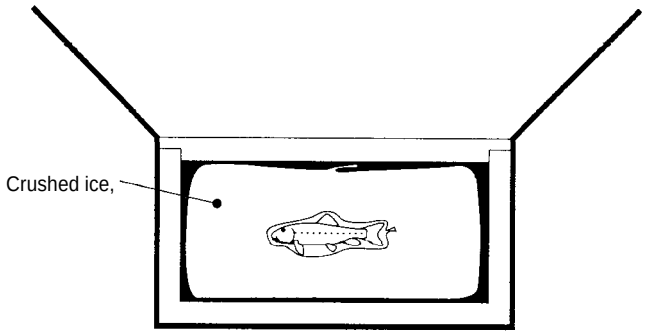
3) Place 3-5 pounds of crushed ice in a strong plastic bag, seal the bag as described above, and place it in the shipping container next to the bagged fish.

4) In a separate, small plastic bag place a note that includes your name, address, telephone number, and information describing the fish and the culture system from which they came (e.g., why you suspect a disease; number of mortalities and their appearance; approximate size of diseased fish relative to other fish being cultured; when and how the shipped fish were collected; stock density; any known water quality parameters). Place the bagged note inside the shipping container.

5) Seal the shipping container. Be sure to indicate which end is "up" and that live fish are enclosed.

CAUTIONS: Take extra care in making sure the container won't leak. "Double bagging" can sometimes help. Ship via a carrier that can provide overnight delivery. It is always best to contact your fish diagnostic laboratory prior to any shipment and to coordinate the receipt of the fish with them.

B. Iced Fish



1) Obtain a strong, waterproof, insulated shipping container (e.g., a disposable styrofoam cooler in a sturdy cardboard box).

2) Wrap each fish individually with several sheets of newspaper to prevent freeze bums that may obscure signs of disease that could be diagnostically important. Place each fish in a separate plastic bag and seal the bag.

3) Place a larger, strong plastic bag in the shipping container and fill the bag with 2-4 inches of crushed ice.

4) Place the individually bagged fish on the crushed ice in the larger bag and cover them with an additional 2-4 inches of crushed ice. Seal the larger bag by twisting the open end shut and securing it closed with several heavy-duty rubber bands or plastic tie-downs. An air tight seal is essential.

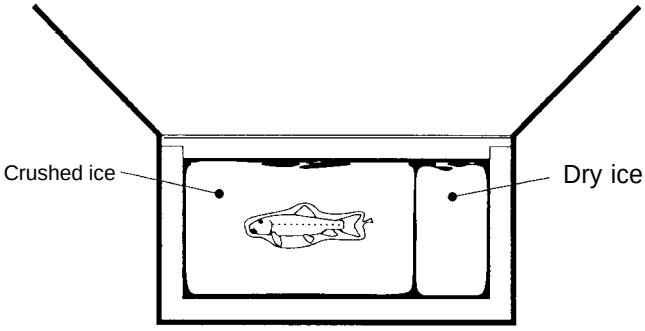
5) In a separate, small bag place a note that includes your name, address, telephone number, and information describing the fish and the culture system from which they came (e.g., why you suspect a disease; number of mortalities and their appearance; approximate size of diseased fish relative to other fish being cultured; when and how the shipped fish were collected; stock density; any

known water quality parameters). Place the bagged note inside the shipping container.

6) Seal the shipping container. Be sure to indicate which end is "up" and that iced (perishable) fish are enclosed.

CAUTIONS: Adequate amounts of crushed ice, usually 10-15 pounds, will be satisfactory to keep the fish chilled during shipment. Ship via a carrier that can provide overnight delivery.

C. Frozen Fish



1) Obtain a strong, waterproof, insulated shipping container (e.g., a disposable styrofoam cooler in a sturdy cardboard box).

2) Place each fish in an individual plastic bag and seal the bag. Freeze the fish in the individual plastic bags.

3) Place a larger, strong plastic bag in the shipping container and fill the bag with 2-4 inches of crushed ice.

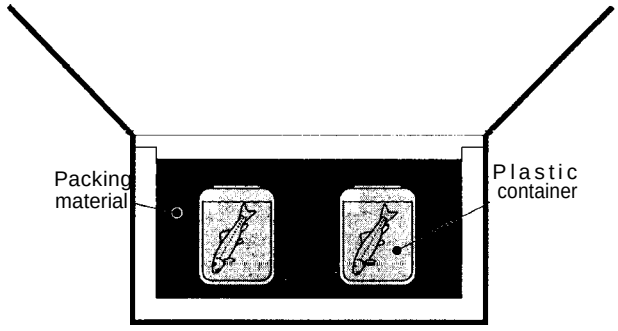
4) Place the individually bagged, frozen fish on the crushed ice. Cover the fish with additional crushed ice and tightly seal the bag by twisting the open end shut and securing it closed with strong rubber bands or a plastic tie-down. If possible, use dry ice to insure that the specimens do not thaw during transit. Five pounds of dry ice will normally keep specimens frozen for 24 to 36 hours, if the shipping container is well insulated.

5) In a separate, small bag place a note that includes your name, address, telephone number, and information describing the fish and the culture system from which they came (e.g., why you suspect a disease; number of mortalities and their appearance; approximate size of diseased fish relative to other fish being cultured; when and how the shipped fish were collected; stock density; any known water quality parameters). Place the bagged note inside the shipping container.

6) Seal the shipping container. Be sure to indicate which end is "up" and that frozen (perishable) fish are enclosed.

CAUTIONS: Check with the commercial carrier for their policy regarding shipment of packages containing dry ice. Ship via a carrier that can provide overnight delivery.

D. Formalin Fixed Fish



1) Make a 10% formalin solution. Neutral buffered formalin is best. Under practical field conditions, water from the culture facility will usually provide adequate buffering capacity to the solution, (To prepare the desired formalin solution, mix 9 parts water with 1 part formalin).

2) Kill the fish before placing them in the formalin solution. This can be done by with an "overdose" of MS-222 (tricaine methane sulfonate at 1 gm per 500 mL H_20). It is important that the fish be rapidly "fixed" by the formalin so that the quality of tissue preservation will yield useful information. Normally, formalin can rapidly fix tissues that are less than $1/_2$ inch thick. For this reason, the abdomen of larger fish must be opened for its entire length with one continuous cut. Most fish disease diagnostic laboratories will prefer to have the entire fish shipped rather than a limited number of tissues or organs. An "apparently normal organ" may yield valuable diagnostic information when examined microscopically. Questions regarding shipment of whole fish or selected tissues should be directed to the diagnostic laboratory before samples are sent. It is also important that adequate amounts of formalin be used to preserve the tissues. As a general rule, **the ratio of formalin solution to tissue must be 10:1** by weight or volume; (ie. 1000 mL of the formalin solution : 100 gm fish).

3) The container with the formalin and the tissue must be tightly sealed. Care should be taken to prevent breakage of the container. Glass containers can break and should be avoided. **Use plastic bottles** such as empty, clean food containers (e.g., peanut butter, mustard, salad dressing — use food service size for large fish) or containers obtained from scientific supply companies,

4) The sealed container should be placed in a shipping container tilled with styrofoam pellets or other suitable packing material. Care should be taken to prevent breakage.

5) In a separate, small bag place a note that includes your name, address, telephone number, and information describing the fish and the culture system from which they came (e.g., why you suspect a disease; number of mortalities and their appearance; approximate size of diseased fish relative to other fish being cultured; when and how the shipped fish were collected; stock density; any

known water quality parameters). Place the bagged note inside the shipping container.

6) Seal the shipping container. Be sure to indicate which end is "up" and that preserved fish are enclosed.

CAUTIONS: Formalin is irritating and toxic. Provide for good skin and eye protection as well as good room ventilation when using this chemical. A good practice when handling formalin or any other potentially irritating or toxic chemical is to use rubber gloves to protect the hands, goggles to protect the eyes, and a breathing mask to reduce inhalation of the chemical.

III. Summary

The manner in which your fish specimens are prepared and shipped will influence what information can be obtained when the specimens are examined by the fish health specialist. Working with a live fish will provide the diagnostician with the best opportunity to gain useful information regarding the fish disease. The fish can be examined for live parasites. Identification of living parasites can be aided by observing and characterizing their movement. Microorganisms (bacteria and viruses) can be cultured from specimens that are delivered to the diagnostic laboratory alive and the sensitivity of bacterial pathogens to potential treatment chemicals can be determined. A histopathological examination can be performed on properly prepared organs and tissues. Tissue changes that are indicative of disease can be identified. It is critical that the tissues be preserved properly to insure that they represent the disease process and not decomposition after death.

Specimens that are shipped on ice or frozen have some important diagnostic limitations. Living parasites may or may not be present on iced fish. Histopathological examination may not yield reliable information, depending upon the time during which the fish were maintained in an iced condition. The limitations of frozen fish are greater. When frozen fish are thawed, the shearing action of melting ice crystals will destroy parasitic protozoa, making their identification very difficult if not impossible. The thawing of frozen tissues will also create a great deal of damage, making tissues of limited or no use for histopathological examination. Iced and frozen specimens are normally satisfactory for the culture of bacteria and viruses.

Specimens shipped in formalin are useful for histopathological examination as long as the specimens have been carefully preserved prior to shipment. As mentioned above, the diagnostician must be able to detect tissue changes that are caused by the disease process and not the result of decomposition after death. This can only be done with a carefully processed sample. The formalin fixed sample may not yield the identity of the disease organism and it will not provide information regarding the antibiotic sensitivity of a bacterium.

The impact of fish handling and preservation on disease diagnosis can be summarized:

Shipment method	Parasitology	Bacteriology	Virology	Histopathology
Live	+++	+++	+++	+++
Iced	+	++	+++	+/–
Frozen	–	++/+	++/+	–
Formalin fixed	+/–	–	–	+++

Legend:
+++ no effect, excellent specimen for examination
++ negligible effect, good specimen for examination
\+ moderate effect, specimen may be usable
+/– substantial effect, specimen may not be useful
– dramatic effect, specimen not useful

Therefore, as stated earlier, the methods of shipment for fish disease diagnosis, from most desirable to least desirable are:

1. Live fish
2. Iced fish
3. Frozen fish
4. Formalin fixed fish

Treatment of Diseased Fish

Once a diagnosis has been made, the diagnostic laboratory will contact the culturist and identify the disease as well as recommend an appropriate and approved treatment or action. In certain cases a change in management is necessary. In other situations it is necessary to add an antibiotic to the feed (for internal bacterial infections) or a chemical to the water (usually for external parasite infestations). It is extremely important that the aquaculturists follow closely the recommendations of the diagnostic laboratory and take appropriate precautions before any disease treatment is applied.

Over the years, four **cardinal rules of fish disease treatments** have evolved:

a. Know your fish
b. Know your water
c. Know your chemical
d. Know your disease

The culturist must know his/her fish. What is their normal behavior, what conditions are likely to stress them, and to what diseases are they most susceptible. Some chemicals are safe and legal to use on certain species and ages of fish, but they may not be appropriate or approved for your fish.

The quality of your water influences the condition of your fish. Each fish species has a preferred temperature. Some fish are more tolerant than others of reduced oxygen, high turbidity, and elevated levels of ammonia. Water chemistry in some systems remains relatively uniform (e.g., single-pass system, properly functioning recirculated system). In other systems, such as ponds, water chemistry can vary widely on a seasonal basis or even during a 24 hour period. Dissolved oxygen and temperature may

change dramatically each day, but alkalinity and hardness vary little in ponds. In a properly functioning recirculated system, dissolved oxygen and temperature remain relatively constant throughout the day and growing season, but alkalinity and hardness can change in a matter of days. In an improperly functioning or overstocked recirculated system, dramatic and rapid changes in dissolved oxygen, ammonia or nitrite can result in high mortality of cultured fish.

One of the most important aspects of chemical treatment has become knowing which chemicals are approved for use by aquaculturists. Each chemical can be used to treat effectively and legally a few to several diseases. No one chemical is appropriate for all diseases or situations. For instance, an antibiotic can be very effective in the treatment of a bacterial infection, but is useless if the disease is caused by a protozoan parasite. All chemicals have precautions and considerations associated with their use. If an aquaculturists has no experience with a particular chemical, a small group of fish should be treated first, as a test before the entire lot is treated, to avoid potentially heavy losses due to toxicity associated with overtreatment. Extreme caution should be practiced when applying any chemical treatment. Water quality influences the toxicity of certain chemicals and is adversely affected by some chemicals. The culturist should be knowledgeable of the water quality in the culture facility. Of particular interest are dissolved oxygen, alkalinity, and the amount of organic material in the water.

Units

Units of measure used in this Publication are primarily metric. Concentrations of chemicals are commonly expressed in terms of milligrams (mg) per liter (L) or parts per million (ppm). When making a chemical application in freshwater these two terms are functionally equivalent. One liter of water weighs 1 kilogram= 1000 grams= 1,000,000 milligrams and 1 mg/ l,000,000 mg (or 1 L) = 1 ppm.

Antibacterial compounds are added to the feed as a treatment for systemic (internal) bacterial infections. They are commonly applied as rates. A generic expression is the weight of antibacterial compound per weight of fish per day for a specified number of days. This may be in terms of mg drug/kg fish weight/day. Historically, some antibacterial treatment rates have been expressed as a combination of English and metric units (e.g., g (gram) drug/lb fish weight/day).

A list of conversion factors are provided at the rear of this publication to assist with calculations.

Aquaculture Chemicals

Below are brief descriptions of some commonly used aquaculture chemicals and precautions/considerations associated with their use. It should again be emphasized that the aquaculturists must be aware of the legal status of using any chemical. A good practice is to maintain only those chemicals that do have specific approval for aquaculture uses at the production facility. The presence of non-approved chemicals at an aquaculture facility may imply their use to an inspector even if they are never used. Regulations concerning approved chemicals for use in aquaculture are continuously being updated. A good source of information is the publication *A Guide to Approved Chemicals in Fish Production and Fishery Resource Management* by R. A. Schnick, F. P. Meyer, and D. L. Gray (see references).

a) **Terramycin** is an antibiotic used to treat systemic (internal) bacterial infections. It is **approved** by the U. S. Food and Drug Administration (FDA) for the treatment of sensitive bacteria of the genera *Aeromonas, Pseudomonas,* and *Hemophilus* in salmonids and catfish. It is used as a feed additive at a rate of 2.5 grams of drug (active ingredient)/lOO pounds of fish weight/day for 10 days. A 21-day withdrawal period is required before the fish may be slaughtered and used for human consumption.

b) **Sulfamerazine is** an antibiotic used at one time for the treatment of furunculosis in salmonid fishes. It was used as a feed additive at 10 grams of drug (active ingredient)/100 pounds of fish weight/day for 14 days. A 21-day withdrawal period was required before the fish may be slaughtered and used for human consumption. (Note: Old fish health literature implies that sulfamerazine is an approved compound for use on food fish, it is **not!** Because many individuals were substituting a generic "sulfa drug" for sulfamerazine, the manufacturer allowed its permit for this drug to lapse. Therefore, it is **not legal** to use this drug for food fish at this time.)

c) **Romet-30** is a combination of two antibacterial drugs that **has FDA approval** for the treatment of furunculosis in salmonids and enteric septicemia in channel catfish. In both cases it is used as a feed additive at a rate of 50 milligrams drug (active ingredient)/kilogram of fish weight/day for 5 days. A 42-day withdrawal period is required for salmonids and a 3-day withdrawal period is required for channel catfish before the fish may be slaughtered and used for human consumption,

d) **Copper Sulfate** ($CuSO_4$) is used to treat a variety of external parasites of fish. It is also an effective and approved algicide, and can kill fish if used improperly. The relationship between toxicity of copper sulfate and alkalinity is very important (alkalinity is the total concentration of alkaline substances in the water expressed as equivalent calcium carbonate). In water with an alkalinity less than 50 milligrams per liter (mg/L), copper sulfate can be very toxic to fish and should not be used unless a bioassay has been run in the water first with a limited number of the fish to be treated. The following general guidelines have been established for the use of copper sulfate:

Table 1. Treatment concentration of copper sulfate in water of various alkalinities (mg/L = ppm)

Alkalinity of water (mg/L)	Permissible treatment (mg/L)
0-49	test for toxicity before use
50-99	0.5 - 0.75
100-149	0.75- 1.00
150-200	1.00- 2.00
200+	ineffective; will ppt as $CuC0_3$

Since copper sulfate is an algicide, consideration must be given to dissolved oxygen in a pond to be treated. If a pond already has low dissolved oxygen, an alternate treatment should be used. Copper sulfate will only aggravate low dissolved oxygen problems by killing the primary source of oxygen (the algae) and by adding a large biological oxygen demand in the form of dead and decomposing algae.

e) **Formalin-F** (formalin) is **approved** for use in the treatment of several external parasites. It is commonly used as an indefinite pond treatment at 15 milligrams per liter (mg/L). Formalin will remove 1 mg/L dissolved oxygen for every 5 mg/L of formalin used as a treatment. Therefore, if dissolved oxygen in a pond is low, aeration must be provided or a different treatment should be used. Formalin must be stored at temperatures above 40° F because it will form very toxic paraformaldehyde at low temperatures.

f) **Potassium Permanganate** ($KMnO_4$) is **approved** for use in Aquaculture as an oxidizer and detoxified. It has been used effectively against a number of external disease organisms of fish. The normal treatment is 2-8 milligrams per liter (mg/L), depending upon the amount of organic matter in the pond to be treated. Ideally, one would like to maintain a "wine red" color in the water for a 12 hour period to ensure an effective treatment. A preliminary test can be performed with a small volume of culture water to determine the appropriate dose for the system.

g) Sodium Chloride **(Salt;** NaCl) **is approved** for AQUACULTURE use as an "osmoregulatory enhancer." Salt can change the osmoregulatory balance (water balance) of aquatic organisms. It can control external parasitic protozoans by placing them in a condition of severe osmoregulatory shock. Care must be exercised to avoid overtreatment which will place the fish in the same condition of osmoregulatory shock. Sodium chloride is used as a 0.590 to 1.090 concentration in water as an indefinite (long-term) treatment or as a 3% concentration in water for 10-30 minutes (stop the treatment earlier if the fish show signs of stress).

Calculation Of Disease Treatments

a) Water treatments are based on water volume. A specified amount of chemical is added to a known quantity of water for a specified time. If too little chemical is added the treatment will be ineffective; if too much is added or if the fish are left in contact with the chemical too long, they may become stressed or die.

b) Feed treatments and fish injections are based on fish weight. A specified amount of chemical is added to. the feed or injected into the fish. Improper doses may result in an ineffective treatment or mortalities.

c) Aquaculturists should compute the volume of each culture unit (e.g., pond, tank, raceway) before a problem occurs, preferably when the system is designed or filled with water for the first time. The information should be stored so it is immediately available when needed. Practice calculations should be done so the culturist is comfortable and familiar with the computation procedure. A useful text is, *"Handbook for Common Calculations in Finfish Aquaculture"* by Gary Jensen (see reference). Culturists are strongly encouraged to obtain and use a copy of this or a similar work book. If you lose or gain a decimal point on a sample problem, you get the answer wrong. If you lose or gain a decimal point in real life, your treatment will likely be ineffective and your fish will continue to die or you may actually kill your fish with the treatment!

Sample Calculations

To provide the culturist with an opportunity to become familiar with the methodology used to calculate fish disease treatments, three hypothetical situations are presented. For each example, there are several ways to correctly compute the amount of chemical to add or the drug to use. Calculations and steps are shown in detail for one method.

Example 1

You have a raceway with rainbow trout that are infected with the parasitic protozoan, *Ichthyophthirius.* You elect to treat with copper sulfate ($CuSO_4$). The raceway contains 5,000 gallons of water with an alkalinity of 75 milligrams per liter (mg/L or ppm). How much $CuSO_4$ would you use?

Computation steps:

1) *Examine Table 1 and determine what concentration of $CuS0_4$ should be added to the system to provide an appropriate and safe treatment.*

You know that the alkalinity is 75 mg/L. Therefore, an appropriate treatment concentration for $CuSO_4$ is 0.5 mg/L.

2) *Determine the quantity of $CuS0_4$ to be added to the raceway to achieve the 0..5 mg/L concentration.*

2a) *Convert the volume of the raceway from gallons (gal) to liters (L).*

(5,000 gal) x *(3.8* L per gal)= *19,000* L in the raceway

2b) *Determine a correction factor for the proportion of chemical ($CuSO_4$) that is active ingredient].*

(100%) / (100% active ingredient)= correction factor= 1.0

2c) *Compute the amount of chemical ($CuSO_4$) that should be added to the raceway,*

(volume of raceway) x (dosage of $CuSO_4$) x (correction factor)

(19,000 L) x (0.5 mg/L $CUSO_4$) x (1.0) = 9,500 mg $CUSO_4$

2d) *Convert milligrams (mg) $CuSO_4$ to grams (g).*

(9,000 mg) / (1,000 mg/ 1.0 g) = 9.5 g **$CuS0_4$** added to the 5,000 gallon raceway

NOTE: Because *Ichthyophthirius* has a complicated life cycle that must be considered in its treatment, applications of chemical are made every third day for 3 to 4 treatments.

Example 2

If alkalinity in Example 1 was below 50 mg/L, $CuSO_4$ would not have been the treatment of choice due to potential toxicity to the fish (Table 1). An alternative treatment would have been formalin.

Computation steps:

1) *Obtain from your diagnostic laboratory a recommended treatment concentration for formalin.*

An appropriate dose is 25 mg/L (or 25 ppm formalin)

2) *Determine the quantity of formalin to be added to the raceway to achieve the 25 mglL (25 ppm) concentration.*

2a) *Convert the volume of raceway from gallons (gal) to liters (L).*

(5,000 gal) x *(3.8* L per gal)= 19,000 L in the raceway

2b) *Determine a correction factor for the proportion of chemical (formalin) that is active ingredient.* NOTE: *Although formalin is 37% formaldehyde gas dissolved in water, for fish treatment purposes formalin is considered to be 100% active.*

(100%)/(100% active ingredient)= correction factor= 1.0

2c) *Compute the amount of chemical (formalin) that should be added to the raceway.*

(volume of raceway) x (dosage of formalin) x (correction factor)

(19,000 L) x *(25* mg/L formalin) x (1.0) = 475,000 mg formalin

2d] *Since formalin is a liquid it is desirable to convert milligrams (mg) to milliliters (mL).*

(475,000 mg formalin) / (1,000 mg / 1.0 g) = 475 g formalin

1.0 g formalin = - 1.0 mL formalin, so

475 g formalin = 475 mL formalin added to the 5,000 gallon raceway

Example 3

You have carp in a garden pond with a diagnosed bacterial *(Aeromonas hydrophila)* infection. The pond contains 10 fish that weigh an average of 2 pounds each, for a total of 20 pounds of fish. The bacterium is sensitive to terramycin. How would you prepare the treatment?

Computation steps:

1) *Determine from your diagnostic laboratory or from aquaculture literature the proper treatment concentration.*

Terramycin is frequently used at 2.5 grams (g) active ingredient per 100 pounds (lb) of fish per day for 10 days. The drug is mixed with the feed and fed to the fish.

2) *Determine the quantity of terramycin needed for the 10 day treatment.*

2a) *Determine a correction factor for the proportion of chemical (terramycin) that is active ingredient.* **NOTE:** *Terramycin premix is often supplied as a 50% active mixture. Always check the label of a specific package.*

(100%) / *(50%* active ingredient)= correction factor= 2.0

2b) *Compute how much teramycin is to be fed each day. (dosage of terramycin) x (lb of fish in pond) x (correction factor)*

(2.5 g terramycin / 100 lb fish) x (20 lb fish) x (2.0) = 1.0 g terramycin per day

2c) *Compute the quantity of terramycin fed for 10 days.*

(1.0 g terramycin / day) x (10 days) = 10,0 g terramycin

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[l]percent active ingredient is the purity of the chemical or the amount that is effective in treatment of the disease. Copper sulfate is usually available in a 100% active form (pure copper sulfate), but many chemicals are not. If the chemical is not 100% active, a correction factor must be generated:

100% percent active ingredient= correction factor

The percent active ingredient information can be obtained from the label on the container in which the chemical was supplied or from personnel at the diagnostic laboratory.

3) *Determine the amount offood that you will feed to the fish during the 10 day treatment period.*

3a) *Ornamental fish, such as carp, might reasonably be fed at a rate of 1% of their body weight per day.*

(20 lb fish) (1.0%/ 100%)= 0.2 lb food per day

3b) *Compute feeding rate for 10 days.*

(0.2 lb food/ day) x (10 days) = 2.0 lb food

4) *Prepare medicated feed and present it to the fish*

Commercially prepared, medicated feeds are available and can be used. Alternatively, medicated feed can be prepared by mixing the 10 grams of terramycin with two pounds of feed. The antibiotic may be mixed in a vegetable or fish oil. It is then spread on the feed pellets which become coated with a thin film of the antibiotic-laced oil. Regardless of the source, 0.2 pounds of the medicated feed are provided to the carp each day for 10 days.

Fish Disease Diagnostic Services

Northeastern United States

The importance of obtaining an accurate diagnosis for a disease problem cannot be overemphasized. The success of any treatment is closely tied to knowing the condition being treated and being aware of any complicating factors. Accurate diagnosis of a fish disease requires specialized technical skills and appropriate laboratory facilities. Fish disease diagnostic services are available from a variety of sources in the northeastern United States. The aquaculturists should contact a laboratory before a problem occurs to determine any specific instructions associated with the submission of fish for diagnostic evaluation. For instance, some laboratories can, due to their funding, only accept submissions from restricted geographical locations and some fish health research laboratories only accept diagnostic cases that are referred by other diagnostic laboratories. An annually revised list of agencies and individuals that provide disease diagnostic services is included in the *"Annual Buyer's Guide"* published by AQUACULTURE Magazine (P.O. Box 2329, Ashville, NC 28802). As of the printing of this document, the following people and laboratories have expertise in fish disease diagnostics:

Connecticut

Mr. Rich Van Nostrand
Whittemore Salmon Station
P. O. Box 215
Riverton, CT 06065
(203) 566-2287, (203) 566-4477
(Limited service available)

Delaware (none known)

Maine

Mr. David Locke, Mr. David Tillinghast
Maine Department of Inland Fisheries and Wildlife
284 State Street
Station #41
Augusta, ME 04330
(207) 289-5261
(Limited diagnostic service to commercial producers)

Mr. Roger Dexter
AFS Fish Pathologist
East Orland, ME 04431
(207) 469-2601 (May - November)
(813) 343-5889 (December - April)

Dr. Bruce Nicholson
Department of Biochemistry,
Microbiology and Molecular Biology
University of Maine
Orono, ME 04469
(207) 581-2810

Northeastern Laboratory
P. O. Box 788
Waterville, ME 04901
(207) 873-7711

Maryland

Dr. Anna Paya
Fish Disease Laboratory
Department of Microbiology
University of Maryland
College Park, MD 20742
(301) 405-5465
(Currently have 24 hour hotline which can result in a field visit within 21/$_2$ hours)

Massachusetts

Dr. Donald Abt, Dr. Robert Bullis
Laboratory for Marine Animal Health
Marine Biological Laboratory
Woods Hole, MA 02543
(508) 548-3705 Ext. 513

New Hampshire

Mr. Jay Hendee
RD 10, Box *375*
Concord, NH 03301
(603) 798-5474

New Jersey

Mr. Edward Washuta
Division of Fish, Game and Wildlife
Pequest State Fish Hatchery
RR #1, Box *389*
Pequest Road
Oxford, NJ 07863
(908) 637-4173

New York

Dr. Paul Bowser
Fish Diagnostic Laboratory
Department of Avian and Aquatic Animal Medicine
College of Veterinary Medicine
Cornell University
Ithaca, NY 14853
(607) 253-3365

Dr. John Schachte, Jr.
Fish Disease Control Unit
New York State Department of Environmental Conservation
8314 Fish Hatchery Road
Rome, NY 13440
(315) 337-0910

Pennsylvania

Mr. John Thoesen, Mr. John Coil,
Ms. Patricia Barbash, Mr. Kimball Selmer-Larsen
Fish Health Unit
U. S. Fish and Wildlife Service
P. O. Box 155
Lamar, PA 16848
(717) 726-6611
(Diagnostic services not available to commercial culturists)

Mr. Ken Stark
Pennsylvania Fish Commission
1225 Shiloh Road
State College, PA 16801
(814) 355-4837
(Limited diagnostic services to commercial culturists)

Rhode Island

Dr. Richard Wolke, Dr. Terry Bradley
Department of Fisheries, Animal and Veterinary Science
The University of Rhode Island
Kingston, RI 02881
(401) 792-2487

Vermont

Mr. Tom Jones
Roxbury Laboratory
Vermont Fish and Wildlife Department
Roxbury, VT 05669
(802) 485-7566

Washington, D.C. *(none known)*

West Virginia (*none available)*

Eastern Canada

(many culturists in the Northeastern United States live close to Canadian service sites and may wish to access them)

Dr. David Groman
Fish Health Unit
Atlantic Veterinary College
University of Prince Edward Island
550 University Avenue
Charlottetown, P,E.I.
CIA 4P3 Canada
(902) 566-0831

Dr. Steve Griffiths
UNB/RPC Fish Health
Food, Fisheries, and Aquaculture Department
Loring Bailey Hall
University of New Brunswick
Bag Service 45111
Fredericton, NB
E3B 6E1 Canada
(506) 452-1365

Dr. Steve Backman DVM
Moore-Clark Co. (Canada), Inc.
Champlain Industrial Park
P. O. Box 585
St. Andrews, NB
EOG, 2X0 Canada
(506) 529-4551

Fish Health Management References

Meyer, F.P., J.W. Warren and T.G. Carey. 1983. ***A Guide to Integrated Fish Health Management in the Great Lakes Basin.*** Special Publication 83-2. Great Lakes Fishery Commission, Ann Arbor, MI. 262 pp.

available from: Great Lakes Fishery Commission
1451 Green Road
Ann Arbor, MI 48105
(cost: free)

Piper, R. G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler and J.R. Leonard. 1982. ***Fish Hatchery Management.*** U. S. Fish and Wildlife Service, Washington, DC 517 pp.

available from: U. S. Department of the Interior
Fish and Wildlife Service
Washington, DC 20240
(approximate cost $30.00)

Schnick, R. A., F.P. Meyer and D.L. Gray. 1989. ***A Guide to Approved Chemicals in Fish Production and Fishery Resource Management.*** Cooperative Extension Service, University of Arkansas. 27 pp.

available from: Cooperative Extension Service
University of Arkansas
Little Rock, AR 72203

U. S. Fish and Wildlife Service
National Fisheries Research Laboratory
LaCrosse, WI 54602
(cost: free)

General Aquaculture References

Boyd, C.E. 1990. ***Water Quality in Ponds for Aquaculture.*** Birmingham Publishing Company, Birmingham, AL. 482 pp.

available from: Alabama Agricultural Experiment Station
Auburn University
Auburn University, AL 36849
(approximate cost: $20.00)

Dupree, H.K. and J.V. Huner (eds.) 1984. ***Third Report to the Fish Farmers.*** U. S. Department of the Interior, Fish and Wildlife Service, Washington, DC 270 pp.

available from: Fish and Wildlife Service
U. S. Department of the Interior
Washington, DC 20250
(cost: single copies free)

Leitritz, E. and R.C. Lewis. 1980. ***Trout and Salmon Culture (Hatchery Methods).*** Agricultural Science Publications, University of California, Berkeley, CA. 197 pp.

available from: Agricultural Sciences Publications
University of California
Berkeley, CA 94720
(approximate cost: $10.00)

McLamey, W. 1984. ***The Freshwater Aquaculture Book — A Handbook for Small Scale Fish Culture in North America.*** Hartley and Marks Publishers, Point Roberts, WA. 582 pp.

available from: Hartley and Marks, Inc.
P.O. Box 147
Point Roberts, WA 98281
(approximate cost: $40.00)

Sources of Shipping and Treatment Supplies

Supplies for shipment and treatment of diseased fishes can be obtained from the sources indicated below. Additional sources are listed in the *Annual Buyer's Guide* published by Aquaculture Magazine. Note, treatment of fish diseases must be made with approved chemicals. The list of approved chemicals changes periodically and the culturist would be wise to consult with the diagnostic laboratory for current guidelines.

Insulated shipping containers—styrofoam coolers from a local hardware store; or fish boxes from a supplier such as Speedling, Inc., P.O. Box 7238, Sun City, FL 33586,800-940-3261.

Plastic jars-may be obtained locally or purchased from a scientific supply company such as Ward's Natural Science Establishment, Inc., 5100 West Henrietta Rd., P.O. Box 92912, Rochester, NY 14692,800-962-2660.

Oxygen —from a local supplier identified in the telephone yellow pages.

Formalin for fixingfish -from a scientific supply company such as Ward's Natural Science Establishment; or an aquaculture supplier such as Argent Chemical Laboratories, 8702 152nd Ave., Redmond, WA 98052,800-426-6258 or Fritz Aquaculture, P.O. Drawer 17040, Dallas, TX 75217,800-527-1323.

Chemicals for treatment of diseases —some may be available locally through a veterinarian or pharmacy, many must be purchased (preferably in advance and stored properly until needed) from an aquaculture supplier such as Argent Chemical Laboratories or Fritz Aquaculture.

Fish food —suitable products may be obtained from your local Agway or feed store; to ensure high quality it is perhaps best to purchase your feed from a recognized aquaculture manufacturer such as Ziegler Brothers, Inc., P.O. Box 95, Gardners, PA 17324, 717-677-6181 or A.J. Balshi, Inc., 350 Fisher Avenue, Catawissa, PA 17820, 717-356-7161.

NOTE: Identification of a source or product does not constitute an endorsement.

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Some Useful Conversion Factors

1 ppm (mg/L) = 0.38 grams per 100 gallons of water
= 3.8 milligrams per gallon of water
= 0.0283 grams per cubic foot of water
= 0.38 milliliters per 100 gallons of water
= 2.72 pounds per acre-foot of water
= 1 milligrams per liter of water
= 1 grams per cubic meter of water
= 0.001 milliliters per liter of water

English : Metric Conversions

1 acre-foot	=	43,560.	cubic feet
1 acre-foot	=	325,850.	gallons
1 acre-foot of water	=	2,718,144.	pounds
1 cubic foot of water	=	7,48	gallons
1 cubic foot of water	=	62.4	pounds
1 cubic foot of water	=	28.3	liters
1 cubic foot of water	=	28.3	kilograms
1 cubic meter of water	=	1,000.	liters
1 cubic meter of water	=	35.3	cubic feet of water
1 cubic meter of water	=	2.203	pounds of water
1 gallon of water	=	8.34	pounds
1 gram	=	0.0353	ounces
1 kilogram	=	2.2	pounds
1 pound	=	454.	grams
1 gallon	=	3.785	liters
1 gallon of water	=	3,785.	grams
1 liter	=	0.26	gallon
1 liter	=	1,000.	cubic centimeters
1 liter	=	1,000.	milliliters
1 liter of water	=	1,000.	grams
1 ounce (weight)	=	28.4	grams
1 gallon	=	128.	fluid ounces
1 fluid ounce	=	29.6	grams
1 inch	=	2.54	centimeters
1 foot	=	30.48	centimeters
1 cubic centimeter of water	=	1.0	gram
1 cubic centimeter of water	=	1.0	milliliter
1 hectare	=	10,000.	square meters
1 hectare	=	2.47	acre
1 acre	=	0.405	hectare
1 acre	=	43,560.	square feet

Percent Solution

For 1 percent solution add:
38 grams per gallon
1.3 ounces per gallon
38 cc per gallon
10 grams per liter
10 cc per liter

Temperature Conversion

Centigrade to Fahrenheit= (C X 9/5) + 32
Fahrenheit to Centigrade= (F - 32) X 5/9